RESEARCH BRIEF

FM Radio and RBDS-Based Emergency Alerting

Volume 2018, 02 – February 2018

Introduction

Federal agencies responsible for regulations and practices concerning the dissemination of emergency alerts have stated that redundancy and reliability are critical to ensuring "communications systems have the capacity to transmit alerts and warnings to the public as part of the public alert and warning system."[1] Regulatory agencies and policymakers are taking the lead to reconcile issues concerning full access to alerts and other emergency information by people with disabilities.[2] The current national alerting solutions are restricted to either cellular networks (i.e., Wireless Emergency Alerts [WEA]), or broadcast stations and cable systems (i.e., Emergency Alert System [EAS]). Each alone is not optimized for accessibility by people with sensory disabilities. WEA regulations regarding multimedia messaging are not yet formulated, and thus access is constrained for certain populations. EAS does not have access to mobile devices, limiting its capacity to reach only people that are near a television or radio. EAS utilizes broadcast spectrum that can send large amounts of data, while WEA uses the cellular network and has data limitations. A synergistic relationship between the traditional broadcast industry and the wireless industry could remedy emergency alert and information access concerns held by providers (network congestion), emergency managers (timeliness of message), and by citizens (full access in the most expedient modality). A possible solution would be the activation of FM chips in mobile devices which would allow emergency alert systems to reach a broader and more diverse population.
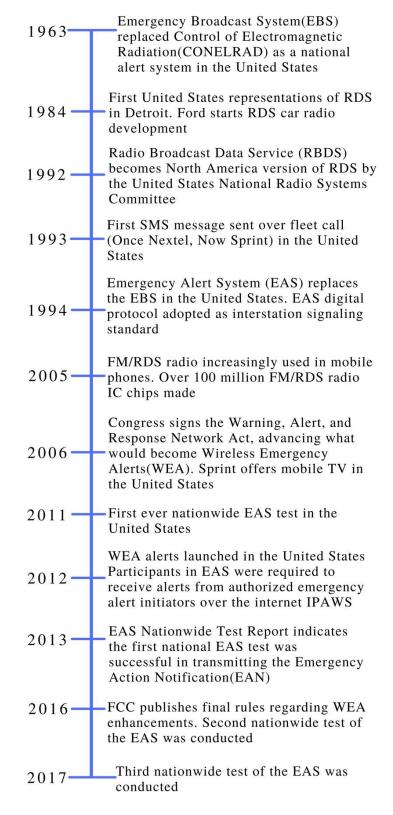
Background on WEA, SMS, and RBDS

Most mobile phones have Short Message Service (SMS) capability, commonly referred to as text messaging. It utilizes space in the signaling system of cellular networks to identify a path that does not interfere with regular data or voice traffic. SMS under 4G, and during non-disaster events is relatively free from congestion.[3,4] The issue with SMS is that it requires that an individual message be sent to every subscriber. SMS messages sometimes arrive several minutes, hours, days late, or they might never arrive. Late SMS arrivals affect emergency response time and can mean the difference between life and death.

Many local emergency managers use subscription-based, SMS alerting systems. As such, they must account for the cost of SMS alerting which is roughly 3-6 cents per text message.[1] If there is a 100,000-person alert base, the cost for one alert message would be $3,000 to $6,000. Costs are further increased when accounting for redundancies in the alert system which typically requires 5-8 messages. Redundancies drive up the average cost to operate an SMS text-based alert system to range from $15k-$30k per incident. Most municipalities cannot afford to maintain and use these high-cost systems.

WEA is more expedient and less expensive than SMS-based warning systems that have proliferated across the United States and are being used by private companies, college campuses, media outlets, and local governments. WEA alerts are delivered to cell phones via cell broadcast, which is a special mechanism to send a broadcast package to all mobile phones (one-to-many) in the range of a cell tower. Cell broadcast is supported by all major cellular technologies, including Long-term evolution (LTE). WEA requires that cell phone handsets be equipped with special hardware to enable software that receives and displays the alert to the user, and the cellular infrastructure must be operational for WEA to function. Regarding the latter, cellular networks are less reliable than traditional analog wire-line phone lines and FM radio. As seen during Hurricane Irma and Harvey in the United States, cellular networks are frequently off-line for days in disaster-stricken areas. This year, 3.5 million people living in Puerto Rico[5] and tens of thousands of residents in Texas[6] lacked a means of communication with emergency personnel in the wake of their respective natural disasters.

The advantages of transmitting information over FM radio, rather than SMS, is that there are no fees or costs for sending messages and long-term contracts are not required. Radio Broadcast Data Service (RBDS) is a standard for providing data-casting transmitted on the 57-kHz subcarrier of terrestrial FM radio stations in the United States. Using RBDS for emergency alerting would combine WEA textual message, receive EAS audio emergency information, and other emergency information broadcast from an FM radio station. RBDS integration into mobile phones could improve access to emergency information for people with sensory disabilities, especially in the event of a power outage.

---

[1] Global Security Systems determined pricing based on basic SMS text cost information from alert providers and extrapolated final figures.

Timeline of Emergency Alerts, SMS, RDS and RBDS in the United States

1963 — Emergency Broadcast System(EBS) replaced Control of Electromagnetic Radiation(CONELRAD) as a national alert system in the United States

1984 — First United States representations of RDS in Detroit. Ford starts RDS car radio development

1992 — Radio Broadcast Data Service (RBDS) becomes North America version of RDS by the United States National Radio Systems Committee

1993 — First SMS message sent over fleet call (Once Nextel, Now Sprint) in the United States

1994 — Emergency Alert System (EAS) replaces the EBS in the United States. EAS digital protocol adopted as interstation signaling standard

2005 — FM/RDS radio increasingly used in mobile phones. Over 100 million FM/RDS radio IC chips made

2006 — Congress signs the Warning, Alert, and Response Network Act, advancing what would become Wireless Emergency Alerts(WEA). Sprint offers mobile TV in the United States

2011 — First ever nationwide EAS test in the United States

2012 — WEA alerts launched in the United States Participants in EAS were required to receive alerts from authorized emergency alert initiators over the internet IPAWS

2013 — EAS Nationwide Test Report indicates the first national EAS test was successful in transmitting the Emergency Action Notification(EAN)

2016 — FCC publishes final rules regarding WEA enhancements. Second nationwide test of the EAS was conducted

2017 — Third nationwide test of the EAS was conducted

Potential use of FM Radio and RBDS for emergency alerting

Currently, most car radios support RBDS. RBDS is used for the transmission of information such as broadcast station call-letters, signs, song names, highway traffic signals, and more. Many home radios also support RBDS. As part of the Federal Communications Commission's (FCC's) Report and Order in December 1994 establishing the EAS, the use of RBDS to transmit EAS messages was strongly encouraged but not required. RBDS has been used and tested successfully in Mississippi, Tennessee, Alabama, Pennsylvania, Louisiana and Washington D.C.[7] RBDS alerting allows authorized alert originators such as emergency managers, university, and government officials to send geo-coded alert messages to citizens. Alert messages include, among other things, severe weather information, Amber alerts, and imminent danger alerts. This capability provides an additional form of alerting citizens and leverages the existing FM radio broadcast infrastructure which has overlapping signals, reliable backup power, and transmitting systems.[2]

RBDS for emergency alerting on mobile devices is not a novel concept. In 2012, researchers noted that FM-RDS[3] was used via DISANET to broadcast emergency communications. DISANET is a disaster communication system developed by both Indian and Japanese researchers.[8] They found that it is both easy to deploy and well-suited for disaster areas. The European Broadcasting Union (EBU) established a broadcasting standard for the Digital Audio Broadcasting (DAB) system to be compatible with mobile devices for which they anticipated emergency communications to be a feature.[9] Researchers in South Korea evaluated how accessible information can be transmitted through radio-based sub-channel transport (such as RDS) and found that a higher bit-rate would allow for multimedia content. This level of accessibility in communications could include audio messaging for people with vision disabilities; video clips related to the emergency that includes an American Sign Language (ASL) interpretation and captions for people with hearing disabilities; and maps depicting the evacuation route or shelter locations.[10]

Similar to broadcasting terrestrial FM radio stations over mobile devices, researchers are exploring emergency alerts on television via mobile devices. South Korea has cellphones and vehicle navigation devices with the capability to receive satellite and terrestrial television signals through the process of digital multimedia broadcasting (DMB).[11] DMB can be used for emergency alerts and is an extension of DAB.[12] DMB is capable of radio broadcasts over mobile devices.

---

[2] The information in this paragraph was provided by Matt Straeb, Global Security Systems, May 2013.
[3] Radio Broadcast Data Service (RBDS) is a standard for providing digital information on FM radio broadcast stations in the U.S. similar to the Radio Data Service (RDS) in Europe.

A 2011 study on mobile digital television for United States emergency communications found that further research was necessary to determine the stability and suitability of the current mobile devices for public safety needs.[13] These researchers suggested that public safety entities strategically assess the use of digital television because there is no limitation on size of subscriber-base in any geographic area, the necessary infrastructure is currently in place, and it does not use the existing public safety spectrum. Other researchers contend that digital television may not be the appropriate channel for the United States, as many Americans spend much of their commute in personal vehicles and many States have outlawed the use of cell phones in automobiles.[14]

A collaborative project, developed by the National Public Radio(NPR) labs with funding from the Department of Homeland Security, Science and Technology Directorate evaluated the utility of FM chips for emergency communications. It consisted of 25 radio stations and more than 260 recruited participants across Texas, Alabama, Florida, Mississippi, and Louisiana.[15] This project demonstrated that emergency alerting systems, with the use of FM chips, can be effective in reaching individuals who are deaf or hard of hearing. The study also served as a case study for the use of FM chips as a compelling means in communicating to the public during emergency events.

Chairman of the Federal Communications Commission, Ajit Pai, released a statement on September 28th, 2017 calling for the mobile device companies to make a shift and activate FM chips in phones. "I have repeatedly called on the wireless industry to activate the FM chips that are installed in almost all smartphones sold in the United States." He added "Apple is one the major phone manufacturers that has resisted doing so" specifically highlighting Apple's reluctance to activate the FM chips in their devices. He later goes on to ask Apple to "Step up to the plate and put the safety of the American people first." Chairman Pai previously mentioned public safety should be a sufficient reason to activate the FM chips in mobile devices.[16]

Some mobile devices have FM radio capability, but currently, there are only a few public Application Programmer's Interface (API) to access RBDS capabilities in the United States and RBDS capabilities are limited in phones with FM radios. Certain carriers disable the FM radio functionality, potentially to push users to listen to streaming audio instead of free FM radio. There is great potential for RBDS and FM radio integration into the emergency alerting environment, but moving beyond deliberations to development and testing on commercially available phone models is constrained by the conflicting interests of markets and social good.

New ways to provide access to emergency alerts

The Wireless RERC has been recommending the use FM Radio and RBDS for emergency alerting for more than ten years. In response to the FCC's 2007 Second Further Notice of Proposed Rulemaking regarding EAS, we recommended[17] that the FCC require broadcast stations using RBDS subcarriers to deploy that technology to distribute real-time notifications emergency situations, weather warnings, homeland security notices, and evacuation instructions with targeted information to persons with disabilities. In 2013 the Wireless RERC addressed the advantages of FM Radio via mobile after observing several years of severe tornados and disrupted cellular and power service during which this technology could have provided an emergency information lifeline. Widespread adoption of FM radio in cell phones would provide a couple of potential ways to improve access to emergency alerts and information.

WEA provides the same basic functionality as the proposed FM radio in cell phones, but it is not as robust. WEA alerts are displayed as text on the mobile phone screen, but with character limitations,[4] impeding the amount of information and level of detail that can be conveyed. People with vision disabilities can use a mobile phone as a primary source of emergency information and must often then consult alternate information sources for additional details. For example, the user first receives a WEA tornado warning on his/her mobile phone, but then in lieu of visiting a website and further congesting an already taxed network, they could use the cell phone FM capability to receive additional details. Many WEA messages direct individuals to check local media. Doing so on the same device, utilizing a method that does not tax the data load, would streamline the effort in a way that is efficient for both the user and the network.

A cell phone with FM radio and/or RBDS text capability provides another method for all citizens to receive emergency information in the event cell service is unavailable. If this capability were available on WEA capable handsets, it would work around the WEA character limitation and address network congestion during emergency events. EAS messages allow for up to two minutes of audio, and often includes websites and or phone numbers where more information can be obtained. Future use of the FM radio chip with RBDS could add functionality to turn on the phone automatically and present the alert information. RBDS capable cell phones could be programmed to monitor the local FM Primary EAS station and automatically provide additional information in an emergency. These features would increase the likelihood of timely alert receipt that compels the end-user to take appropriate protective actions.

---

[4] Though the FCC's 2016 WEA Enhancements Report & Order allows for up to 360 characters, the extended length will only be displayed on phones on the 4G LTE and above network, potentially leaving segments of the population out of the longer version of WEA.

A further possibility would be to allow the user to choose a local FM station that provides EAS alerts and program their cell phone to monitor for that station's EAS digital or Two-Tone Attention Signal. The monitoring feature would be triggered by the phone's receipt of a WEA alert. The phone would not need continuous active monitoring for the EAS signals; thereby reducing the demand on the battery to run the program/app.

Obstacles to RBDS and FM chip activation

The largest obstacle to RBDS use is the lack of programming APIs to access the RBDS functionality of the FM radios. This obstacle can be overcome just like other technical obstacles such as cell phone power consumption and internal antenna designs.

Various trade organizations have been arguing over the inclusion of FM radio for several years. CTIA, the trade association that represents the cellular industry, has openly opposed a government mandate of FM chips in phone handsets.[18] The National Association of Broadcasters (NAB) supports the voluntary inclusion of FM radios in handsets but also opposes a government mandate requiring such implementation.[19] NAB acknowledges the usefulness of FM radio in mobile devices for emergency alerting.[20] Access to RBDS and FM chips has decreased as it is absent in some newer versions of phones and phone operating systems. For example, neither the iPhone 7 nor iPhone 8 contain FM chips, which is significant since iPhone accounts for 44% of market share.[21]

Market Solutions

Market solutions regarding FM chip activation are possible and can lead to universal adoption in mobile devices if an effective strategy is taken. Approximately 34% of mobile phones in the U.S. market allow access to FM radios with apps.[5] Access to the FM chips using apps demonstrates that FM chips are still available and used by mobile phone owners. For example, the app "Nearby" developed by Google serves as an interface that allows app users, both Android and IOS, to determine one another's location. This API allows for development on two separate operating systems, and a similar styled API can be developed to access FM chips in different operating systems.

The potential exists for one of the major phone producers to activate FM chips and market their phones as a safer option when emergencies occur. The marketing campaign would be an expensive alternative, but without public awareness of this safer option, the shift to universal activation would remain stagnant.

---

[5] The mobile phone sample included 213 phones available from the top four U.S. providers, one pre-paid provider, and five randomly selected lifeline carriers. This research was conducted by the Rehabilitation Engineering Research Center for Wireless Inclusive Technologies (Wireless RERC).

Marketing this chip can cause the company to have a differential advantage which could create a competitive environment in which the other phone manufacturers might be compelled to activate their chips to prevent loss of revenue.

Regulatory Solutions

Currently, FM chip activation in mobile phones is not a regulatory requirement. Phone manufacturers include or exclude FM chips in an arbitrary fashion throughout the industry. Chip activation, from the public's perspective, may seem like the clear choice, particularly in emergency situations, but the mobile phone industry has pushed back since there is no perceived financial benefit of activating the chip. There are two ways by which the industry can begin activating the FM chip. Both options have the potential to advance FM chip utilization.

- *The first option would be a federal regulation mandating implementation and activation in all or a percentage of mobile devices.*
   For enhancing access to emergency information, the FCC could mandate the inclusion of FM radio with RBDS capability in all new handsets, or in a certain percentage of handsets/number of handsets or encourage voluntary inclusion. Estimations of the impact of FM chip activation in smartphones include a reach of 250 million Americans[22,23], which accounts for 77% of the United States population, and 6 million (15%) Americans with disabilities.[24,25,26] A regulation that requires FM chip activation would affect most Americans and phone manufacturers.

- *The second option would be to encourage voluntary activation of FM chips for use during mass emergencies.*
   FM chip activation and the resultant FM radio feature provides a differential advantage. An industry leader could market FM radio as a safety feature and their device as a safer option during an emergency. Consequently, from the viewpoint of public safety, their competitors may be at a disadvantage, which could incentivize them to begin activating the FM chips in their devices, so as not to be perceived as the less optimal device.

Either option would require support from key players in government, such as the FCC, Department of Homeland Security (DHS), and the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS), as well as support and cooperation from both the wireless and broadcast industries. Even with this, it could be an uphill battle for the FCC to *require* inclusion of FM radio with RBDS capability in cell phones.

Recommended Regulatory Action. The voluntary market fix would be preferable. Limited FM chip activation in mobile phones reduces the methods by which state and local emergency managers can communicate to the public during emergencies. The Integrated Public Alert and

Warning System(IPAWS) was created to reach the public during times of emergency using as many "communications pathways as practicable."[27] FM radio via mobile is a possible and pragmatic pathway that is not currently being utilized. Mobile device manufacturers would activate FM chips if they embraced the competitive advantage and social good incentives. If an industry leader in the mobile market, demonstrated the differential advantage they would have over their competitors by adopting and activating the FM chip, they could potentially sway other manufacturers to adopt the technology. The market solution, however, may require a regulatory push.

Given the recent natural disasters, and projections of stronger and more frequent catastrophic weather events, Chairman Pai is to be commended for his September 2017 statement to activate the FM chip. Still, if there remains "silence" on the issue from industry, the FCC should formally reintroduce the proposition of using the FM chip for public safety in a Public Notice. However, given the urgency of improving the ability to reach the public when cell service and power is limited, a Notice of Proposed Rulemaking may stimulate a stronger response from stakeholders.

Health-Economic Impact

Injuries that occur during and after a disaster event may be related to the ability (or not) to receive emergency information conveying safety measures and current hazards. In the absence of information from an official source, people may take risks they otherwise would not. A case study found a differential impact on college students evacuating during an emergency at a school for the Deaf and Hard-of-Hearing.[28] Many hard-of-hearing students at the college left their dormitories seeking more information on an impending tornado because the local news station had not yet made closed captioning available in their broadcasts. Meanwhile, students who were deaf had understood the on-screen ASL interpreter's instructions to shelter in place. In this scenario, the students who were hard-of-hearing experienced higher risk of bodily injury because they could not understand the emergency information presented.

In 2016 there were 1,276 injuries and 458 deaths associated with natural disasters in the United States.[29,30] One can assume that most of these injuries were treated in an emergency hospital health-care setting. A health policy study found that 32% of emergency room visits were non-urgent, 26% of emergency room visits were semi-urgent, and 42% of emergency room visits were urgent[31]. The different categories had a range of costs associated with them. The average cost of emergency room visits in 2017 was $2,526. With a 20% margin of error applied,[32,33] the estimated dollar amount of emergency-related medical expenses that the United States could save is up to $33 million over a ten-year period. Thus, the activation and use of FM chip technology for public safety needs could provide the information to prevent risk-taking that could result in injuries, thereby having both a health and economic impact.

Research and Development propositions

FCC regulations require that the attention signal used for WEA alerts be identical to the attention signal used for EAS alerts. This specific signal could be one way to monitor for an FM station's EAS alert. The hearing public is very familiar with the sound of the attention signal as it is received on both WEA and EAS alerts, but in the following possible solution, the mobile device is listening for the signal, not the user.

A mobile application (app) can be developed that would operate as follows; (1) a WEA alert is received on a cell phone that has FM receipt capability, (2) the app is activated on the cell phone, and it begins monitoring for a local FM stations EAS digital or attention signal, (3) an FM station transmits the EAS signal followed by audio emergency information and, (4) the cell phone receives the EAS signal and emergency information from the FM station. In this scenario, the app is only activated after receiving a WEA alert. The cell phone user receives both the WEA text alert and the FM station's EAS audio emergency information and regular radio broadcast. The time that the app is actively searching for an FM station's EAS signal could be limited as well. Equally important, when there are large scale power and cell outages the system would provide a failsafe method to receive vital information.

Global Security Systems (GSS) has proposals to demonstrate FM cell phone applications that can provide emergency information following receipt of a WEA alert. These proposals would utilize GSS assets. They would demonstrate how users who are vision impaired or hearing impaired would receive additional emergency information.

Conclusion

Communications during emergencies are changing. Often traditional SMS, such that is used with subscription-based alerting, is slow during disasters in population dense areas. WEA alerts are more expedient; however, they have limitations that constrain the content of the message. Additional information could be provided via terrestrial radio. Further, there are some EAS activations originated by local officials that are distributed through local broadcast stations. These may not go through FEMA IPAWS and consequently WEA, especially if the local officials (1) are not authorized to connect to IPAWS, (2) do not have the software and equipment to connect to IPAWS, (3) do not have Internet connectivity, or (4) know that the cell towers in the affected area are inoperable. Therefore, those local EAS activations would be missed by cell phone users unless there is a capability in the cell phone to receive the local EAS activation via FM radio. To address these environmental and circumstantial constraints, the following is recommended:

1. It is important to advance a robust, redundant and reliable system; particularly because people with disabilities must be enabled to receive emergency alerts in as many formats as needed on their device of choice.
2. A cell phone user should have the capability to receive all official emergency information concerning a disaster event. One way to accomplish this is to link EAS and WEA emergency information on the cell phone.
3. Development of WEA and EAS links through cell phone FM and/or RBDS capability should be a priority of government and industry. The resulting capability can be implemented by industry on a voluntary basis. Pending implementation of WEA enhancements such as providing URL's and increasing the allowable character length in a WEA alert will help.

The benefits FM chip activation can extend to an estimated 250 million Americans that have access to smartphones and the 6 million smartphone users with disabilities; saving lives, preventing injuries and saving millions of dollars each year. A robust relationship between the broadcast industry and the wireless industry which respects both sides of the issues could remedy emergency alert and information access concerns held by providers, emergency managers, and by citizens. The potential uses for RBDS are great especially in some locations such as in rural areas where broadcast signals are readily available, or areas where RBDS is already being researched and developed. Such a synergistic relationship between broadcast and wireless industries could greatly benefit populations disproportionately impacted during disasters including underserved minority, people with disabilities, Americans living in rural areas, youth and aging populations, which when taken together comprise at least 53% of the United States population.[6]

Accessory software development would allow RBDS in conjunction with mobile devices to interpret ASL, provide text-to-speech, or drive a bed shaker. Furthermore, socially vulnerable populations, including ethnic minorities and people with disabilities, both with high adoption of FM radio and mobile phones, would benefit and become increasingly more aware of emergency communications during disasters. Key support from the FCC, NWS, NOAA, DHS, and FEMA could improve the functionality of RBDS over mobile devices.

Acknowledgements

---

[6] The baseline estimate was calculated using data from Pew Research Center, CDC, Census Bureau, Disability Compendium, Rural Health Information, and the Kaiser Family Foundation.

(Georgia Tech, Center for Advanced Communications Policy), and Ed Price (Georgia Tech, Interactive Media Technology Center).

About the Wireless RERC

References

[1] *Executive Order*, Section 2(a)(iii). Section 3(b) (iii) of the *Executive Order* which directs the Commission to adopt rules.

[2] FCC (2010) FCC Implementation of the Twenty-First Century Communications and Video Accessibility Act [Pub. L. 111-260]. Available at https://prodnet.www.neca.org/publicationsdocs/wwpdf/113010fccpresentation.pdf

[3] Gompa, N. (2015, April 01). ExtremeTech explains: What is LTE? Retrieved from Extreme Tech.

[4] Segan, S. (2015). 3G vs. 4G: What's the Difference? PC Magazine and PC PCMag.

[5] Rogers, A. (2017, October 10). *In Puerto Rico, No Power Means No Telecommunications*. Retrieved from www.wired.com

[6] Reardon, M. (2017, September 19). How the wireless carriers fared during Hurricane Harvey. Retrieved from www.cnet.com.

[7] Department of Homeland Security: Science and Technology. (2014). *Accessible Common Alerting Protocol Radio Data System Demonstration: Gulf Coast States.* Department of Homeland Security.

[8] Jalihal, D., R.D. Kolipillai, P. Khawas, Keiji Takeda, Kotaro Kataoka. (2012). A Rapidly Deployable Disaster Communications System for Developing Countries. IEEE.

[9] Emergency Broadcasting Union-Union Europeenne de Radio-Television (EBU-UER). (2006). Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to Mobile, Portable and Fixed Receivers. ETSI EN 300-401 V1.4.1

[10] Choi, Seong Jong. (2007). Analysis of Emergency Alert Services and Systems. *2007 International Conference on Convergence Information Technology.*

[11] Shim, J.P., Kyungmo Ahn, and Julie M. Shim. (2006). Empirical Findings on the Perceived Use of Digital Multimedia Broadcasting Mobile Phone Services. *Industrial Management & Data Systems* 106(2):155-171.

[12] Choi, Seong Jong. (2007). Analysis of Emergency Alert Services and Systems. *2007 International Conference on Convergence Information Technology.*

[13] Desourdis, Jr., Robert I., Kevin Vest, Mark O'Brien, and David J. Mulholland. (2011). Digital Television for Homeland Security: Broadband Datacast for Situational Awareness and Command Coordination. IEEE

[14] Shim, J.P., Kyungmo Ahn, and Julie M. Shim. (2006). Empirical Findings on the Perceived Use of Digital Multimedia Broadcasting Mobile Phone Services. *Industrial Management & Data Systems* 106(2):155-171.

[15] Department of Homeland Security: Federal Emergency Management Agency. (2010). *DEMONSTRATION REPORT AND RBDS Product Specification for Integrated Public Alert and Warning System (IPAWS) Radio Broadcast Data System (RBDS) study.* Washington, DC: Department of Homeland Security.

[16] Pelkey, T. (2017, September 28). Chairman Pai Urges Apple to Activate FM Chips to Promote Public Safety . Washington D.C., U.S.A.

[17] Mitchell, H., Yancey, L., Baker, P. (2007). Comments submitted to the FCC in response to *Review of the Emergency Alert System, Second Report and Order and Further Notice of Proposed Rulemaking* (2nd R&O and FNPRM), [EB Docket No. 04-296]. Federal Communications Commission: Washington, DC, December 3, 2007.

[18] Flatley, D. (2017). Apple Urged to Activate iPhone's FM Radio Chip After Hurricanes. Bloomberg Technology

[19] February 3, 2012, NAB for Immediate Release, NAB Statement on Voluntary Inclusion of FM Chips in Cellphones

[20] Smulyan, Jeff. (2012) Statement of Jeff Smulyan, Emmis Communications Corporation Hearing on "The Future of Audio," before the United States House of Representatives Committee on Energy and Commerce, Subcommittee on Communications and Technology. June 6, 2012.

[21] Statista. (2017). *Subscriber share held by smartphone operating systems in the United States from January 2012 to June 2017.* Statista.

[22] Pew Research Center. (2017). *Mobile Fact Sheet.* Pew Research Center.

[23] N.Lowitz, M. R. (2017). *iPhone US Installed Base Growth Slows.* Chicago: Consumer Intelligence Research Partners, LLC.

[24] United States Census Bureau. (2017, November 16). *https://www.census.gov/popclock/?intcmp=w_200x402*. Retrieved from www.census.gov.

[25] Kraus, L. (2017). 2016 Disability Statistics Annual Report. Durham, NH: University of New Hampshire.

[2626] Perrin, M. A. (2017). *Disabled Americans are less likely to use technology.* Pew Research Center.

[27] FEMA. (2010). Strategic plan for the integrated public alert and warning system (IPAWS) program. Retrieved from https://www.fema.gov/pdf/emergency/ipaws/ipaws_strategic_plan.pdf

[28] Phillips, B. D. 2005. "Social vulnerability issues in critical infrastructure loss: A research assessment and agenda." Presented at the Critical Infrastructure Conference, Rotorua, New Zealand.

[29] NOAA, National Weather Service. (2016). *Weather Fatalities 2016.* National Weather Service.

[30] National Weather Service. (2017). *Summary of Natural Hazard Statistics for 2016 in the United States.* National Weather Service

[31] Nolan Caldwell, T. S. (2013). *"How Much Will I Get Charged for This?" Patient Charges for Top Ten Diagnoses in the Emergency Department.* PLOS.

[32] Robert M. Williams, M. D. (1996). *The Costs of Visits to Emergency Departments.* The New England Journal of Medicine.

[33] Bureau of Labor Statistics. (2017). *CPI Inflation Calculator.* NE Washington, DC: U.S. Bureau of Labor Statistics.