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Cell Phone Technology and Big Data Applications in Emergency Evacuations

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DEDICATION

I dedicate this thesis to my wife Tammy. Without her patience, understanding, support, and, most of all, her love, the completion of my educational goals would not have been possible.

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My studies in Emergency and Disaster Management have been very fulfilling and afforded me the opportunity to appreciate the theoretical context for the discipline while providing me with practical applications that I have been able to use in my present vocation.

ABSTRACT OF THE THESIS

CELL PHONE TECHNOLOGY AND BIG DATA APPLICATIONS IN EMERGENCY EVACUATIONS

by

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This research examines the viability of cell phone tracking to enhancing emergency manager's situational awareness of compliance with evacuations orders and using big data analytics for the purpose of identifying special populations. Cell phone tracking and big data analytics are emerging technologies and can be seen as complementary to one another. Therefore, this research will consider the two technologies together for applicability to emergency evacuations. The research methodology is a ground theory qualitative strategy as it provides the best approach to examine the complex behavioral response to real world evacuation events in the social, political and legal context. There is strong evidence that both cell phone tracking and big data analytics would afford emergency managers valuable insight to evacuate

response dynamics and enhanced information on special population. The research also makes clear that the necessary legal foundation for the use of these technologies by emergency managers for evacuations is lacking. There are no clear statutory or regulatory foundations for using such technologies. Therefore, despite the potential practical value the technologies offer, the absence of legal support for use places both technologies outside the emergency manager's evacuation toolbox.

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Cell Phone Technology and Big Data Applications in Emergency Evacuations

The goal of this research is to examine opportunities to use information obtained from cellular radios (personal cell phones) to aid emergency managers in understanding the effectiveness of the response to emergency evacuation orders. A second component of this research will look at an emerging technology, typically referred to as "big data analytics," to determine if it can aid emergency managers in providing actionable information about special populations in advance of or during evacuation orders. A base assumption of this research is that greater knowledge of a population's actual behavior during an evacuation is important information for emergency managers.

There is an old saying that a man's home is his castle. Although there is no clear origin for this cliché; it may derive from the days when men did live in castles and certainly points to the sanctity a home represents. The home is the sanctuary of the family. In most jurisdictions it is recognized as being so sacred as to be defensible with the use of deadly force. These laws are often termed Castle Doctrine laws in that they hold that a person is under no obligation to retreat from harm when upon their own premises, (i.e. in their castle), and they believe their life, family or property are in serious threat of danger or harm (*Beard v. U S*, May 27, 1895).

Emergency evacuation orders issued by governmental entities are the polar opposite of a threat of harm to self or family caused by an individual or group invading an individual's home. Threats to real property (real estate), in the US typically come from forces of nature and not people (Haddow, Bullock, & Coppola, 2011). Emergency evacuation orders are normally issued to protect people from harm and are typically issued only when the authorities reach a determination that their duty to protect citizens requires they tell people to leave their homes and communities.

Despite the fact that emergency evacuation orders are issued to aid rather than harm individuals and communities, there is more than ample evidence that educated, clear thinking, rational people often do not heed evacuation orders (or do so at varied speeds and energy), even when the orders are mandatory (Drabek, 1999). There was much fanfare and reaction when, as Hurricane Irene approach the coast of New Jersey, the Governor went on television to tell his constituents who chose to remain on the beaches of the barrier islands, because the storm had not yet arrived, to "get the hell off the beach" (Bacon, 2011, p. 1)

Such apparent indifference for evacuation orders can be seen in even greater evidence when the nature of the threat is unprecedented in magnitude (Weinstein, 1989). In October 2012, Superstorm Sandy struck the Atlantic coast of New York and New Jersey with a force not seen in a very long time, if ever. Again Governor Christie of New Jersey took to the television to tell people who had not evacuated, to get off the barrier islands (under a mandatory evacuation order.) Governor Christie went so far as to announce that it is selfish of people to make him send brave responders to rescue them once the storm arrived simply because they were not smart enough to get out before the storm arrived (Saletan, 2012, p. 1).

In November 2014, an early but extreme snow storm was forecast for the Buffalo, New York area. Weather forecasters and emergency management officials were warning residents of the severity of the impending storm and that residents should remain off the roadways unless absolutely necessary. In spite of these clear, early and repeated warnings, schools activities continued and residents still ventured out on the highways. The snow arrived with such ferocity that roadways became snow impacted and responders needed to rescue hundreds of people that became stranded when roads became impassable; including an entire school bus of student that were trapped for about 23 hours.

Hurricane Katrina represents one of the greatest examples in recent US history of the tragic outcomes of citizens either not responding to evacuation orders or possibly not having access to the means to evacuate. New Orleans, long known to be a "soup bowl" sitting below sea level and surrounded by levees had survived, in reasonably good fashion, many past hurricanes that had entered the Gulf of Mexico. In the case of Katrina, forecasters were much more worried. Katrina was a Category 4 hurricane with winds gusting above 130 miles per hour, and a storm surge thought to potentially be a 30-50 foot wall of water. To complete the ominous picture, weather forecasting models predicted the track of Katrina would bring it on shore at a location that placed New Orleans in the most severe impact quadrant.

The outcome is now a matter of US history. The storm surge did come, pushed ashore by Category 3 hurricane winds along with driving rains. Levees failed and were overtopped. Pumps intended to rapidly redirect the water out of the low lying areas failed. New Orleans experienced significant flooding. According to many news sources, New Orleans flooded like never before (CNN, 2014). Those same news sources also state that more than 1500 souls in New Orleans perished!

It is beyond the scope of this research to investigate the physical, sociological and psychological reasons people remain in their homes and communities when issued evacuation orders. The research will assume one of two high level reasons why evacuation orders are often ignored by some segments of the population. Either the non-evacuating population did not get the evacuation order or the evacuation order was not presented in a manner that was effective in eliciting the desired response by the non-evacuating population; however the answer to these questions are irrelevant to this research.

What is meaningful for this study is the information that emergency managers know about the behavior of the population in evacuation zones once the order is issued. The other important issue being studied is whether the technology commonly called big data analytics can assist emergency managers in learning information about special populations before or even after an evacuation order is issued.

Evacuation orders are typically broadcast via multiple methods, including television, radio, internet and loudspeaker from emergency responder's vehicles. The multimedia nature of evacuation order results in wide dissemination of the message to the effected population. Exposure to the messages alone does not mean that the message was effectively received. In most populations, there is some segment that suffers from various states of diminished capacity. People with diminished capacity fall into a category called a special population (Haddow et al., 2011). Emergency managers must give enhance attention to special populations during evacuations.

The experience from Hurricanes Katrina, Irene, Sandy and other evacuation events demonstrates that a formal diminished capacity is not the only reason the people do not heed evacuation orders. It is clear that some people make a decision to stay despite having been exposed to the order to leave; a decision is made to "ride out the storm." The real-time knowledge that people are or are not leaving a targeted impact zone following an evacuation order is actionable information for the emergency manager. It would be an additional benefit to know whether the populations not responding to the evacuation order are members of a special population. Special populations can be divided into the categories of institutionalized special populations and non-institutionalized special populations.

Institutionalized special needs populations, such as prisoners and those confined in hospitals present a more organized and concentrated target for emergency managers to address. Special populations that are home based, such as elderly persons needing assistance, those of diminished capacity that are high functional and can live alone under normal circumstances and those with substance dependency problems present unique challenges. There will also be discussion that those with certain economic limitations needing to be treated as a special population. Considering economically disadvantaged areas under the special population umbrella gained traction in the emergency management community following Hurricane Katrina.

This theoretical research will examine the viability for using cell phone tracking and a sub-discipline of information science generally called big data analytics as tools for emergency managers to use to enhance the effectiveness of evacuation operations, including whether the tools can aid in identifying non-institutionalized special populations for help in egress. The research will look at which tools might be available, how they might be used to aid emergency managers in conducting evacuations more effectively and what legal and civil liberty issues might influence the viability of such tools for lawful implementation.

Literature Review

The literature review will be divided into four sections. Each section will address the literature of the topic areas being covered by the research presented in this paper. First to be presented will be a review of the literature related to current evacuation planning and monitoring practices. Next will be a review of the literature that examines the current state of the art of cell phone tracking technology and the opportunities that may be presented for its use in evacuation monitoring. The current research on big data analytics will be reviewed for potential application by emergency managers for population identification before and during emergency evacuations.

Finally, research on legal and privacy concerns associated with the uses of advance technologies like cellular telephone tracking and big data analytics will be considered and evaluated in the context of emergency management evacuations.

Current evacuation planning

The benefits that can be obtained by improving emergency evacuations are measured in human lives. According to a December 9, 2014, article in the Los Angeles Times, government and emergency planners credited improved evacuation efforts with helping to avert greater tragedy and loss of human lives when Typhoon Hagupit slammed into the Philippines earlier in the month (De Leon & Zavis, 2014, p. 1). Although remote villages still needed to be reach, the Red Cross had confirmed 22 deaths in the Philippines as of the date of the article. This contrasted with 7300 souls that perished a year earlier when the Philippines were hit by Typhoon Haiyan.

Removing a population from the path of storms saves lives by taking people out of harm's way. Emergency evacuations can present very difficult problems for emergency planners and managers. Evacuations take time and a tremendous amount of planning to accomplish safely. There have been some reports that during Hurricane Rita there were more deaths caused by evacuating than from the actual storm (Associated Press, 2006). Evacuation planners also need to consider individuals with special needs, which might include a lack of transportation. Special needs may result from physical, mental or other infirmities that make it more difficult than the general population to respond to an order to evacuate.

It should be noted that federal policy is for the state governments to take the lead in emergency evacuation actions. Governors have authority under State laws and emergency declaration powers to declare a state of emergency and order evacuations, including mandatory

evacuation for the protection of their citizens (Hunter, 2009). Instead of taking a leading role in evacuations, the federal government's primary role is to aid the states and support them with resources and potentially manpower.

The Robert T. Stafford Disaster and Relief Emergency Assistance Act allow the President of the United States to direct the Department of Defense to engage in activities to protect life, safety and property. While federal troops may not engage in law enforcement activities directly as doing so would violate posse comitatus (The Posse Comitatus Act, 1981), a law designed to prevent the federal government from using federal troops against the citizenry, the military can provide extensive support functions to aid in evacuations.

Action, such as deploying the military by the President may even take place before any formal emergency or disaster declarations as allowed under the President's Stafford Act authority (Stafford Act, 2014). Following Hurricane Katrina, the President was given even more extensive authority to transport people prior to and after disasters (satisfying the need to return evacuees to their home locations) by amendments to the Stafford Act (Post Katrina Emergency Management Reform Act of 2006, 2006).

In addition to the use of the Department of Defense, the federal government aids the States in evacuations through the use of other federal agencies and departments. The National Response Framework (NRF), which is administered by the Federal Emergency Management Agency (FEMA) and the Department of Homeland Security (DHS), assign duties to federal agencies when disaster events overwhelm, or threaten to overwhelm State and local governments (FEMA, 2013). The NRF includes that Mass Evacuation Incident Annex that assigns to FEMA and DHS the responsibility to coordinate mass evacuations with Tribal, State and local governments.

Analysis and formal studies of past evacuations identified ways to make evacuations more effective. Many of the lessons learned are practical in nature and don't really directly discuss the enhanced use of the technologies examined by this research; however, the use of technology does appear to have application to these lessons. For example, some of the lessons learned from past disasters include ensuring that people have information about evacuation routes and places to stay if they do evacuate. In addition, the most accurate information about the threat requiring the evacuation is also important for those affected by an evacuation order (Perry, Lindell, & Greene, 1981, p. 145).

Much of the previous effort in emergency evacuation planning has gone into the physical verses the technological aspects of evacuation. According to Perry and Lindell, the focus has been on the physical egress route planning such as ensuring there were resources available for refueling vehicles. Other aspect included such practicalities as sanitary facilities, highway counter-flow (turning inbound lanes to outbound lanes), and ensuring other ancillary resources were available such as tow vehicles and bottled water (Perry & Lindell, 2007, p. 172-173).

A large scale evacuation event would provide the best proving grounds for testing the state of the art in evacuation planning and execution techniques; including the opportunities for the integration of federal, State and local planning and interjurisdictional-operations. If true, Hurricanes Katrina was that test. Unfortunately, according to a select bipartisan committee of the United States Congress formed specifically to investigate the preparation for and response to Hurricane Katrina, the grade was a "fail" (United States Congress, 2006). According to the committee, included in the almost 100 findings was "the failure of complete evacuations led to preventable deaths, great suffering, and further delays in relief."

According to the Congressional report, almost every element of the evacuation effort in New Orleans and Jefferson Parish were conducted so badly that they will have broader implications for future evacuation efforts for years to come. Analysis shows the evacuation orders were regarded as being "weak, bureaucratic and confusing" (Brinkley, 2006, p. 59). There was also evidence of other interferences that might be able to be mitigated through better management such as "shadow evacuations."

Shadow evacuation is a term used when people self-decided to evacuate from an area in such numbers prior to a formal evacuation order. While anyone trying to get out of harm's way seems, on the surface, like a good thing, it creates challenges for emergency managers. Shadow evacuations tend to clog roadways planners were expecting to be available for necessary evacuees (Lindsay, 2011). Shadow evacuation or not, the literature is very clear, during Hurricane Katrina, the willing and able were not given sufficient notice to depart. Special populations, those less able to self evacuate faced even more difficult challenges (United State Congress, 2006).

According to DHS, non-institutional special populations include the economically disadvantaged, those with pets, and those with various forms of physical and mental disabilities (DHS & FEMA, 2008). According to Mandelbilt, everyone should be involved in the process of helping to identify those with disabilities or who otherwise fall into the category of a special population. This includes employers, security personnel (police for those living in the community and security staff for those institutionalized), co-workers, relatives, neighbors and friends (Mandelbilt, 2004). Mandelbilt goes on to point out that disabled people are ill prepared and have great anxiety about their safety according to a national survey on the subject.

In other words, those who should be clearly identifiable in society, the physically disabled, have little faith in the authorities ability to identify and assist them during a disaster evacuation situation; imagine the situation that more vaguely identifiable special populations (such as those with substance abuse issues), might find themselves. Enerson shows that Hurricane Katrina highlighted the need for paying greater attention to vulnerable populations. Prior to Katrina, the term special populations referred almost exclusively to a narrowly defined group of persons who lived either in institution or in the community (Enerson, 20007).

As Enerson points out, socially and economically disadvantaged populations may require special attention during evacuation events and emergency managers needed to gain a better understanding of this potentially significant segment of the community. Unfortunately, according to Enerson, little progress has been made in developing techniques or approaches for emergency managers to identify population segments that may fall into the socially and economically disadvantaged segments of the community requiring enhanced focus (Enerson, 2007).

The present use of technology in evacuations appears fairly limited based on this literature review. Evacuation areas and maps are currently printed on paper. Emergency centers and media outlets are the primary method for distributing information. In some circumstances antiquated phone banks are constructed to answer evacuee's questions. The harsh reality is that when evacuation time comes, it is typically local firefighters or law enforcement personnel who are dispatched with loudspeaker equipment to identify and motivate those who didn't evacuate early in the emergency (US Fed News Service, 2012).

State of the art of cell phone tracking

While cell phones have typically been treated as telephones because the hardware and software technology utilizes 10 digit dialing and the devices are equipped with ring tones and behave like a wired telephone with which people have long been familiar, the simple fact is that the devices carried around as cellular telephones are in fact radios (Bedell, 2014). Naturally people use cellular telephones for the same tasks they use their home (land line) telephones, including calling for help from police and fire departments.

By the late 1990's, a Federal Communications Commission (FCC) survey of the source of calls to the emergency telephone number 911 showed that 70 percent of calls to 911 for help were coming from cellular telephones (FCCa, 2014, p. 1). This presented a number of unique challenges when compared to emergency calls from traditional home phones or the system referred to in the telephone industry as the plain old telephone system (POTS.) Telephone numbers in the POTS system are physically tied to a specific street address. So if a call came in for an emergency and something happened to the caller before the emergency operator answered (i.e. the phone dropped and there was no one on the other end when the call was answered), emergency resources (police, fire or EMS), could be dispatched to the source of the call based on the address linked to the phone number (FCCa, 2014).

Another challenge of receiving calls for emergency assistance from cellular phones was being able to identify which emergency dispatch center to direct the call. In the United States, emergency calls from the POTS system came from within a geographically identifiable area based on the second series of three digits in the calling number called the exchange or "pre-fix number" (Alcatel-Lucent, 2006). Cell phone calls can come from anywhere as long as there is a cell tower receiving antenna in range to pick up the signal. In the early days of the cellular

telephone network, calls to 911 were often missed directed resulting in additional delays and confusion (FCCa, 2014).

A third problem with calls placed from cellular devices is that the caller may not know their own location information with enough precision to inform emergency services where to respond. For example, a person might be driving across a State on a major highway. They might know the highway number they are on and the State they are in, but little else. Should they develop mechanical trouble, a medical problem or have an accident, they may not be able to give emergency responders detailed information on their location.

In order to address these various problems, in 1999, Congress passed the Wireless Communications and Public Safety Act of 1999 (Wireless Communications and Public Safety Act of 1999, 1999), and the FCC developed a number of rules and mandates that lead to the implementation of the Enhance Wireless 911 Systems or E911 system. Since the mandates required the development of technologies that did not currently exist, the FCC "chunked" the program into three phases. Ultimately, this lead to the current system where cell phones manufactured after 2011 typically have Global Positioning System (GPS) capabilities to provide longitude and latitude of the location the call is being generated in addition to other important information about the cell phone making the call (FCCb, 2011).

The E911 technology means that the call can be directed to the nearest emergency dispatch location to where the call is originated. Emergency services can be dispatched to the location of the call even if the caller cannot provide precise information on their current location. According to Hatch, the effect of the implementation of E911 provides the capability to identify the location of the cellular radio in the pocket of any individual at any time. In other words, it is

not necessary for the cell phone to make a call in order for the cell phone to be made to report its location information (Hatch, 2011).

According to the FCC, when placing a call for emergency services, the receiving organization does not need to ask for permission to obtain positioning information of the location where the call is being generated (FCCa, 2014). As far back as 1997, when the FCC began actively discussing the topic of obtaining positioning information for cellular telephones, the magazine BusinessWeek presented an article about the potential for uses to aid citizen in distress (Arnst, 1997). The article went on to state that the information would have commercial value in addition to any benefit in an emergency or disaster situation.

According to Arnest in 1997, the commercial value of such location positioning information could be as high as eight billion dollars (Arnst, 1997). Although there is not a great deal of case law and the statutes are somewhat imprecise (Hatch, 2011), commercial users of cellular telephone's position information nearly always ask for permission to obtain information about the cell phone users physical location. According to some reports, at least some agencies of the US government do not believe an individual's permission is required to track their movements.

Dozier and Braun reported that the head of the US National Security Agency (NSA), General Keith Alexander told congress that NSA performed tests in 2010 and 2011 to evaluate the technical feasibility of tracking individuals movement using cell phone data (Dozier & Braun, 2013, p. 2A). General Alexander indicated that the test were successful for tracking an individual's movements. The General went on to say that the NSA no longer uses the technology and indicated that the Federal Bureau of Investigation (FBI) had taken over such activities as part of building criminal cases.

Nakashima states that the FBI routinely requests court orders for cell phone companies to provide the exact location of a cell phone in order track the movement of suspected drug traffickers and other suspected criminals (Nakashima, 2007, p. A-7). The information provided by the cell phone companies is of sufficient precision that criminal cases are often built using the cell phone tracking data. Such use does not appear to be limited to just the FBI. Devlin as recently as November 2014, reported that the United States Marshals Service (US Marshals), were collecting cell phone tracking data over mass geographies from airplanes (Barrett, 2014).

The US Marshals planes are equipped with a device called a "dirtbox" (named for the unit of the Boeing Company that manufactures the devices), that mimic cell phone towers and cause all cell phones in range to registers and report position information that is then collected by the federal agency. Because the dirtbox technology essentially behaves like the existing cell phone network, even the latest encryption technologies implemented on the newest mobile devices, such as Apple Computers iPhone 6 (Apple, 2014), are not resistant to the US Marshals data collection technique (Barrett, 2014).

There are four important elements to using the dirtbox technology according to Devlin. The technology can be used by government agencies (at present, the United States Justice Department (DOJ) – the parent federal department responsible for the US Marshals Services neither confirms nor denies that dirtboxes are in use by the US Marshals), to collect cell phone positioning information over very large geographic regions. Second, the technology does not need the assistance of the cell phone network providers (AT&T, Verizon Wireless, Sprint and T-Mobile) to collect the data because it "dupes" the cell phone into registering its position. Third, No properly functioning cell phone can defeat the collection methodology used by dirtboxes. And fourth, the process has reportedly been used without obtaining the court's permission.

There cannot be complete certainty about the courts non-involvement; however there is no evidence to indicate that court permission is being obtained by the US Marshall Service for the use of dirtbox technology. Devlin points out that the full extent of the use of such technologies appears to test the abilities of courts in general to apply existing laws to an entire new generation of data gathering technologies.

The literature on big data

Gobble points out that the world has 90% more data today than just two years ago. Such a figure indicates that the world is creating data at an amazing pace. Accordingly, by the year 2020, there will be 44 times more data than exists today. The point of Gobble's numbers is that the first definition of big data is simple that people all over the world are generating a lot of data and the pace is accelerating (Gobble, 2013).

Gobble makes the clear distinction that the data itself is not the significant new idea embodied in the concept big data, but the uses of the data for the purpose of developing new ways and strategies for converting the bits and bytes of data into information and ultimately knowledge. This is the real essence of the "promise" of big data. This promise is not small. Gobble suggests that big data can reshape every aspect of modern life. This includes the way government operates, how business is conducted, and the way science is done.

Big data is distinguished from the more traditional discipline of data process because the data has grown too large for conventional data handling techniques to harness it into useful information. One example Gobble provides is the volume of data generated by the Twitter application. Twitter is one of the emerging social media platforms gaining acceptance in the marketplace (Twitter, 2015). As of January 2013, the twitter application was generating 12

terabytes of data per day. A terabyte of data is a million-million bytes of data and is written mathematically as 2^{40} (or two to the fortieth power.)

Big data should be understood as referring to more than simply the size of the data alone. Volume of data (or the size) is just one of the markers of big data. Others include how fast the data is changing and that the data is not stored in a structured or readily useable way; meaning that it is not being stored in a context familiar to traditional data processing methods (i.e. tables and databases.) Watters states that much of the data captured by the many new technology infused devices (such as cell phones) utilize unstructured methods for retaining the data (Watters, 2010).

A 2010 McKinsey Quarterly article discussing the definition of big data points to an acceleration in the implementation of sensor devices that allows entirely new paradigms of information collection communications and analytics. The shift in the ability to collect data is so significant that it could spur, new business models, change business processes and potentially reduce cost and risk (Chui, Loffler, & Roberts, 2010). As an example, a farmer placed water sensors in a field to collect real-time data on moisture levels that caused a change in irrigation which resulted in higher crop yields and reduced water consumption. A clear challenge of dealing with the actual or even the potential volume of data is how to process it and make effective use of the information. Based on the research of LaValle, Hopkins, Lesser, Shockley and Krushwitz, 60% of executive have more data at their fingertips than they are able to use effectively as a management tool (LaVale, Lesser, Shockley, Hopkins, & Kruschwitz, 2013). LaValle et. al. point out that this is often referred to as a "data deluge."

LaValle et. al. make clear that private industry views big data analytics as a defining technology that will separate winners from bigger winners going forward. The expectation is

that over the next two years, corporate decision makers will be looking to augment the current historical reporting they receive by adding new approaches. These approaches are expected to include big data analytical approaches that use information to create scenarios and run simulations. It is believed that big data will give executives greater insight into what the data means and how it can be acted upon to create the greatest value.

The literature examination has provided some definition of big data; however, it is important to look at the impact of big data applications. Davenport, Barth and Bean seek to address that question by further examining how the insights from big data analytics will potentially differ from traditional analytics. Davenport et. al. acknowledge that modern society has too much data and it is too unstructured to use traditional means to analyze (Davenport, Barth, & Bean, 2013). Big data analytics focuses on looking at the flow of data verses the stock of data, working with data scientist instead of data analysts, and applying the application to operational and production functions.

Davenport et. al. reveal the means and methods for applying information garnered from data prospectively as opposed to simply considering historical data as information about a historical point in time. This means that big data analytics offer emergency managers and planners the opportunity to use knowledge about "what is" and not simply "what was" in evacuation applications. The new power of information provided by big data analytics comes from considering the perspective Davenport et. al. offer in referring to using the flow of data (i.e. data in motion.) The research shows that by examining the flow of information, real-time assessment can be made with far greater accuracy and confidence than simply by referring back to historical data alone. The historical record does have value in big data analytics as it establishes target points that the later data can either confirm or question.

This is where Davenport et. al. discuss the use of data scientists and go beyond simply relying on traditional data analysts who would review the historical records and attempt to provide inference about future events based on history. The data scientist approach provides the opportunity of practitioners to begin from historical records and take more real-time multipoint inputs to confirm the historical information and in so doing make inference with a far higher degree of confidence than traditional data analytics.

An example of big data with applicability to emergency evacuations can be seen in the work of Papelis, Bair, Manepalli, Madhavan, Kady and Weisel in discussing modeling human behavior in crowds using a cognitive feedback approach. Studies in psychology offer many qualitative examples of how stimuli are processed to effect emotional states. For examples, it is noted that in large crowds, members often take queues on decision making from observing the actions of others. From this the authors develop a quantitative model using information about perceived emotions in order to effect the emotion and responsiveness of others (Peacock, Kuligowski, & Averil, 2011).

Davenport et. al. discussed the applicability of such models using big data techniques for the purpose of identifying target audiences and messaging that would be appropriate to the understanding of how big data analytics differs from traditional analytical modeling. The fundamental differences are found in the velocity of the data or the idea that changes in real-time inputs will have the impact of affecting the output on the same basis. This is in contrast to the analytical models of the past where historical data would be collected, combined, analyzed and mined for potential future actions and information.

According to Davenport et. al., to make such an application effective for emergency evacuations, the most effective approach would be to include both historical data about the

population and real-time date about situational dynamics in a multivalent statistical model to afford the most productive results (Davenport et al., 2013). This would necessarily require both deep pools of historical data and reasonably accurate real-time feeds of situational information.

Boyd and Crawford take a broader view of applications of big data to a full range of cultural, technological, and scholarly phenomenon (Boyd & Crawford, 2012). It is important to acknowledge that Boyd and Crawford express concern about the inadequacy of the definitions for big data. In fact, they go so far as to call big data a poor term (Boyd & Crawford, 2012, p. 663). This is in part because some have defined it based upon the size of the computer technology needed for process the data set. What once took a supercomputer to effectively process can today be manipulated with a desktop or laptop personal computer and standard off-the-shelf software. No longer are specialty computer environments and staffs required for dealing with data sets traditionally requiring specialized experience.

Boyd and Crawford express concern about assigning too much significance to big data analytics. It is acknowledged that the phenomenon is occurring in an environment of uncertainty and dynamic change, there is an acknowledgement that current decision about big data will have an influence on the evolution of both the technical and social science. This raises concerns about who is developing the algorithms and whether there is any regulation in the process. The researchers argue that considering the stakes, issues such as algorithm quality and regulation are important topics when the stakes are very large for academia and society at large.

The questions Boyd and Crawford raise are vital and go beyond the classroom or the laboratory. Big data requires very large historical data sets and rapidly moving (real-time) data. There is a need for sophisticated algorithm development. High end computer technology is required for the rapid processing of the information and this begs the question whether a new

intelligentsia is being created that does not benefit from the social perspective on the economic disadvantaged or underclass. In other words, how can a group on data scientists make inference about a social group of which they have only a studied knowledge, but no real firsthand experience to provide the full nuanced grasp necessary to properly use such power?

Boyd and Crawford argue that to fully understand the meaning of big data requires an understanding of the titanic shift it implies. The analogy to the innovation brought about by Henry Ford on manufacturing is offered as a reasonable parallel in the understanding of the magnitude of shift big data implies (Boyd & Crawford, 2012). Just as Henry Ford's early twentieth century innovative manufacturing system changed manufacturing for the remainder of the twentieth century, so too might big data cause such a shift in the 21st century.

Ford's mass production using specialized machinery, interchangeable parts and assembly line production techniques replaced craftsmanship, unique machined precision and individual attention. This shift was so significant that it became known as 'Fordism' and lead to significant impacts on world economies, cultural practices, consumerism and shifts in family structure over time (Boyd & Crawford, 2012). So too will the impact big data is likely to have on every aspect academic research, social, political, economic, and cultural existence.

It is important to fully appreciate the depth and extend of the potential shift being anticipated by the new technology of big data. Considering that big data analytics is expected to touch every aspect of life, including the disciplines of emergency and disaster management and by extension evacuation execution and planning, it is appropriate that its use should be considered carefully.

Privacy issues related to cell phone tracking and big data analytic technologies

There is only limited evidence that government tracking of people's cell phone locations has been restricted. A limited discussion of the statutory privacy restrictions will be valuable to the research. Title III of the Omnibus Crime Control and Safe Streets Act of 1968 was passed to enhance the privacy protection of citizens using radio and wireless communications before cell phone technology was in wide use in the United States (Thompson, 1997).

The need to strengthen the legal protection on radio based communications, Congress passed the Electronic Communications Privacy Act of 1986, which amended Title III to cover things like home wireless phones and increase penalties for violations. In 1994, Congress passed the Communications Assistance for Law Enforcement Act of 1994, popularly known as the Digital Telephony Act, to updates legal protections for changes in cellular telephone technology (called telephones; however, the devices are still essentially radios.) The clear intention of the Digital Telephony Act was that law enforcement agencies would have to obtain a warrant to tap cell phones in the same way as land-line telephones of private citizens (Thompson, 1997).

Although cell phones behave very much like land line telephones, there are some clear differences in how they work. First, cell phones are radios and short range radios at that. This means that it is necessary for the system to work, cell phones must be in contact with a specific cell tower and this defines, within reasonable boundaries, where the cell phone user is located. In addition, the fact that the cell phone can be moving requires the technology to include other features such as signal strength indications and linkages with multiple cell receivers to determine when a different cell receiving tower should take control of the signal from the personal cell phone (Bedell, 2014).

These technologies taken together mean that the essential functioning of a cell phone requires that the cellular network know, at least approximately, where the cell phone is located.

In fact, by 2013, the technology was so well evolved that the cellular telephone network has a very precise fix on a cell phone's location because of a concept call triangulation. Triangulation is a technique of the three nearest cell antenna towers measuring the location of the cell single to locate radio's position with a fair degree of precision (Thompson, 1997).

To enhance the ability to locate a cell phone with even greater precision, by 2018, all cell phones sold in the United States are required to include a global positioning system (GPS) transponder so the precise coordinates of the cell phone can be transmitted (Hannsberry, 2011). This is so that the police emergency phone system E911 can locate precisely where an emergency call is coming from so help can be dispatched, even if the caller is incapacitated and unable to provide precise location information. According to Bedell, most cell phones sold in 2013 already included GPS technology (Bedell, 2014).

There is ambiguity whether the law and statutes cited in this research where intended to prevent appropriate government tracking of cell phone location for legitimate emergency purposes. Clearly, based on the statutes, for law enforcement investigational purposes, cell phone conversations and other potentially incriminating situations, the statutes and court decisions make clear that a warrant is required by law enforcement to listen or obtain specific information about the phone and its location (Wempe, 2013). The ambiguity comes into play when considering whether government, unless specifically authorized, is denied warrantless access of cell phone information based on the theory that the fourth amendment to the US Constitution guarantees a citizen's right to be left alone by the government apart from the due process of law.

Late in 2014, the Florida Supreme Court weighed in on the subject in the case of police using cell phone tracing information to establish that a suspected drug dealer was in a particular

geographic area. In this situation, the Florida Supreme Court ruled that warrantless tracking of people's location using their cell phone signal was unconstitutional (Koebler, 2014). Nothing in this case or the court's ruling addressed the ambiguity of government using a private citizens cell phone signal for beneficial purposes, such as aiding emergency managers in the conduct of an emergency evacuation when potential disaster is reasonably anticipated.

The ambiguity of government tracking individual's location based on cell phone signals is a central concern for civil libertarians and organizations like the American Civil Liberties Union (ACLU). The ACLU takes the position that government entities have no right or permission to track an individual's location based on their cell phone signal apart from a court issuing a warrant based upon the government's presentation of a probable cause affidavit. The ACLU argues that government's current practices and tracking 'at will' tramples on citizens fourth amendment right to have judicial review and a proper check and balance against executive branch overreach (ACLU, 2012).

Theoretical Framework/Approach

This paper is exploratory research intended to look at the viability of using existing or evolving technologies to provide emergency managers with improved situational intelligence about a population, both the population's response dynamics and needs in evacuation situations. With regard to a population under an evacuation order, the goal of the research is to examine whether there currently exists technologies that will aid the emergency manager's knowledge of a population's capability or capacity to comply with an emergency evacuation order and whether such technology's use is legally available to governmental organizations.

An examination of existing research will be the primary tool for this exploratory study. The first issue to be examined is the current state of evacuation situational awareness. The tools

used by emergency managers for decimating information about the need for a population to evacuate in the face of an event that is expected to present a significant threat to human life and property.

The next issue is an exploration of the emergency manager's knowledge of the population's reaction to the emergency evacuation order. What does the emergency manager know about whether the population is responding to the evacuation order and at what pace is the population responding. The exploration of response time is considered a critical data point for the emergency manager's situational awareness. Situational awareness of the rate an area is depopulating is a potential input to decisions about tactics used for disseminating follow on evacuation information (i.e. enhancing notification strategies.) This also could potentially be relevant to the information content provided to the evacuating population. For example, if a population is evacuating at a rate that raises the probability the some in the population will become exposed to the harm, such information could be included in warnings to provide additional motivation for accelerating the rate of movement.

In the final analysis, any tools that have a positive effect on the emergency manager's situational analysis should be considered a positive change. One important concern is the potential for dis-information from any innovative technology brought online for the emergency manager's use. If the manager is placed in a position where she must assess whether the new technology is providing false positives or offering other feedback that either does not accurately represent the situation on the ground or worse still, providing information that impedes the emergency manager's ability to effective understand the situation, than the technology must be assess as doing harm to the practice of managing emergency environments.

The first technology to be explored is the use of information from or access to cellular radios. Can cell phone location or tracking information be used to aid the emergency managers in tracking the progress of emergency evacuation orders? The first exploration must be whether the technology as it currently exists in the marketplace provides accurate information that will aid the emergency manager in making effective determinations. The answer will turn on two questions. First, can the devices report position information with sufficient accuracy and in sufficient quantities? Second, does the information report within a time domain which makes it useful in providing enhanced situational awareness for the emergency manager? Simply stated, is the information real-time enough to be useful.

A final area of exploration is whether cellular telephone devices offer benefits to emergency managers in communicating with evacuation targeted populations. This communication can be considered in either a mono-directional or bi-directional capability. Cellular telephone technology has expanded the communication pathways from the historical voice telephony communication to include the Short Message System (SMS). SMS messaging in the commercial and non-commercial cell phone environment provides 160 characters of textual information to passes between two devices.

The other technology to be explored is big data. Big data is being explored to determine if it has value for the emergency manager with regard to the identification and communication with special populations. For the purpose of this research, the Federal Emergency Management Agency's (FEMA), definition of special populations will be used. FEMA's definition of special population is given in the *Interim Emergency management Planning Guide for Special Needs Populations* (August 15, 2008), and includes individuals in need of additional response assistance, individuals with disabilities, individuals who live in institutionalized setting, elderly

individuals, children, people from diverse cultures who have limited English proficiency or who are non-English speaking, and those who lack transportation (DHS & FEMA, 2008).

Apart from those in special populations who are institutionalized, such as in hospitals, nursing homes, prisons or other group home settings, the identification of special populations living on their own depends on self-identification through a registration process (Phillips & Morrow, 2007). Although some may consider it controversial, there is research that looks at households with pets as being a potential qualifier for the special population category (Heath, Bech, Kass, & Glickman, 2001). The exploratory research will look at whether big data has value to offer to the emergency manager in identifying special populations for the purpose of ensuring there are methods for them to evacuate.

Big data and cellular telephone technology are explored as complements to one another and hence the inclusion of both technologies in the research exploration. Big data may use cellular telephone information as an input along with other potential complementary inter-relationships between the two technologies. The two technologies are both relatively new; however, both are in prevalent use in society today. According to Pramis, the number of cell phones in use exceeds the population (Pramis, 2013, p. 1). Big data's technical expertise comes from a discipline called 'Data Science.' According to the US Bureau of Labor Statistics (BLS), people with the needed skill sets for working with big data are in short supply and are in high demand in the economy (BLS, 2013).

As the issue of using cellular telephone technology and big data analytics have potentially socially invasive aspects, it is impossible to discuss either in an emergency management or evacuation context without considering the ethical issues that may be involved. As emergency management is ultimately a governmental responsibility, it is important that the

use models comply with existing laws and statutes. The acceptable usage standards should be reasonably straight forward. These standards are stated as follows: the use of cell phone tracking for determining depopulation rates and big data analytics for identifying specific members of special populations must be conducted lawfully by local, state or federal government entities during emergency evacuations.

The literature review does not provide clear evidence that the use of cell phone tracking is currently in broad use to aid emergency managers for situational awareness of emergency evacuations. There is also no compelling evidence that big data is being used to identify actual or potential members of special needs populations who may need additional assistance to evacuate during an emergency.

Therefore, the hypothesis of this research is that cell phone tracking is not a viable technology for emergency managers to use during evacuations, including for evaluating neither the effectiveness of evacuation messaging nor the pace of depopulation of an evacuation zone. This hypothesis incorporates and is equally applicable to the use of big data analytics as an aid to emergency managers identifying, tracking and assisting special populations during evacuation events. The hypothesis flows from a basic assumption that if the technologies of cellular telephone tracking and big data were viable, useful and legal tools for emergency managers to aid in evacuation planning and execution, the tools would currently be in use.

Beyond technical effectiveness of the two technologies, an important factor in evaluating the hypothesis is whether one or both are illegal for emergency managers to use. If such a conclusion is reached, the hypothesis will be considered accepted. It would be inappropriate to reject the hypothesis based on either or both technologies being considered functionally viable but illegal as the illegality would still place them out of reach for use by emergency management

professional and therefore the hypothesis should be accepted if one or both technologies are determined to be illegal.

Research Design/Methodology

This research attempts to further the understanding and explore whether technological advances in personal cellular telephone use along with the application of big data analytics techniques can assist emergency managers in effectuating better outcomes for emergency evacuations; which is a human problem or phenomenon. As such, the philosophical perspective taken throughout this research will be social constructivist in nature. The strategy of this inquiry about observable human behavior is qualitative and the research method used is data analysis.

The philosophical perspective of social constructivism is research that seeks to gain a better understanding of the world as it exists today (Creswell, 2009, p. 8). It is an inquiry into the observable reality of emergency situation that will necessitate the evacuation of populations. It is known from the historical record that evacuation orders issued by emergency managers are met with various levels of response by citizens.

It is also known that the personal cellular technology discussed in this research is in nearly universal use among the citizens of the United States today. In addition, big data techniques are being used for marketing purposes (i.e. attempts to influence human behavior or be persuasive regarding taking actions (typically purchase decisions) on goods or services.)

The confluence of evacuation behaviors, the personal use nature of cell phone technology and attempts to make inference using big data analytics about individuals puts the elements of this research squarely in the space of subjective decisions making by humans about objects and things. The potential for varied and complex views as opposed to narrow meaning in limited

categories supports the social constructivist philosophical perspective for this research and qualitative strategy of inquiry for this research.

The grounded theory qualitative strategy is used as it will examine and abstract theory of the process of evacuation that result from some emergency or disaster situations and make theoretical inquiry into the use of technologies (cellular) and social manipulation techniques (big data) to project opportunities for such cross discipline implementation and use.

In selecting a qualitative approach as the research methodology, alternative methods were considered. Some of the discussion in this research is related to computers, databases, sophisticated mathematical algorithms and exotic cellular technology; hence there would appear to be a strong argument for the use of a quantitative research approach or, at the minimum, a mixed methods research approach. Both were examined for their value and decided against.

The reason for rejecting the quantitative method or the mixed method is because their focus misses the point of the research. The issues being examined is sufficiently mathematically course that they would not benefit from an examination via a normal distribution curve or discussing the skewness or kurtosis of a normal curve. In fact, such analysis might lead to a misunderstanding of the topics being discussed. This research examines the benefits the emergency manager can obtain from knowing, even at the visual level, whether the little dots on a display screen that represent cellular radios in the pockets of individuals are leaving an area or not. The big data analytics elements are fairly simple too. Big data analytics can assist a marketer in how to position one Android tablet against another even when both offer basically the same features. This level of detail is not necessary and distracting from this research. Hence quantitative method, or mixed methods in effect could be seen as harming the result verses

helping arrive at theoretical answers. Therefore both the quantitative and the mixed method research approaches have been rejected for this project.

In addition, the research attempts to consider the theoretical impact and response by the evacuation population of the legal and civil liberties issues that may be involved. At each level, primary characteristics are being compared with theoretical samplings to identify the difference or similarities in outcomes; hence making grounded theory and qualitative most appropriate for this research.

Data analysis will use existing research regarding the effectiveness of current techniques used by emergency managers to analyze the effectiveness of evacuation orders. Existing research on the methods used by emergency managers to identify special populations will also be examined. Available data on the penetration of personal cellular technology will be analyzed to draw inferences about potential effectiveness of its use for evacuation monitoring will also be part of the research.

Published research on techniques used in big data analytics will be considered for its theoretical application in both identifying special populations and theoretical benefits for message targeting in an evacuation context. Using existing research on big data analytics, inferences will be considered regarding potential application for the emergency manager in evacuation situations. In addition, due to the personally invasive nature of using information obtain from personal cellular technology and big data analytics, existing research on the legal, social, and political implications of application of these technologies and techniques for evacuation management in emergency situation will also be considered. The potential legalities of governmental units using the technology will also be considered and discussed. It is noted

that illegal but effective technologies are still illegal and inappropriate for use by governmental organizations.

Discussion

As Brinkley makes clear, current evacuation situational analysis is based upon techniques and practices that are both established, tested and not particularly new. Whether the time tested reasoning of 'we've always done it this way' or simply standard practice is the prevailing reasons would take more research to determine with any authority. It is clear that evacuation practices used in the US today are not much different from those used 50 years ago (Wolshon, Urbina, Wilmot, & Levitan, 2005).

It is reasonable to argue that laboratory environments would be difficult to construct for testing innovative practices to evacuate large populations. There are several reasons for this situation. The reasons include the fact that evacuation situations are by nature dynamic and each emergency evacuation has unique qualities. Hence, it is appropriate to question what conditions would be effective to use in simulations or 'laboratory' testing of evacuations. Scale is also a factor as evacuations areas can be very large and it would be difficult to determine whether result from a small evacuation study would extrapolate effectively for larger situation.

For example, would lessons learned from testing in a county in Oklahoma be applicable to the evacuation orders given for Hurricane Sandy? The answer is very unlikely due to the different dynamics of the threat, population at risk and geography involved. Therefore, it is not surprising, and even understandable, that changes in evacuation methodology evolve slowly (Trainor, Murry-Tuite, Edara, Fallah-Fini, & Triantis, 2013). The other factors are the risk calculations. Risks associated with changes in evacuation practice can be very high. The old adage that no one ever got fired for using established practice (whether those practices are the

most effective or not) would appear to apply in the area of evacuation practice as much or more than in any other discipline.

The thought process behind a cautious approach to innovation is very understandable. The environment is governmental; hence there is no profit motive as would apply in a private industry setting. The stakes are extremely high. Mistakes can be measured in lost human lives. So the implementation of innovative methodologies must be able to be completed while traditional methodologies are still in use. This requirement may play to the benefit of the technologies of cell phone tracking and the use of big data analytics for the identification of special populations. No change in fundamental practice is required to 'layer' these new technologies on to the existing practices used currently for evacuating populations by emergency managers.

As with the literature review, the discussion of the implementation of cellular tracking, big data and the privacy or individual liberty concerns will be divided into sections and addressed individually. A final section will be used for a discussion of the integration and implementation of the collective technologies and the privacy issues will be discussed before the conclusions are considered.

Application of cellular technologies for emergency evocations

At the most basic level the concept is simple. According to Pew, 91% of Americans own cell phones (Pew, 2013, p. 1). This is a remarkable statistic as 91% penetration rates are not found in the US population for many items. As described by Katsaros, Nanopoulous and Manolopoulos, a cell phone is a radio that by the nature of its basic function needs to reveal its location in order to function (Katsaros, Nanopoulous, & Manolopoulos, 2005). This point must be clearly understood. Even without the advanced technology that utilizes the global positioning

system technology as required by the Federal Communication Commission (FCCb, 2011), nine out of every ten American are carrying radios in their pocket or on their persons that essentially identify where they are physically located.

If the FCC required GPS technologies were to be considered, the geographic fix of each individual shifts from a few hundred feed to about one to ten square meters of planet earth. This would argue that the first technical hurtle is addressed. It is physically, practically and technologically possible to identify with certainty that at least a person's cell phone is at a particular location. If a person's cell phone location can be established at a certain point in time and reestablished at a later point in time and the location has changed, it is reasonable to conclude that the cell phone (and the person carrying it), is moving or at least, is not stationary. This is the place where assumption is an aid to the analysis. With allowance for some 'forgotten phones' it is logical to assume that in an environment where disaster looms (i.e. an approaching hurricane, tornado, forest fire, or other impending disaster potentially requiring an evacuation), an individual would reasonably exhibit a propensity to keep a cell phone in close proximity to her person.

Certainly assumptions have the potential to be fraught with inaccuracy; however, the potential need to communicate one's own needs for assistance (i.e. call for help), or to stay in close contact with one's loved ones or family would support the argument that an individual who owns a cell phone would keep the device in close proximity to their person when disaster is pending. Such a self preservation need increases the potential for emergency managers that, in general, if you find the location of a person's cell phone, you've found the location of a person.

It is an important issue or concept that should not be easily passed over. If it were common practice to intentionally leave behind a cell phone in an emergency situation or when

there is an impending disaster, the ability to map a cell phone's location to the general location of a person or persons would be diminished or more probabilistically questioned. If the assumption is valid that during a disaster or emergency situation an individual is more prone to ensure a cell phone in nearby in case help needs to be summoned or to reassure loved ones that a person is either safe or taking actions directed by emergency planners, than the existing cell phone technology can provide a significant amount of utility to emergency planners.

If the assumption that individuals will maintain their cell phones in close proximity to their person during emergency situations can be taken as valid, there are many direct implication that can be considered in emergency evacuation situations. The first of these is that emergency managers can track the effectiveness and rate of response to an emergency evacuation order. This is based on the idea that either with the assistance of the major cell phone carriers or by leveraging technologies such as 'dirtboxes' responders can track the location of cell phones without network provide assistance and display location information (with the assistance of GIS software mapping cell phone locations to physical locations on the ground), in an emergency operations center (EOC) on a Cathode Ray Tube (CRT) or flat screen technology. This provides emergency managers with quick, visual feedback on evacuation dynamics. The dots representing the cell phones are leaving, hence the evacuation is underway.

Accurate information about the physical location of a population under an evacuation order alone is a valuable data point for emergency managers when there is an impending disaster approaching a location. When emergency managers can use technology that dependably reports out on individual's physical location, the emergency managers situational awareness is enhanced. Knowledge verses projection or speculation on the evacuation behavior of a population is extremely valuable information for a number of reasons.

The first element of information that the emergency manager can assess is the degree to which the evacuation order, as presented, is being responded to by the target population. If the signals from the 'body' radios (cell phone in individual's pocket or otherwise on their person), are reporting within the evacuation zone with no evidence occupants are leaving, the emergency manager may surmise that the order, as issued, was not effective for motivating the population to leave or evacuate.

Alternatively, if the display showing the location of each cell phone reflects that the cell phone's locations are on highways and moving in the direction away from the evacuation was ordered, the emergency managers can have greater confidence that he evacuation order is being responded to by residence based upon the observational information. It would also assist the emergency manager in assessing the level of shadow evacuation that may be ongoing. This could help is deciding if alternate counter-flow routes or need or simply the need to provide better traffic information on broadcasts.

The observational data can be considered first order data or information as it is being reported passively by the cell phone itself without human intervention. Depending upon the data being observed regarding the position of the individual or personal cellular radios, emergency managers should be able to determine the level and speed of response by the population that is under an evacuation order. Under a scenario where the cellular radios are not observed to be departing or leaving the evacuation area, emergency managers may determine that additional community involvement and/or notification action is needed to raise the alarm.

In this case, there are a number of actions that can be taken. First, emergency managers can go back to their media outlets to enhance messaging on broadcast media. This may include television, radio and any associated or unaffiliated internet outlets emergency managers may

have access to for message distribution. Emergency managers may choose to consult with public relations, community involvement and communications or media specialist to determine the best methods on messaging an increased urgency to evacuate. Emergency managers may even use the tactic of notifying non-responsive populations that they have evidence that people are not leaving and that ultimate evacuation may be inhibited by too many people attempting to evacuate at once as a form of motivation.

One alternative might be for emergency managers to use Wireless Emergency Alerts (WEA) messages. WEA messages, once known as CMAS which was an acronym for Commercial Mobile Alert System or Personal Localized Alerting Network (PLAN) is a system designed to enhance public safety by allowing people with cell phones to get geographically appropriate messages that behaves like the Short Message System (SMS) (or text messages.) The difference between WEA and text messages is that the technology is built to insure that messages sent over the system are not delayed by other message congestion on the cellular network (FCCc, 2006). This technology is required by the Warning, Alert and Response Network Act (WARN).

The WARN network was required by changes to the Code of Federal Regulation (CFR) in 2006 it enable cellular broadcast in addition to any mass broadcast technologies already in use, such as the Emergency Alert System used on commercial radio or the Weather Information Radios System used by the National Weather Service (NWS). It was intended to be used for alerts from the President of the United States, notices of immediate threat to life and safety and it is also the system used to notify when a child may have been abducted. This portion of the system is typically referred to as America's Missing: Broadcast Emergency Response (AMBER Alerts) (Common audio attention signal, 2006).

Unfortunately, in studies by the United States Department of Homeland Security (DHS), using the WEA for providing urgent notification of an emergency situation or the need to take action has not demonstrated sufficiently productive results (Bean et al., 2014). According to Bean et. al., sending messages in 160 character groups is not effective for providing the necessary understanding of the severity of the threat or impending danger. The fact that the message is unsolicited by the receiver causes confusion as to whether the receiver was actually the intended target, which appeared to be another inhibitor to motivating action. In the Bean et. al. study, the inclusion of maps and other graphics did not appear to increase actionable response noticeably. Both lack of knowledge about the WEA system and the use of acronyms by the message sender also were determined to be factors that made the messages less effective for motivating a response action by the receiving party (Bean et al., 2014).

So while the 'narrow casting' approach (i.e. sending an individually relevant message to an individual or small group), of message delivery could be hoped to be a more effective method to motivate population in an evacuation zone to quickly take action, the Bean et. al. study appears to indicate that direct alert messaging to individual cell phone about an impending threat actually appears to be an ineffective method for communications. It is possible that better or more targeted message development may result in significantly improved population response in the emergency evacuation zone.

Were WEA messaging shown to be effective, it is possible that it would allow a targeted approach to emergency evacuations. Instead of the current media broadcast methodology that tends to put large volumes of automobile traffic on the highways at once, an evacuation message could be targeted at micro-populations in a geographically segmented fashion. Such an approach might effect a more orderly evacuation by targeting the population in segments or groups and

avoiding the mass exit approach that is the current norm in the US today. While this goes beyond the original discussion of simply using cellular radios or cell phones to raise emergency manager's situational awareness of emergency evacuation responsiveness, it does demonstrate that the technology may have applications beyond simple identification of the cell phone and by extension, the person's physical location. It is also possible that using big data analytics might provide insights into improved messaging based on information derived about individuals in a specific geography.

Potential application of big data to emergency evacuations

As the work of Davenport, Barth and Bean shows, big data is used today throughout industry in order to present information more effectively to consumers so they will respond and take action on the messages is presented (Davenport, Barth, & Bean, 2013). Stated in its most simplest form, big data analytics takes advantage of the touch points individuals have with the external world to develop a profile of the person's life situation, purchases, reading interests, political interests, social interests and in essence builds a virtual model of the individual.

This is possible because of the fact that modern society in the United States is extremely electronically oriented. Products are ordered online over the internet, many purchases are made with either credit cards or debit cards which capture the purchasers identity, location, product, price, and time of the transaction. Vehicle registrations are processed electronically, banking is done electronically, groceries are purchased with payment cards, and prescriptions are obtained with insurance information. In essence everything that people do in-person, on the phone, or online generates some form of data that can be aggregated, tracked, categorized and analyzed by big data algorithms. In short, if an individual did it, someone tracked it, it can be aggregated or

re-segmented for actionable purposes and that is the essence of the definition of big data analytics (Howard, Rainie, & Jones, 2001).

Whether these big data inroads into people's lives make individualistic, autonomous, "free" Americans happy or not; the fact is that basic actions of daily life in the modern world allow for the creation of a profile to be built of an individual based on their activities. This allows for a reasonably clear picture of an individual's personal situation to be defined. In other words, if a person regularly purchases diabetic supplies, wheel chairs and other mobility equipment, and various other products that would be associated with mobility challenged, diabetic individual, they most likely are a mobility challenged, diabetic individual.

Beyond this, if people use Face Book, Twitter, Instagram or other social media outlets and in anyway discuss their personal situation or challenges, the purchase behavior and other market and situational related information about them can be further confirmed. Marketers (if not emergency managers), know what people's physical, social, emotional situation is for the purposes of selling them products and by extension, if the software were developed, emergency managers would be able to look at these individuals and ones like them and make the decision that they fall into a Special Population category and ensure that special and appropriate attention were extended for their benefit.

While such individuals have the opportunity to register with local emergency management officials so that such extraordinary measures as big data analytics must be taken to identify these individuals are unnecessary, few members of special populations actually take advantage of such opportunities (Mcguire & Silvia, 2010). This makes the point that some mechanism beyond "self registration" is necessary for aiding emergency managers in identifying special populations within evacuation targeted communities.

Two significant issues are surfaced by this discussion. First, emergency managers have an obligation to identify and address special populations. Second, apart from extraordinary measures, emergency managers have, at best, limited methods for identifying special population that reside individually in the community. This is where big data analytics has the opportunity to bridge the gap. While there is limited evidence that big data analytics is having a significant impact on emergency mangers situational analysis today, Oxendine has studied some work being done with geographic information systems (GIS), that moves in the direction of using big data analytics for identifying special populations. So using more technology in the identification effort is at least being considered (Oxendine, 2013).

From an emergency and disaster management perspective, the situation can be view as somewhat to significantly concerning. This is because marketers clearly know and understand who these special population individuals are and where they live, yet emergency managers do not have access to the same data. So assuming they survive the storm or other emergency, marketers will be able to present their products to them for sale, but emergency managers have no ability to identify them to save them from an impending disaster and no opportunity to offer assistance in rescuing them, should they survive, following the disaster. Clearly this must be seen as a problem that demonstrates that societal priorities need reforming.

Big data analytics can also be used for broader or more general categories of special populations. Economically disadvantaged populations, for example, can be identified by the same big data techniques. As previously discussed, these can be considered special populations too (DHS & FEMA, 2008). These populations would be reasonably easy to identify based on records that should be accessible to governmental agencies. As discussed by Kharas and Rippen, poverty leaves a footprint (Kharas & Rippin, 2013). Therefore, applying big data analytics to the

databases of persons on public assistance, motor vehicle registrations, and other salient metrics and statistics should allow for the identification of geographic areas that are densely populated by economically disadvantaged communities. Historic events like Katrina and others demonstrate that transportation, special messaging and other resources may be appropriate for effecting evacuations of economically disadvantaged special populations.

The identification of these special populations should not be a challenging effort as it has been done in the past with far less technology in a technique known as “red lining” used by banks to identify geographic areas where banks would generally not lend money for mortgages and other needs (Ross & Tootell, 2004). The tools and technologies of big data analytics are far more sophisticated than those used by banks for redlining and hence should provide more effective results.

Whether the motivation for identifying economically challenged communities’ flows from good emergency management practice or political expediency, the outcomes can be the same – emergency managers can plan and execute actions that will enable the evacuation of these populations more effectively. Hurricane Katrina made it clear that emergency management’s failed effort to effectively evacuate economic disadvantaged communities can carry a high price both in human and political suffering. By current emergency management standards in 2015, emergency managers are expected to consider economic special population and provide a sufficient solution for evacuation that meets that community’s needs. To simply assume that they, like more economically capably populations, will simply heed broadcast messages to evacuation is no longer considered acceptable.

It is understandable to see the reasons for economically challenged communities have come into focus. To simply broadcast urgent evacuation messages to populations that have

neither the trust in the messenger nor the physical means to evacuate fully fit the definition of the tree that falls in the wilderness and no one hears it; it didn't make a sound! Big data analytics offers a technology that can both identify these populations and have a better grasp on the messages that will cause them to take action.

Economic special population provides a particularly strong example of the crossover between the use of cell phone tracking and big data analytics. Big data analytics can identify the geographic areas generally inhabited by economic special populations and cell phone tracking can provide a micro-focus on whether populations within the economically challenged communities are evacuating or not.

This discussion leads to the next topic for discussion – privacy issues and concerns. While such concerns about privacy have broad application for US citizens as a whole, they may have heightened concerns for economically disadvantaged special populations. Recent events involving the deaths of unarmed black man, Michael Brown in Ferguson, Missouri and Eric Gardner in New York City, New York, potentially make economically disadvantaged communities more concerned about techniques that can be seen as invasions of privacy or eavesdropping by governmental authorities specifically on these communities.

Privacy concerns with the use of cellular tracking and big data for emergency evacuations

The two issues that will be discussed in this section are US citizen's expectations to be left alone by the government, a notion embodied by the fourth Amendment to the US Constitution and the more recent idea that certain risks to the Republic trump an absolute adherence to such a right. More specifically, following the terrorist attacks on September 11, 2001, in New York City and the Pentagon in the Washington, DC area, it can be argued that

exceptions have been taken to a strict adherence to fourth amendment protections by government agencies.

These “exceptions” have come to light, most notably, following the disclosures by a Booz Allen Hamilton contractor working for the National Security Agency (NSA) named Edward Snowden (Roppolo, 2014). According to Snowden’s accusations, which appear to be un-denied by the US Government, the NSA has been tracking phone and internet traffic of a wide range of individuals including US citizen who have neither been accused nor convicted of any wrongdoing. Simplistically stated, the argument appears to be that in the process of attempting to identify and track terrorist’s phone and internet traffic, large volumes of US citizens information gets trapped in the “sieve” be the nature of how the technology works.

Whether Americans are accepting of the NSA’s techniques is difficult to tell with certainty. Polls like Rusmussen’s and other seems to indicate that at some point in time US citizens saw it as a necessary evil and were essentially understanding of the need and at other times (later dates with more information known), were not as willing to give the federal government a free pass on telephone and internet eavesdropping (Rusmussen, 2013). While there is clear discomfort with the general notion of government eavesdropping, it would appear according to Wheeler that the American people are willing to accept that the federal government must conduct at least some of these eavesdropping activities to keep the United States people safe from terrorists (Wheeler, 2013).

The parallel to be considered for the purpose of the present research is whether the use of technologies, such as cell phone tracking and big data analytics, for evacuation planning and execution, which are invasive of personal privacy and by extension personal liberty, should be “acceptable” in the same, or maybe even on a superior basis, as the justification argued by the

government to protect the population from terrorism. Stated more directly, is it moral, ethical and legal to use cell phone tracking to determine if people are leaving an evacuation area and big data analytics to identify special populations that may need more assistance in evacuating as a tool to save lives when impending disaster threatens?

Hence the argument is that the "minor" snooping by emergency planners and managers on the domestic population is for their direct benefit. Using the technology allows emergency planners and manager to do their jobs more effectively and raise the alarm louder when they see people not evacuating (through cell phone tracking), or determining they need to find other messages that will be more effective in causing people to respond and get out of harm's way more quickly.

What is wrong with using the same big data analytics techniques that Amazon.com might use to more effectively sell products to people or a Google might used to more effectively target them for advertising as a mechanism to identify people that might need a cop or other first responder to go visit and assist in evacuating? This raises the question of whether in a free society the use of such technologies by government is a good and legal practice?

At least some acknowledgement must be given to the fact that the United States has turned more politically to the "right" in recent elections. In the US Congress, the Republican Party, the party of the right or non-governmental intervention in the lives of citizens, has won majorities in both the US Senate and the US House of Representatives. In the later, the US House, the majority of the "conservative" party is substantial. Considering that there is a non-silent minority with the Republican Party that considers itself ultra-right wing in their politics (collectively referred to as "the tea party"), questions can be raised about such "big brother" techniques as cell phone tracking and the use of big data analytics by governmental agencies.

Zietlow discusses this issue as popular originalism in the context of the Tea Party and Constitutional theory (Zietlow, 2012). The argument, simply stated, is that the federal government has no role in the emergency response needs of the states and as such actions such as federal emergency management officials participating in such behaviors as cell phone tracking and using big data analytics to aid in emergency evacuations is extra-constitutional at best and violates the provisions of the Constitutions that protect citizens from such governmental actions at worst. On the surface, such an argument may sound odd that the federal government cannot participate directly in saving its citizens; however, Haddow et. al. make clear that that for most of the history of the nation, the US has not had a formal structure for aiding the states with emergency management or emergency response needs and that each act of federal assistance was a one-off by the federal government that came during the recovery phase of a disaster (Haddow et al., 2011).

Currently the authority for federal assistance or control primarily would be activated by a Presidential Disaster Declaration made under the Stafford Act (Stafford Act, 1988). While the Stafford Act is the primary, there are other methods provided for federal entry into mass evacuations as the result of lessons learned from Hurricanes Katrina and Rita in 2005. These include authorities provided by changes to federal laws and other regulation to implement the changes (Post-Katrina Emergency Management Reform Act of 2006, 2006). One of these changes was the enhancement of the Mass Evacuation Annex to the National Response Framework (NRF) (FEMA, 2013).

While a full discussion of when, if and how the federal governments becomes involved in evacuations is beyond the scope of this research, some limited discussion is appropriate to outline some challenges and concerns state governments may face in undertaking the

implementation of cell phone tracking and the use of big data for special population identification if they were forced to do so without federal involvement.

There would not appear to be any argument that apart from whatever role the federal government might play in emergency evacuation response, the states have full authority to order such evacuations. The difficulty comes with the national or multistate coordination needed with the cell phone network providers who would have to facilitate exposing the locations of each of their cell phone customers. As these carriers are regulated by the federal government, liability and other legal concerns may cause the national cell phone network operators (AT&T, Verizon, Sprint and T-Mobile), to ignore requests that came from any political governmental authority below the federal government. This would or could make the entire effort ineffective and unworkable.

With regard to state governments using big data technologies in a potentially privacy invasive way, federal laws such as the Health Insurance Portability and Accountability Act (HIPPA) and other laws and the protections of the Fourth Amendment of the US Constitution may be sufficient deterrents for state governments to tread carefully in big data analytics space for emergency response needs. Another reason often cited by the states is that they simply do not have the resources for such large and highly technical undertakings as developing big data analytics programs for such purposes (West, 2004).

Results

The nature of the results is to summarize the existing information on current evacuation practice, research on cell phone technology and tracking, the current state of the art of big data technology and how the use of these technologies is or is not compatible with existing laws are regulations.

Evacuation results

The number of available technologies for distributing evacuation orders in 2015 enhances evacuation message penetration. At one time, evacuation messages were distributed through broadcast media (television and terrestrial radio), and augmented by various methods used by in-person methods. In-person methods were typically implemented by local law enforcement, fire departments and emergency management staff where it existed. The in-person message distribution may have ranged from bullhorn to door-to-door message distribution.

The historical message distribution methods are augmented in 2015 by cell phone message alerts, internet information distribution which might take many forms including news distribution websites, message pushes, and social media to name a few. Social media may include facebook, instagram, google+, Linkedin, or a plethora of present and ever increasing communications vehicles that fall under the social media umbrella. Mobile devices, including cell phones, smart phone and tablet devices may get evacuation messages via social media methods mentioned above over either cellular networks or WIFI technology.

The methods of message distribution has expanded from methodologies in use 30-40 years ago; however, simply using the expanded array of messaging capabilities does not of itself enhance the emergency managers situational awareness of the evacuation response or the pace or speed of the response. Despite the expansion of message distribution outlets, emergency managers must still generally rely upon measuring traffic outflows and the reports of in-person observations, whether done from the ground or fixed or rotary wing aircraft overhead. There is no hard evidence to indicate that the number of per capita in-person observers have increased from decades past and as a result, with methodologies remaining constant and with no clear evidence of more observers, there is no clear evidence that emergency managers situational

awareness of evacuation response or information about the pace of the evacuation has improved from historical experience. The evidence of more information outlets do not de facto support the idea that evacuation response has improved.

Cellular technology can increase situational awareness

The literature strongly supports that the technical capability of capturing the location information on cell phone/smart phone geographic position currently exists. In fact, personal cellular devices like cell phones and smart phones that exist in the market today have redundant technologies to allow for the geo-positioning of the devices. Methods that include triangularization (measuring the strongest signal between three cell receiver towers) and Global Positioning System transponders to report exact location are technologies commonly used by law enforcement for various purposes of locating individuals. Even if the cellular network companies and cell phone manufactures would not cooperate with the government's desire to use this information, federal agencies have already demonstrated the use of technologies like 'dirt boxes' that can be used for cell phone position tracking that function entirely apart from any assistance the commercial cell phone infrastructure would be able to provide.

Combining the geographic positioning information with Geographical Information Systems, the display of scatter plots on computer or other computer driver large screen displays are well within the range of known and well understood computer programming technology. By adding additional software programs, reasonably simple calculations can be made to numerically or graphically display the rate, pace or time an emergency manger could expect an area to be substantially evacuated based on constantly updated information.

Big data analytics can identify special populations effectively

The current use of big data analytics technology has been demonstrated to be extremely effective in identifying groups and individuals to target with various messages. Admittedly, these technologies are currently used primarily for marketing purposes. As such, they have proven so effective for identifying not only where an individual is located, how they interact with the outside world and what marketing messaging they tend to respond to, that major US corporations like Amazon, Google, General Motors, Walmart, and others are willing to invest billions of dollars in using and enhance big data analytic infrastructure.

Matching the information produced by big data analytics with Geographic Information Systems, emergency managers could identify, with reasonable certainty, individuals living at home that have medical challenges, handicap individuals, elderly populations, economically challenged communities and others who may be deemed to need special assistance in evacuating. Were emergency managers to combine the two technologies of cell phone tracking and big data analytics, the emergency manager may be able to identify where an individual member of a special population lives, and also be able to tell if she is still in their house.

A very unclear legal landscape

The legal authority for the use of personally invasive technologies like cell phone tracking and the use of big data analytics for the purposes of identify individual's location and potential need for evacuation assistance is very unclear. There is no authority written in the US Constitution or subordinate laws (assuming they could be made compatible with the US Constitution), that makes it acceptable for government to implement such personally invasive techniques even if the public authorities can argue they are acting nobly and in the best interest of the health and safety of those they seek to protect.

The text of the Fourth Amendment to the US Constitution makes the case in a very compelling fashion “The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized” (U.S. Const. amend. IV). To date, no court has ruled that an approaching weather system, such as a major hurricane or other potentially dangerous condition, trumps this basic legal right to privacy by the federal or any state government.

There are legal mechanisms for law enforcement to remove individuals found within a certain geographic area that has been declared a mandatory evacuation zone. Even this clear legal ability of government has been used sparingly historically. The issues examined by this research are far different and distinct from an individual being forcibly removed from a mandatory evacuation zone. The techniques of cellular tracking and using big data analytics on mass populations can objectively be claimed to be an invasion of personal liberty and privacy that does, and should, require specific statutory authority for use by governmental agencies in the United States. Even if the government argues that the technologies are being used for the populations own good, they should only do so with clear legal authority.

It can be questioned why the use of cell phone tracking and big data analytics are routinely used by corporate America while being considered beyond the reach for use by government. The answer goes to the distinction or special place that government holds as defined by law and specifically Constitutional law which place certain restrictions on government. Corporations, under law, are not immune to claims of personal privacy violations for using cellular tracking and big data analytics. Such claims would have to be raised in the

civil courts and the corporations would be required to defend any actions taken based upon contract rights or other arguments available to them under the law for access and use of the data.

Conclusions and Recommendations for Additional Research

The conclusions of this study are reasonably complex as the subject matter being studied mixes the human phenomenon of emergency evacuations with technological capabilities and innovations of the modern world. Emergency evacuations practices effect people and are conducted by governments. As emergency evacuations involve group dynamics, they are sociological events and certain norms of behavior and expectations by the participants apply. The fact that emergency evacuations are governmentally controlled events requires that they be conducted within the prevailing political and legal framework.

The political influence means that the decisions of elected officials related to the emergency evacuation are, at least in part, influenced by consideration for any effects the decision will have during the next election. The legal framework constrains behavior of elected officials and emergency managers in that, despite the emergency nature of the event, decisions and actions must conform to prevailing laws and regulations.

Technology, in isolation, has no moral, legal or political code. Apart from society's moral, political and legal considerations, cell phone tracking and big data analytics are only constrained by the current limits of science, existing infrastructure and currently available data. It might also be argued that available time could be considered another constraint of the cellular and big data technologies.

In discussing conclusions in the context of the research hypothesis regarding whether cell phone tracking and big data analytics are viable technologies for emergency managers to use as tools in emergency evacuations, technical, moral, political and legal considerations must be

considered. For the hypothesis, as stated in this research, to be false cell phone tracking and big data analytics must be technically valuable for improving the evacuation outcome and politically and legally acceptable to use. The juxtaposition of the technological and the political/legal is what makes the conclusion complex.

There is abundant evidence in the literature that the technology exists to track individual cell phones, even in large numbers, and the availability of geographic information systems affords a plethora of potential analytics capabilities that would both inform emergency managers about evacuation behavior and well as provide valuable insights about special populations. While specific algorithms may need to be developed, they would be well within the range of the existing mathematical and computer sciences.

The literature on big data analytics is equally, if not more, compelling that industry can analyze a range of commercially available datasets to build individualized characteristic profiles with sufficient accuracy to identify any special population that emergency managers wished to inquire about; and accurately determine where they live. The value of the analytics data results in targeting first responder resources to assist the most vulnerable, (i.e. that special populations could be easily identified), is well supported by the research and would have an obvious positive impact on increasing the effectiveness of an evacuation event.

The challenge to rejecting the hypothesis is presented by the absence of clear legal foundation for governmental organizations to utilize such personally invasive technologies for emergency evacuation events. The use of either cell phone tracking or big data analytics is de facto an invasion of individual privacy and personal liberty and, as such, reaches to the very heart of the foundations the social contract Americans have with government and upon which the United States was founded. Therefore, the hypothesis of this research must be accepted and the

viability of emergency managers using cell phone tracking and big data analytics in emergency evacuation situations is rejected.

The acceptance of the hypothesis is not an easy conclusion to reach. If the use of these technologies would "mechanically" assist emergency managers in conducting more effective emergency evacuations, can the argument not be put forth that the societal benefit outweighs the offense to personal liberty? This question can be answered by comparing the efforts of law enforcement seeking dangerous criminals. Clearly, there is a societal interest in catching law breakers. Does that mean society allows police to use any tactic that is effective for arresting criminals? The answer is clearly no! Law enforcement's pursuit of dangerous and even notorious criminals must be done in conformance with prevailing laws and regulations. The argument that the technology's positive social benefits does not eliminate the need for a proper legal framework for using the technologies must be accepted.

Therefore, the hypothesis is accepted due to an absence of clear legal authority to use cell phone tracking and big data analytics technologies for the purposes of evacuation planning and execution by governmental organizations. While this does not mean that some emergency manager will not use cellular tracking or forms of big data analytics for emergency evacuation believing they are justified by the results. Unfortunately, it would appear that in so doing, they could be exposing themselves to substantial civil and possibly even criminal penalties. It is also possible that any elected officials who can be tied to the use of these technologies would be exposing themselves to uncertain political risks.

This offers tremendous opportunities for future research into approaches to address the present vacuum for legal and regulatory authority for using cellular tracking information and big data analytics in emergency evacuation situations. Emergency managers can benefit from the

real-time data cell phone tracking would provide regarding the response dynamics of a population in an evacuation zone. Greater knowledge of the location of special populations that big data can provide would aid in both evacuation planning and execution. Additional knowledge of the potential or actual need for enhanced efforts to assist certain members of special population is valuable to emergency managers in the conduct and management of an evacuation. Additional research can help to define and recommend approaches to making access to cell phone tracking data and the use of big data analytics clearly legal for emergency managers' use during emergency evacuations while protecting the personal liberties of every citizen.

References

ACLU (2012). How the government is tracking your movements. Retrieved 1-3-2015, from https://www.aclu.org/how-government-tracking-your-movements

Alcatel-Lucent (2006). 5ES Switch. Retrieved 12-19-14, from https://support.alcatel-lucent.com/portal/productContent.do?productId=5ESS&entryId=1-0000000000359

Apple, Inc. (2014). Understanding privacy and Location Services on iPhone, iPad, and iPod touch with iOS 8. Retrieved 1-4-2015, from http://support.apple.com/en-us/HT203033

Arnst, C. (1997). Tracking cell phone users in distress. Retrieved 12-21-14, from http://www.businessweek.com/1997/22/b3529137.htm

Associated Press (2006). In Texas, governor orders improvements to evacuation plans. Retrieved 12-14-14, from http://www.nytimes.com/2006/03/22/national/22texas.html?_r=0

BLS (2013). Fastest growing occupations, 2012 and projected 2022. Retrieved 1-10-2015, from http://www.bls.gov/news.release/ecopro.t04.htm

Bacon, J. (2011). Gov. Christie: 'Get the hell off the beach'. Retrieved 11-20-2014, from http://content.usatoday.com/communities/ondeadline/post/2011/08/gov-christie-get-the-hell-off-the-beach/1#.VHKDstLF_RU

Barrett, D. (2014). Americans' cellphones targeted in secret U.S. spy program. Retrieved 1-13-2015, from http://yw6vq3kb9d.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info%3Aofi%2Fenc%3AUTF-8&rfr_id=info:sid/summon.serialssolutions.com&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&rft.genre=article&rft.atitle=Americans%27+cellphones+targeted+in+secret+U.S.+spy+program&rft.jtitle=Denver+Post&rft.au=Devlin+Barrett&rft.date=2014-11-

13&rft.pub=Denver+Post&rft.issn=1930-2193&rft.externalDocID=3496935031&paramdict=en-US

Bean, H., Liu, B., Madden, S., Mileti, D., Sutton, J., & Wood, M. (2014). Comprehensive testing of imminent threat public messages for mobile devices. *National Consortium for the Study of Terrorism and Response to Terrorism*, 1-193. Retrieved from http://www.start.umd.edu/research-projects/comprehensive-testing-imminent-threat-public-messages-mobile-devices-mdp

Beard v. U S, 158 U.S. 550 (1895) No. 842 (May 27, 1895).

Bedell, P. (2014). *Cellular networks: Design and operation - a real world perspective*. Denver, CO: Outskirts Press.

Boyd, D., & Crawford, K. (2012). Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon. *Information, Communication & Society*, *15*(5), 662-679. Retrieved from http://www.tandfonline.com/doi/pdf/10.1080/1369118X.2012.678878

Brinkley, D. (2006). *The great deluge*. New York, NY: HarperCollins.

CNN (2014). Hurricane Katrina statistics fast facts. Retrieved 11-25-14, from http://www.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/

Chui, M., Loffler, M., & Roberts, R. (2010). The internet of things. Retrieved 1-5-2015, from http://www.mckinsey.com/insights/high_tech_telecoms_internet/the_internet_of_things

Common audio attention signal, 47 CFR § 10.520 (U.S. Government Printing Office 2006).

Creswell, J. W. (2009). *Research design* (3 ed.). Thousand Oaks, CA: SAGE Publications, Inc.

DHS, & FEMA (2008). Interim Emergency Management planning guide for special needs populations . Retrieved 12-14-14, from http://www2.ku.edu/~rrtcpbs/resources/pdf/FEMA_CPG301.pdf

Davenport, T. H., Barth, P., & Bean, R. (2013). How 'big data'is different. *MIT Sloan Management Review, 54*(1), 43-46. Retrieved from http://search.proquest.com.ezproxy1.apus.edu/docview/1124397830?pq-origsite=summon

De Leon, S. L., & Zavis, A. (2014). Evacuation effort credited with minimizing typhoon casualties in Philippines. Retrieved 12-10-14, from http://www.latimes.com/world/asia/la-fg-philippines-typhoon-20141209-story.html

Dozier, K., & Braun, S. (2013). NSA defends cell phone tracking: Chief says information gathered from cell-site data was never used. Retrieved 12-21-2014, from http://yw6vq3kb9d.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info%3Aofi%2Fenc%3AUTF-8&rfr_id=info:sid/summon.serialssolutions.com&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&rft.genre=article&rft.atitle=NSA+defends+cellphone+tracking&rft.jtitle=Charleston+Daily+Mail&rft.au=KIMBERLY+DOZIER&rft.date=2013-10-04&rft.pub=Charleston+Newspapers&rft.spage=A.2&rft.externalDocID=3089841721&paramdict=en-US

Drabek, T. E. (1999). Understanding disaster warning responses. *The Social Science Journal, 36*(3), 515-523. Retrieved from http://www.sciencedirect.com/science/article/pii/S036233199900021X

Enerson, E. (2007). Identifying and addressing social vulnerabilities. *Emergency Management: principles and practice for local government*, 257-268. Retrieved from http://www.colorado.edu/hazards/resources/socy4037/Identifying%20and%20Addressing%20social%20vulnerablilities.pdf

FCCa (2014). 911 Wireless services. Retrieved 12-19-2014, from http://www.fcc.gov/guides/wireless-911-services

FCCb (2011). 9-1-1 Service. Retrieved 12-21-14, from http://transition.fcc.gov/pshs/services/911-services/

FCCc (2006). Wireless Emergency Alerts (WEA). Retrieved 1-2-2105, from http://www.fcc.gov/guides/wireless-emergency-alerts-wea

FEMA (2013). National response framework, Second edition. Retrieved 1-15-15, from http://www.dhsem.state.co.us/sites/default/files/2013%20National%20Response%20Framework.pdf

Gobble, M. M. (2013). Big data: The next big thing in innovation. *Research Technology Management*, *56*(1), 64-66. Retrieved from http://search.proquest.com.ezproxy2.apus.edu/docview/1315657208?pq-origsite=summon

Haddow, G. D., Bullock, J. A., & Coppola, D. P. (2011). *Introduction to emergency management* (4 ed.). Burlington, MA: Butterworth-Heinemann.

Hannsberry, E. (2011). GPS mandatory on mobile phones by 2018. Retrieved 1-15-2015, from http://www.informationweek.com/mobile/mobile-devices/gps-mandatory-on-mobile-phones-by-2018/d/d-id/1100561?

Hatch, D. (2011). Congress looks at cell-phone tracking. *National Journal*. Retrieved from http://search.proquest.com.ezproxy2.apus.edu/docview/1418436243?pq-origsite=summon

Heath, S. E., Bech, A. M., Kass, P. H., & Glickman, L. T. (2001). Risk factors for pet evacuation failure after a slow-onset disaster. *Journal of the American Veterinary Medical Association, 218*(12), 1905-1910. Retrieved from http://avmajournals.avma.org/doi/abs/10.2460/javma.2001.218.1905

Howard, P. E., Rainie, L., & Jones, S. (2001). Days and nights on the internet the impact of a diffusing technology. *American Behavioral Scientist, 45*(3), 383-404. Retrieved from http://abs.sagepub.com/content/45/3/383.full.pdf

Hunter, N. D. (2009). *The law of emergencies*. Burlington, MA: Buttersworth-Heinemann.

Katsaros, D., Nanopoulous, A., & Manolopoulos, Y. (2005). *Wireless information highways*. Hershey, PA: IRM Press.

Kharas, H., & Rippin, N. (2013). The United Nations High-Level Panel's vision forending poverty. *Development Co-operation Report 2013,* 1-10. Retrieved from http://www.die-gdi.de/uploads/media/4313111ec015.pdf

Koebler, J. (2014). Court limits police 'StingRay' cell phone tracking for the first time. Retrieved 1-13-2015, from http://motherboard.vice.com/read/court-limits-police-stingray-cell-trackers-for-the-first-time

LaVale, S., Lesser, E., Shockley, R., Hopkins, M. S., & Kruschwitz, N. (2013). Big data, analytics and the path from insights to value. *MIT Sloan Management Review, 21*(1). Retrieved from http://sloanreview.mit.edu/article/big-data-analytics-and-the-path-from-insights-to-value/

Lindsay, B. R. (2011). Federal evacuation policy: Issues for congress. Retrieved 1-17-2015, from https://www.fas.org/sgp/crs/homesec/RL34745.pdf

Mandelbilt, B. (2004). Planning evacuation for the disabled. *Security, 41*(4), 43-44. Retrieved from http://search.proquest.com.ezproxy2.apus.edu/docview/197807252?pq-origsite=summon

Mcguire, M., & Silvia, C. (2010). he effect of problem severity, managerial and organizational capacity, and agency structure on intergovernmental collaboration: Evidence from local emergency management. *Public Administration Review* , *70*(2), 279-288. Retrieved from

Nakashima, E. (2007). Cellphone tracking raises concerns. Retrieved 12-27-2014, from http://www.lexisnexis.com.ezproxy1.apus.edu/hottopics/lnacademic/?verb=sr&csi=144577&sr=HLEAD(CELLPHONE%20TRACKING%20RAISES%20CONCERNS)%20and%20date%20is%202007

Oxendine, C. E. (2013). Analysis of Volunteered Geographic Information for Improved Situational Awareness during No-Notice Emergencies. Retrieved 1-13-15, from http://digilib.gmu.edu:8080/jspui/handle/1920/8262

Peacock, R., Kuligowski, E. D., & Averil, J. D. (Eds.). (2011). Modeling of human behavior in crowds using a cognitive feedback approach. *Pedestrian and Evacuation Dynamics* (pp. 265-273). New York, NY: Springer US.

Perry, R. W., & Lindell, M. K. (2007). *Emergency planning*. Hoboken, NJ: John Wiley and Sons.

Perry, R. W., Lindell, M. K., & Greene, M. R. (1981). *Evacuation planning in emergency management*. http://dx.doi.org/10.1111/j.1467-7717.1980.tb00136.x

Pew (2013). Pew: 61 Percent In US Now Have Smartphones. Retrieved 1-3-2015, from http://marketingland.com/pew-61-percent-in-us-now-have-smartphones-46966

Phillips, B. D., & Morrow, B. H. (2007, August). Social science research needs: focus on vulnerable populations, forecasting, and warnings. *Natural Hazards Review, 8*(3), 61-68. http://dx.doi.org/10.1061/(ASCE)1527-6988(2007)8:3(61)

Post Katrina Emergency Management Reform Act of 2006, P.L. 109-295 Senate and House of Representatives of the United States of America in Congress assembled § 601 (2006).

Post-Katrina Emergency Management Reform Act of 2006 , Public Law 109-295 U.S.C § (2006).

Pramis, J. (2013). Number of mobile phones to exceed world population by 2014. Retrieved 1-14-2015, from http://www.digitaltrends.com/mobile/mobile-phone-world-population-2014/

Roppolo, M. (2014). Edward Snowden, NSA whistleblower, to speak at South by Southwest. Retrieved 1-13-15, from http://www.cbsnews.com/news/edward-snowden-nsa-whistleblower-to-speak-at-sxsw-south-by-southwest/

Ross, S. L., & Tootell, G. (2004). Redlining, the Community Reinvestment Act, and private mortgage insurance. *Journal of Urban Economics, 55*(2), 278-297. Retrieved from http://www.sciencedirect.com/science/article/pii/S0094119002005089

Rusmussen, S. (2013). 52% Think it's good NSA domestic spying was exposed, 23% disagree. Retrieved 1-13-15, from http://www.rasmussenreports.com/public_content/politics/general_politics/july_2013/52_think_it_s_good_nsa_domestic_spying_was_exposed_23_disagree

Saletan, W. (2012). Sandy socialists. Retrieved 11-20-2014, from http://www.slate.com/articles/news_and_politics/frame_game/2012/10/hurricane_sandy_why_does_chris_christie_think_it_s_selfish_to_ignore_evacuation.html

Stafford Act, 42 U.S.C. § 5121 (GPO 2014).

The Posse Comitatus Act, 18 U.S.C. § 1385 (GPO 1981).

Thompson, K. R. (1997). Cell phone snooping: Why electronic eavesdropping goes unpunished. *The American Criminal Law Review, 35*(1), 137-162. Retrieved from http://search.proquest.com.ezproxy1.apus.edu/docview/230353264?pq-origsite=summon

Trainor, J., Murry-Tuite, P., Edara, P., Fallah-Fini, S., & Triantis, K. (2013, August). Interdisciplinary approach to evacuation modeling. *Natural Hazards Review, 14*(3), 151-162. http://dx.doi.org/10.1061/(ASCE)NH.1527-6996.0000105

Twitter, Inc. (2015). What is a Tweet. Retrieved 1-9-2015, from https://about.twitter.com/what-is-twitter/story-of-a-tweet

U.S. Const. amend. IV.

US Fed News Service (2012, June 02). Building a better evacuatiion. *US Federal News Service*. Retrieved from http://search.proquest.com.ezproxy1.apus.edu/docview/1018118019?pq-origsite=summon

United State Congress (2006). A failure of initiative: Final report of the select bipartisan committee to investigate the preparation for and response to Hurricane Katrina. Retrieved 12-15-14, from http://www.uscg.mil/history/katrina/docs/USHouseOfRepKatrina2006MainR1eport.pdf

Watters, A. (2010). The age of exabytes: Tools and approaches for managing big data. Retrieved 1-12-2015, from http://www.slideshare.net/readwriteweb/exabytes-rww-final

Weinstein, N. D. (1989). Effects of personal experience on self-protective behavior. *Psychological Bulletin, 105*(1), 31-50. http://dx.doi.org/10.1037/0033-2909.105.1.31

Wempe, K. (2013, October). United States v. Flores-Lopez: protecting privacy rights in cell phone searches incident to arrest. *University of Kansas Law Review, 62*(1), . Retrieved from http://yw6vq3kb9d.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info%3Aofi%2Fenc%3AUTF-8&rfr_id=info:sid/summon.serialssolutions.com&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&rft.genre=article&rft.atitle=United+States+v.+Flores-Lopez%3A+protecting+privacy+rights+in+cell+phone+searches+incident+to+arrest&rft.jtitle=University+of+Kansas+Law+Review&rft.au=Wempe%2C+Kevin&rft.date=2013-10-01&rft.pub=Kansas+Law+Review+Inc&rft.issn=0083-4025&rft.eissn=1942-9258&rft.volume=62&rft.issue=1&rft.spage=195&rft.externalDBID=n%2Fa&rft.externalDocID=363942236&paramdict=en-US

West, D. M. (2004). E-Government and the transformation of service delivery and citizen attitudes. *Public Administration Review*, *64*(1), 15-27. Retrieved from http://search.proquest.com.ezproxy2.apus.edu/docview/197171168?pq-origsite=summon

Wheeler, M. (2013). Government spying: Why you can't 'just trust us'. Retrieved 1-12-15, from http://www.thenation.com/article/174888/government-spying-why-you-cant-just-trust-us#

Wireless Communications and Public Safety Act of 1999, Public Law 106–81 U.S. Congress, H. R. § 106-81 (& Suppl.).

Wireless Communications and Public Safety Act of 1999, art. 106-81 § 81 (1999).

Wolshon, B., Urbina, E., Wilmot, C., & Levitan, M. (2005). Review of policies and practices for hurricane evacuation: Transportation planning, preparedness, and response. *Natural Hazards Review, 6*(3), 129-142. http://dx.doi.org/Retrieved from

Zietlow, R. E. (2012). Popular originalism-The Tea Party Movement and Constitutional theory. *FLorida Law Review*, *64*(483). Retrieved from http://heinonline.org/HOL/LandingPage?handle=hein.journals/uflr64&div=17&id=&page=