Wireless Emergency Alerts

Mobile Penetration Strategy

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Preface

The objective of this analysis, performed for the Department of Homeland Security (DHS), Science and Technology Directorate, was to independently assess the coverage and penetration of the Wireless Emergency Alert (WEA) system, and to offer recommendations to improve the availability, coverage, and penetration of WEA to the U.S. public.

The intended audience of this report is U.S. government decision makers; commercial mobile service providers; mobile wireless device manufacturers; and federal, state, local, and tribal alert originators. Each of these parties has a role in implementing WEA, and is positioned to take unique actions to improve the penetration of WEA.

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Executive Summary

On December 22, 2008, a retention pond dam in Roane County, Tennessee, broke, spilling over a billion gallons of coal fly ash slurry into the Emory River and the surrounding countryside. The Emory River flows into the Tennessee River, which supplies water to millions of people.

When a disaster occurs, such as the one in Roane County, many people need to know about it. In the past, the news of such an event would go out over radio and television broadcasts. However, that process takes time, and many people might not be watching television or listening to the radio. An increasingly large segment of the population listens to music on smartphones rather than the radio, watches entertainment programs on tablet computers instead of on television, and relies on mobile phones instead of landlines. Sending alerts to wireless mobile devices is faster and provides a way to contact those who would otherwise miss the alert.

Recognizing this problem, Executive Order 13407 directed the modernization of public alert and warning systems. One result from this effort was a system that is now called Wireless Emergency Alerts (WEA),[1] which provides a new way to send emergency alerts to the U.S. public. Under the WEA service, alerts are sent to mobile devices connected to participating commercial mobile service provider (CMSP) networks. In 2011, the National Telecommunications and Information Administration (NTIA) and the Department of Homeland Security (DHS) agreed that the DHS Science and Technology (S&T) Directorate should develop a WEA Mobile Penetration Strategy.

The objectives of the DHS WEA Mobile Penetration Strategy are to

1. Characterize the WEA coverage achieved at initial capability in 2012, and later when CMSPs and mobile device manufacturers have fully fielded WEA-capable mobile devices
2. Identify barriers to adoption, including demographic factors
3. Suggest options for improving WEA penetration.

DHS S&T tasked the National Defense Research Institute (NDRI) to help address these tasks. Information was collected from a wide range of commercial and government

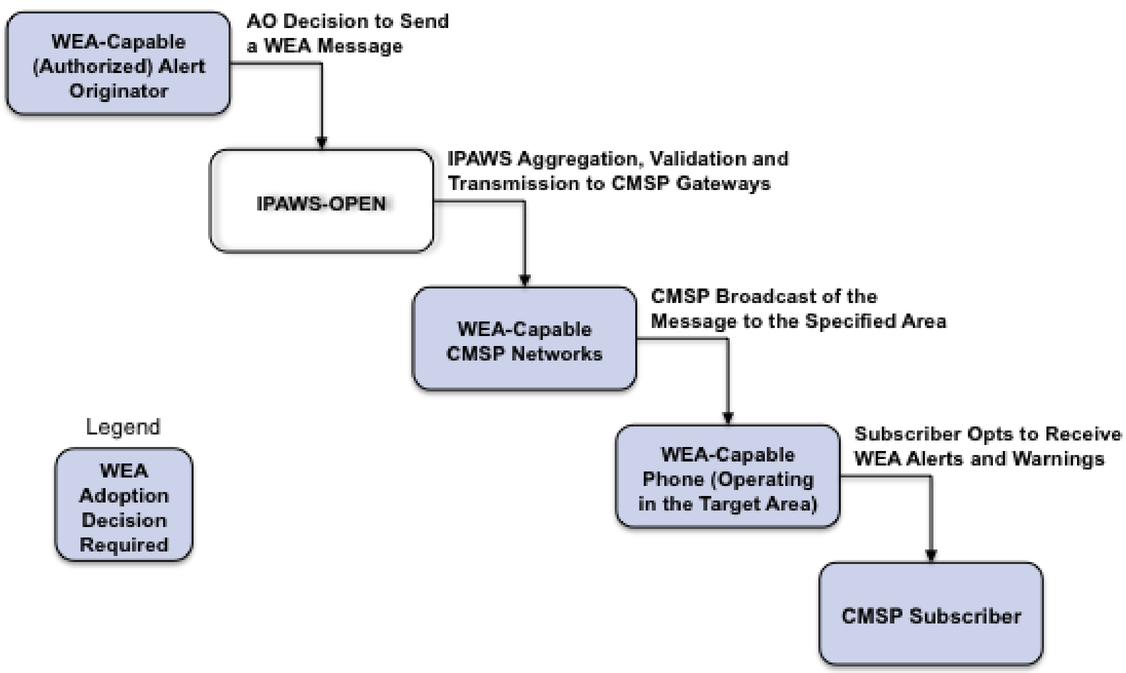
[1] WEA was formerly known as the Commercial Mobile Alert System (CMAS).

sources to estimate WEA penetration and coverage levels in various ways: geographically, demographically, by wireless carrier coverage, and by mobile device populations. Interviews with officials in the public and private sectors throughout the country provided insights into issues that could reduce or increase WEA penetration.

How WEA Works

Figure S.1 depicts an end-to-end model of how WEA works. Alert originators (AOs) (e.g., the National Weather Service, state and local emergency managers) prepare alert messages and send them to the Federal Emergency Management Agency (FEMA), which operates a system that aggregates alerts from AOs and disseminates them[2] to CMSPs, who subsequently deliver them to subscribers. If a given entity agrees to participate in WEA, it is said to have "adopted" it.

Figure S.1. An End-to-End View of WEA



[2] FEMA's alert aggregator is called the Integrated Public Alert and Warning System-Open Platform for Emergency Networks (IPAWS-OPEN). It collects and routes messages sent by alerting authorities to IPAWS-compliant public alerting systems.

The reach of WEA is frequently described in terms of "adoption rates" that indicate how widely WEA is accepted. Because adoption is voluntary, participants at nearly every level can limit WEA use and availability.

WEA *coverage* is defined at the levels indicated in Figure S.1 (i.e., AOs, CMSPs, mobile device manufacturers, and subscribers) as the number or percentage of entities at each level that choose to adopt WEA or act to enable the use of WEA by others. The U.S. public's ability to receive an alert, as subscribers to CMSPs, depends on the public- and private-sector organizations indicated in the figure. If any of these organizations do not adopt WEA, the percentage of the public that cannot receive WEA messages increases. Thus, WEA *penetration* (adoption) is a critical factor in the system's success and effectiveness. WEA availability to the U.S. public depends on WEA penetration at the levels above the subscriber, as indicated in the figure. Even if all the organizations and individuals depicted in Figure S.1 adopt WEA, important questions still arise regarding the public's ability to receive the alert or warning, and how the public will respond to such messages.

Methodology

The analyses in the WEA Mobile Penetration Strategy drew on a wide variety of data sources. Every effort was made to ensure that the data sources used were the best available.

Estimates of potential WEA-capable AOs were made using FEMA web page listings of approved IPAWS-OPEN interconnections. Data on WEA adoption by AOs were supplemented with available open-source information and qualitative information obtained from AOs and businesses that comprise the telecommunications industry, including interviews with state- and territory-level AOs and emergency managers. Information describing WEA adoption intentions could be gathered on approximately 80 percent of states and territories. American Roamer data on the advertised coverage of CMSPs were used to understand the coverage footprints of CMSPs. Mobile device ownership data from comScore, Inc. were used to characterize WEA penetration at initial capability and to project the rate of adoption of WEA-compatible phones. The demographic analyses drew upon data from the Decennial United States Census, American Community Survey, National Assessment of Adult Literacy, and Pew Research Center's Internet and American Life Project. These data were used to estimate mobile

device ownership for age-, income-, language-, and location of residence-adjusted populations in different geographies.

Findings —WEA Coverage

Most State Emergency Managers Plan to Use WEA

Interviews with state emergency managers indicated that, as of the second quarter of 2012, the majority of states were planning to implement WEA and use it to issue emergency alerts. Ten states and the National Weather Service were authorized to disseminate alerts via IPAWS-OPEN as of May 2012. While some state emergency managers see no issues with adopting WEA, others cite cost, equipment acquisition, and procedural concerns as matters that may prevent or slow WEA adoption.

The WEA adoption rate is significantly lower at the county level. As of mid-August 2012, FEMA data indicated that 83 of 3,141 counties (or 2.6 percent) were connected to or planning to disseminate alerts via IPAWS-OPEN. Awareness and understanding of WEA is low, especially among local emergency managers, who want a better understanding of policy and governance structures, more information on WEA, an explanation of potential liability, and improved WEA geo-targeting and testing capabilities. The data also cited the potential for message fatigue—when subscribers start ignoring WEA messages or opt out of the service because they receive too many irrelevant or not useful messages—if the system is not used carefully.

All Tier I and Most Tier II Commercial Mobile Service Providers Will Implement WEA

The four major CMSPs with national coverage—called Tier I CMSPs—provide service to over 280 million phones. All Tier I, the majority of the Tier II, and approximately one-quarter of the several hundred Tier III CMSPs will eventually implement WEA, although exactly when some CMSPs will implement it is uncertain. As of April 2012, Verizon, Sprint, and T-Mobile declared that they had achieved WEA coverage throughout almost their entire nationwide networks.[3] Among Tier II CMSPs, ALTEL, Metro PCS, and US Cellular indicated that they would provide WEA coverage

[3] By the end of 2012, all Tier I carriers (AT&T, Sprint, T-Mobile, and Verizon) had announced rolling out WEA nationwide.

over their entire coverage area by April 2012 or shortly thereafter. While only about one-quarter of Tier III CMSPs plan to implement WEA, the percentage increases to approximately 50 percent if only the largest Tier III CMSPs are considered and pager companies are discounted.

A significant uncertainty regarding WEA coverage is whether members of the public who obtain mobile phone service from Mobile Virtual Network Operators (MVNOs) will receive WEA service. MVNOs do not own or operate network infrastructure, and were not required to report their participation in WEA under Federal Communications Commission (FCC) regulations. A question remains as to whether these companies will require their mobile device suppliers to provide mobile devices that can receive and display alerts disseminated over the MVNO's parent network, which at present is not required. Absence of such a requirement raises the possibility that MVNO subscribers, a significant fraction of the U.S. public, will not be able to receive WEA messages.[4]

CMSPs Can Provide WEA to Almost All of the U.S. Public

The coverage areas of CMSP networks vary widely. The widest coverage offered is by Tier I CMSPs, which provide service to the majority of the nation's mobile device subscribers and cover 72.7 percent of the nation's landmass. Fully or partially WEA-compliant Tier I CMSPs cover an estimated 99.2 percent of the U.S. population. However, simply living in an area covered by a given CMSP does not ensure receipt of a WEA if the individual does not subscribe to a participating provider. CMSP network coverage is a necessary but only intermediate step to understanding overall WEA penetration.

According to American Roamer data, an estimated 73.2 percent of the nation's landmass is covered by at least one CMSP that intends to implement WEA fully or partially. The estimated fraction of the nation's population that resides in the coverage area of at least one WEA-capable CMSP is 99.4 percent, a number that compares favorably to 99.5 percent with voice coverage. In the long term, WEA penetration is expected to increase to almost the current mobile device penetration rate, if factors such

[4] The largest MVNO is TracFone Wireless. At the end of 2012, it was the fifth largest wireless communication provider, with 22.4 million subscribers (América Móvil, 2012).

as the availability of WEA-capable phones and user acceptance do not cause WEA penetration to fall over time.

Findings—Barriers to WEA Use

Compatible Devices Pose the Highest Barrier to WEA Use

The most significant limitation on WEA penetration in the near term is the unavailability of WEA-compatible devices. This shortcoming affects all CMSPs implementing WEA. As of April 2012, only 3 percent of mobile devices were WEA-capable.

While WEA-capable devices will eventually increase substantially among Tier I CMSPs, a significant number of their mobile device offerings may still not be WEA-capable for several years. Analysis of mobile phone purchases and other data indicates that two-thirds of the mobile phones are replaced approximately every two years. Using turnover rates to project how the number of WEA-capable phones will grow over time, it is likely that a 90-percent penetration rate will not be achieved among Tier I subscribers until 2017.

Because the newest and most capable devices first become available on Tier I networks, the penetration of WEA-capable devices in Tier II and Tier III networks will increase more slowly. However, it is possible that some devices could receive software upgrades that would provide WEA capability.

Demographic Factors Also Affect WEA Use

Demographic factors, such as age, income, language, and disabilities, can affect both the likelihood of owning a mobile device and the ability to understand a WEA message. National surveys by the Pew Research Center’s Internet and American Life Project show that individuals with lower income, the very old, and very young are less likely to have mobile devices. Programs such as Lifeline, which provides free or reduced-cost mobile phones to qualified low-income households; CMSPs; and MVNOs, such as Jitterbug or Cricket, target these populations, providing potential avenues for increasing WEA penetration.

Individuals with hearing or vision disabilities may have difficulty noticing and/or understanding text-based messages. Technological solutions may alleviate these challenges. Cognitive disabilities, on the other hand, may limit the ability of an individual to understand message content, highlighting the importance of testing messages for

comprehension with a wide range of recipients of diverse abilities and backgrounds. Similarly, because WEA is currently an English-only system, difficulty with English will limit comprehension among illiterate and non–English-speaking populations.

The prevalence of all of these populations varies geographically across the United States, and the primary challenges faced within one region will differ from those in other regions. As a result, any national strategy for WEA use will need to be flexible so that state- and local-level implementations can target the main challenges faced in those locations.

Public Awareness of WEA Is Low and Acceptance Uncertain

A variety of sources, including emergency management personnel and the results from informal social media surveys, indicate that public awareness of WEA is very low (as of third quarter 2012 or about three months after the system was declared operational). AOs at a forum held early in 2012 reported that the public in their jurisdictions had little awareness of WEA. An informal survey of social media responses to recent WEA messages issued in Pennsylvania, New York, New Jersey, and other states indicate that many members of the public are surprised when they receive extreme weather alerts on their mobile phones.

User acceptance of WEA is an important consideration to ensure the overall effectiveness of the system. If users find WEA messages to be too numerous, too confusing, or not useful, they may develop message fatigue and decide to opt out of the system, lowering the overall WEA penetration rate over time.

Recommendations to Improve WEA Adoption

The findings identify issues that could reduce WEA penetration and user acceptance. Recommendations are presented in Table S.1 that help ensure WEA will become widely available and useful to the U.S. public. These recommendations constitute the core elements of a strategy to increase both WEA penetration and the number of stakeholders in the WEA public-private partnership.

Table S.1. WEA Mobile Penetration Strategy Recommendations

Issue	Recommendations
Maximizing WEA Penetration Among AOs	FEMA: • Share CMSP WEA rollout information with emergency management and AO communities. • Publish guidelines on how to use the current WEA message standard to transmit alert information in other languages. DHS S&T: • Consider providing incentives for state and local emergency management organizations so they can acquire the equipment and training necessary to disseminate alerts via IPAWS-OPEN. • Develop a WEA AO best practices guidebook and disseminate it widely to the AO community. FEMA and DHS S&T: • Share aggregate results of regional and national WEA tests (that do not reveal proprietary network performance information) with state and local emergency managers.
Maximizing WEA Penetration Among CMSPs	FCC: • Require MVNOs to declare whether they will participate in WEA and to inform their subscribers of their choice. • Require CMSPs to forward WEA messages to subscriber mobile devices via Wi-Fi or small cells.
Maximizing WEA Penetration Among Mobile Wireless Devices	FCC: • Establish the following goal for the wireless CMSPs and device manufacturers: By December 2013, 90 percent of the mobile devices offered by Tier I and Tier II CMSPs will be WEA compatible. • Encourage the major CMSPs and mobile device manufacturers to push software upgrades to existing devices so they become WEA-capable. • Encourage Tier I CMSPs and major tablet computer manufacturers to add WEA capability to their tablet offerings that have wireless cellular data connectivity.
Maximizing WEA Penetration in Disadvantaged Populations	FCC: • Require CMSPs participating in the Lifeline program to adopt WEA. • Consider establishing guidelines for mobile device manufacturers to improve accessibility for future versions of WEA.
Maximizing WEA Public Awareness and User Acceptance	DHS S&T: • Provide a unified U.S. government–linked web presence for increasing public education and awareness. • Consider improving the geo-targeting accuracy of WEA as soon as possible. • Conduct further research on WEA message design for high- and low-precision geo-targeted messages. • Develop and pilot test templates for WEA messages for different types of emergencies and different sized geo-targeted areas DHS S&T and FEMA • Conduct WEA tests with devices from multiple vendors to verify system end-to-end performance and so the timeliness of WEA message delivery can be measured in realistic conditions. FCC: • Direct the wireless CMSPs and other retailers (e.g., Best Buy) to provide WEA educational materials furnished by DHS at the point of sale for mobile devices. • Direct the wireless CMSPs who adopt WEA to send short WEA “infomercials” to all phones once per quarter or once every six months to help educate the public.

1. Introduction

The Warning, Alert, and Response Network (WARN) Act of 2006 directed the Under Secretary of Homeland Security for Science and Technology to establish a research program for the Commercial Mobile Alert System (CMAS), with a goal of increasing the number of "commercial mobile service devices that can receive emergency alerts."[5] In 2011, the National Telecommunications and Information Administration (NTIA), the Federal Communications Commission (FCC), and the Department of Homeland Security (DHS) agreed that DHS Science and Technology (S&T) Directorate would develop a mobile penetration strategy for CMAS, which was renamed the Wireless Emergency Alerts (WEA) service by the FCC in 2013. The WEA service provides a new communications path to issue emergency alert messages to the U.S. public by means of the Integrated Public Alert and Warning System (IPAWS). WEA messages are sent directly to mobile phones and other wireless mobile devices connected to commercial mobile service provider (CMSP) networks.

This chapter first describes the roles and responsibilities of the various government agencies in the development and deployment of WEA. The discussion is followed by a description of the Integrated Public Alert and Warning System–Open Platform for Emergency Networks (IPAWS-OPEN) architecture, through which all WEA messages must pass. After the IPAWS-OPEN architecture is presented, a discussion of the WEA service is provided. Finally, this chapter discusses the structure and content of the messages that CMSPs pass along to their subscribers.

Government Roles and Responsibilities

The WEA service is a complex system of systems that includes components and networks owned and operated by government and private organizations. The service is based on a public-private partnership, which over time will ideally include a growing list of private-sector organizations and state and local government emergency management agencies. The private-sector organizations that are essential for the success of WEA are

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[5] The history of emergency alert systems and the motivation for them is described in Appendix C.

the CMSPs. Both WEA and the older public alert system called EAS (Emergency Alerts System) allow federal, state, and local emergency management agencies to communicate with the public. Different government organizations have different roles in IPAWS-OPEN and WEA, as explained below.

Federal Partners

DHS was directed under Executive Order 13407 to modernize and update the EAS. DHS gave the Federal Emergency Management Agency (FEMA) the responsibility of managing the development and operation of the IPAWS-OPEN aggregator.

Pursuant to the WARN Act of 2006 (Title VI of Pub. L. 109-347), DHS S&T manages a research, development, testing, and evaluation program for WEA, with research and development in particular focused on the geo-targeting of alerts and improving the public response to warnings.

In accordance with a Memorandum of Understanding (April 5, 2011) between the NTIA, Department of Commerce, and DHS, DHS S&T, in coordination with FEMA, was tasked to:

1. Conduct national and regional pilot tests of WEA
2. Develop alert-origination best practices and tools
3. Develop and implement a testing and simulation environment that will allow CMSPs and commercial software vendors to test the functionality of the IPAWS-OPEN aggregator
4. Develop a public alert and mobile penetration strategy
5. Conduct mobile alert and warning systems integration.

Accordingly, FEMA established the IPAWS-OPEN program office and coordinated with the FCC to integrate WEA into IPAWS-OPEN. FEMA's key role is thus to develop and operate IPAWS-OPEN as the alert aggregator for the system.

The FCC, as the primary regulatory agency for CMSPs, has a role in overseeing the implementation of WEA. While WEA was under development, the FCC provided oversight of the Commercial Mobile Service Alert Advisory Committee (CMSAAC). This advisory committee developed a set of recommendations that specify the design and operation of WEA. The FCC largely adopted these recommendations.

Some of the key CMSAAC recommendations became WEA design specifications:

- County-level geo-targeting
- A 90-character limit for alert messages

- A technology-neutral policy for alert transmission technology
- Web links or media will not be included in WEA messages

Federal Alert Originators

At the federal level there are currently two primary alert originators (AOs): the President and the National Weather Service (NWS). Presidential alerting authority for IPAWS-OPEN mirrors the alerting authority granted to the President in earlier public alerting systems, such as Control of Electromagnetic Radiation (CONELRAD), Emergency Broadcast System (EBS), and EAS. The President has always been granted the authority to communicate an emergency alert to anyone in any location in the United States.

As of August 2012, no presidential alert has ever been issued to the public using IPAWS-OPEN or its predecessor emergency alerting systems. This lack of use may have been due to many factors: the belief that government officials can issue timely emergency alert information more effectively through the news media, lack of confidence in EAS, lack of familiarity in EAS by some decision makers and advisors, or because past presidential advisors were aware of its limitations, such as the inability to send alerts to a specific area (i.e., EAS did not have a sufficient geo-targeting capability), and were concerned about alarming members of the public not at risk in the emergency situation. Irrespective of the reasons, WEA has been designed to enable the President to issue emergency alert messages. Furthermore, with its improved geo-targeting capability, the President may decide WEA will be more useful than its predecessor systems for emergency alerting purposes.

The National Weather Service

The NWS plays the role of both an AO and alert disseminator and is expected to originate the majority of IPAWS-OPEN alerts and possibly the majority of WEA messages. The NWS already has an extensive infrastructure for generating and disseminating information about severe weather events. Based on its history with EAS, the NWS is likely to continue to be the largest AO for imminent-threat alerts. The NWS will originate alerts to WEA for only the most life-threatening subset of weather events. The National Oceanographic and Atmospheric Administration (NOAA) operates a system called HazCollect that disseminates IPAWS-OPEN alerts over the NOAA weather radio network.

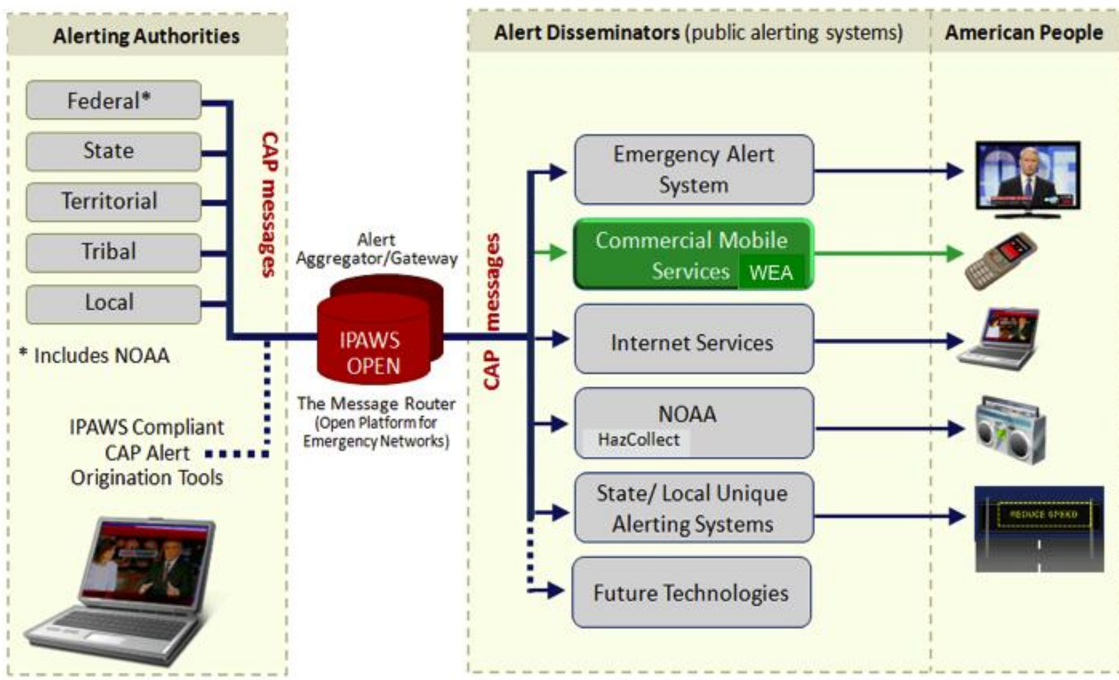
State and Local Emergency Managers

State and local governments also have a role to play in the operation of WEA. States are designated the role of gatekeepers for all potential AOs within their jurisdiction. FEMA relies on state agencies to approve applications from counties and localities seeking to issue alerts through WEA (via IPAWS-OPEN). States (acting as an originator or aggregator for counties and localities), counties, or local jurisdictions can seek to originate WEA (IPAWS-OPEN) alerts.

IPAWS-OPEN System

The central networking, message authorization, and routing roles of the IPAWS-OPEN aggregator are shown in Figure 1.1. To perform these functions effectively, the aggregator must be interoperable with the networks and messaging systems used by the wide range of AOs shown in the figure. The aggregator is built on publicly available secure messaging and networking standards to enable industry competition for such equipment. The IPAWS-OPEN aggregator can receive alerts from any alert origination systems and/or services that comply with these standards.

Figure 1.1. Operational View of the IPAWS-OPEN Architecture



Source: DHS S&T, 2012

A variety of commercial and open-source tools that AOs can use to initiate alerts in Common Alert Protocol (CAP) format already exist. CAP is expressed using the Extended Markup Language (XML) maintained by the Organization for the Advancement of Structured Information Standards (OASIS). A CAP-compliant message identifies and accounts for all message elements that IPAWS-OPEN needs to decode and disseminate, using one or more of the means available, including WEA.

IPAWS-OPEN receives and authenticates alerts from approved AOs and disseminates them to the appropriate dissemination channels, which, depending on the alert content, will include a subset of participating CMSPs. Another essential requirement for the system is the capability to interpret a wide range of alert messages from AOs and to ensure they are disseminated effectively. The aggregator serves as the U.S. government’s sole alert messaging interoperability gateway that verifies and delivers alerts to multiple private-sector networks.

The aggregator uses secure network connections and message validation protocols. It can receive alerts from authorized AOs and forward them securely to authorized alert disseminators, such as CMSPs and television broadcasters. The security features of the IPAWS-OPEN aggregator are designed to ensure that unauthorized users cannot issue a false alert message. These security features help to ensure public trust in the validity of information received by means of the system. Public awareness and trust in the system are essential for maximizing the system’s utility and continued use by the public, especially in the case of WEA. Members of the public can opt-out of some WEA messaging capabilities. They may do so if they lose trust in the system, or if they believe the alerts they receive from it are not relevant or useful.

All AOs and alert disseminators in the IPAWS-OPEN architecture shown in Figure 1.1 must be able to create, route, and disseminate CAP-compliant messages. One means to initiate alerts is via a free, open-source tool called EDXL Sharp (Codeplex, 2012). With expert assistance, it can be installed on a PC and used to send alerts to the IPAWS-OPEN aggregator through a secure and authorized network connection.[6] In addition, there are a variety of third-party services that enable emergency managers to send EAS alerts and communicate with emergency responders. Many of these service providers

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[6] The degree of use of EXDL Sharp is unknown. Open-source software is a viable option when a vibrant user base exists. Without widespread use and contributions from the user base, the software will quickly become obsolete.

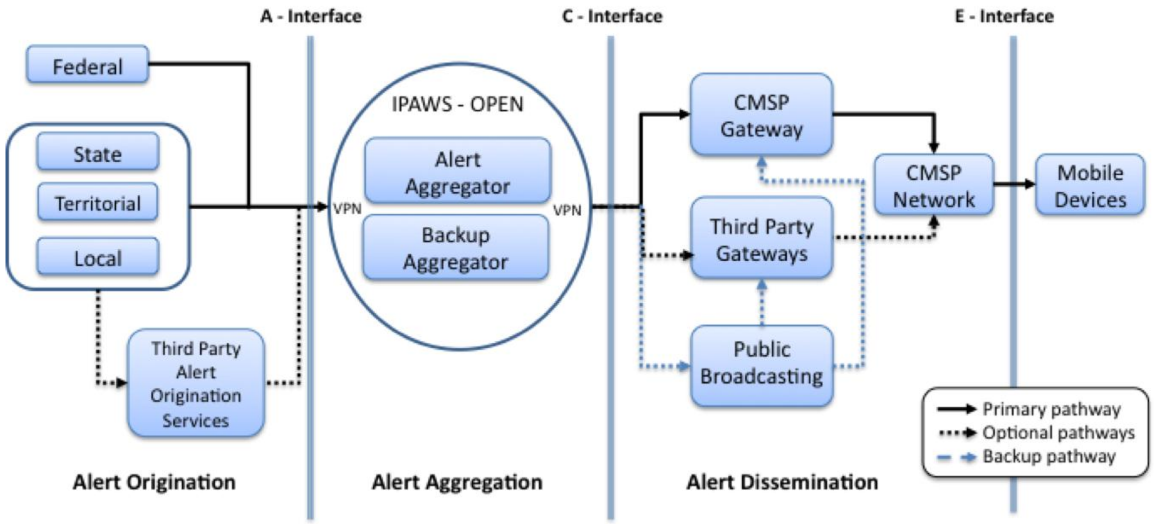
have updated their offerings to allow their subscribers to send IPAWS-OPEN–compatible alerts.

Wireless Emergency Alert System

As a component of the larger IPAWS-OPEN architecture, WEA shares the same alert message origination and routing infrastructure, up to and including the IPAWS-OPEN aggregator. Figure 1.2 provides an overview of the WEA system architecture, including the key nodes and interfaces on the communications path from the AO to the end user device, a CMSP-connected mobile device, which in most cases today will be a mobile phone. The A interface specifies the secure network connection and CAP messaging standards needed to send WEA messages to the IPAWS-OPEN aggregator. The C interface specifies a secure network connection and messaging standard that enable CMSPs to connect to the aggregator (Alliance for Telecommunications Industry Solutions [ATIS] and the Telecommunications Industry Association [TIA], 2009a).

The wireless interface to mobile devices is also indicated in Figure 1.2. This network connection is provided by the cell tower infrastructure of the CMSP. However, in contrast to the standard data channels used by mobile device owners, the WEA wireless channel is unique to WEA and has limited capacity. The cell broadcast channel can only support text messages of 90 characters or less, but it does have the advantage that it does not contend for network or wireless bandwidth resources. This provides the advantage that in an emergency there is a high probability that the cell tower will transmit WEA messages effectively even if the other "primary bearer" wireless data channels at the cell tower become congested because of heavy user traffic.

Figure 1.2. The WEA Architecture



As previously mentioned, the WEA wireless cell broadcast interface has limited capacity. The CAP message standard was originally developed for alert disseminators, but when the CAP message standard was examined for use in the WEA system it was deemed to impose too much overhead and was considered too large for effective transmission over the wireless WEA interface. Consequently, an effort was undertaken to develop a means of truncating CAP message for use in WEA. ATIS and TIA jointly developed a standard (ATIS/TIA, 2009a) to transmit the alert from the IPAWS-OPEN aggregator to CMSP and third-party alert gateways, as shown in Figure 1.2.

CMSPs can choose to connect directly to the IPAWS-OPEN alert aggregator or to employ a third-party service (termed third-party gateway in Figure 1.2). WEA CMSP gateway equipment is expensive, and in the early stages of the WEA system development such equipment was only available from one vendor—the Alcatel Lucent Broadcast Message Center (BMC). Over time, additional gateway equipment vendors entered the market with lower cost equipment and service options. Research indicates that smaller CMSPs tend to prefer third-party WEA gateways or services because they cost less than the BMC. Larger CMSPs tend to prefer the direct connection provided by the BMC because the cost of this equipment can be distributed over a larger subscriber base.

In prescribing the protocols and standards for WEA, the FCC adopted the following CMSAAC recommendation:

> CMS providers that elect to participate in the WEA should "not be bound to use any specific vendor, technology, software, implementation, client, device, or third party agent, in order to meet [their] obligations under the WARN Act" (FCC, 2008, p. 15).

The above discussion indicates that a variety of equipment and service options now exist for implementing WEA in CMSP networks. The FCC did not prescribe the means of dissemination of a WEA message. Interviews with CMSPs indicate that most CMSPs have selected cell broadcast as the means for distributing alerts. However, some providers and third-party services have chosen to use a standard text message or Short Message Service (SMS) or a smartphone application alongside a cell broadcast solution. To date only small CMSPs have chosen to implement WEA using SMS, it is not clear that SMS-based WEA solutions would scale to larger CMSPs with a high density of mobile device subscribers.

Cell broadcast is a one-way transmission that does not require a mobile device to acknowledge receipt of a message, as does SMS, and provides no way to discover how many devices received the message. Thus, cell broadcast reduces the demand for network transmission capacity by not requiring an acknowledgement receipt.[7] A cell broadcast transmission can be targeted to one or more cellular towers or antennas, automatically including any WEA-compatible device within the transmission range of those towers. This can include individuals roaming on the transmitting network. Because cell broadcast does not require the CMSP or AO to know the location of the device, it does not require collecting private location information to implement the service.

Cell broadcast–capable phones are just entering the commercial market. SMS-based alerts will work on nearly any mobile phone on the market today. Thus, WEA messages can be disseminated to phones that are not yet configured to receive cell broadcast transmissions, if the participating CMSP uses SMS for WEA dissemination.

Smartphone applications are potentially capable of conveying much more information than a 90-character alert message. A smartphone application can be designed to display the entire CAP alert as transmitted from the originator, thus providing the user with more information. Both SMS and application-based alerts are capable of conveying the alert to an interested individual who is outside the geo-targeted area of the alert. Some

[7] The prohibition of links in messages also aims to reduce the demand for network transmission capacity by not encouraging a recipient to request additional information about the alert.

parents of young children and children of the elderly already monitor existing (non-IPAWS-OPEN) emergency information[8] feeds for their relatives in geographically disparate locations. SMS and application-based alerts can also serve individuals with this desire for information.

CMSP Requirements

A CMSP is defined in U.S. Code, Title 47, Section 332(d)(1) as an entity that operates a network of fixed or mobile radio communication services for profit and that interfaces with the public telephone network. In practice, this means that any organization licensed by the FCC to provide fixed or mobile radio communications service is a CMSP. Such service providers include cellular voice and data services and pager services. The largest CMSPs in the United States are AT&T and Verizon. Additional entities offer commercial mobile device service but do not operate a physical network. These are known as Mobile Virtual Network Operators (MVNOs). Because MVNOs do not operate a physical network, they are not licensed by the FCC and are not considered CMSPs for the purposes of WEA.

In 2008, the FCC issued an order requiring all CMSPs to declare whether they would participate in disseminating WEA messages (FCC, 2008b). Over 600 licensed CMSPs responded, including pager-only companies, but not MVNOs.

A CMSP electing to participate in WEA agrees to interface with the IPAWS-OPEN aggregator, geographically target any alerts to their subscribers, and configure their subscriber devices to receive and deliver an alert with a unique tone and vibration in accordance with the relevant standards (ATIS/TIA, 2009b). Participating CMSPs are required to configure subscriber devices to opt-in automatically to receive all WEA messages. The device should also be configured to allow the subscriber to opt-out of receiving imminent threat and AMBER alerts, but not presidential alerts.

If a CMSP elects not to participate in WEA, it is required to notify its current subscribers in writing and potential subscribers at the point of sale that the CMSP's service offerings do not include WEA.

[8] These are typically referred to as reverse-911 services and are operated by counties or localities on a subscription (opt-in) basis.

WEA Messages

To conform to the size limitations of a cell broadcast channel, WEA messages are designed to be short—no more than 90 characters. WEA messages are also prohibited from including hyperlinks, telephone numbers, and images to limit potential congestion of CMSP networks, either from the transmission of image data or from the public response to receiving a link or phone number. An AO can construct a WEA message as "free" text—equivalent to sending a short text message or email (although no acknowledgement of receipt is possible). If the AO uses the multiple dissemination paths of the IPAWS-OPEN system (of which WEA is one), then the IPAWS aggregator constructs the WEA message using the relevant components of the CAP message provided by the AO. The relevant CAP components include (FCC, undated, p. 18)

- event type or category
- area affected
- recommended action
- expiration time (with time zone)
- sending agency.

The 90-character limit in WEA was selected because it would allow more alert disseminators to participate in WEA with smaller investments in infrastructure upgrades. In particular, the Code-Division Multiple Access (CDMA) protocol (used by Verizon, Sprint, and a number of smaller CMSPs) placed the greatest constraints on the amount of information that could be sent in a single cell broadcast. Options for overcoming this limitation include updating the CDMA standard and, subsequently, CDMA network equipment/devices to carry a larger payload, or by designing the WEA transmission standard to allow for multi-part transmissions. Both of these options were considered and rejected due to concerns about cost and complexity, respectively.

The wireless industry has been moving away from the current third generation (3G) technologies, based on the Global System for Mobile Communications (GSM) and CDMA, toward a fourth generation (4G) mobile network technology, called Long Term Evolution (LTE). The data transmission standards for LTE have been finalized and CMSPs are currently deploying LTE technology in their networks and mobile devices. The LTE voice and cell broadcast standards are still under development and are expected to be finalized soon (Ericsson, 2012).

2. WEA Mobile Penetration Strategy

This chapter speaks to the objectives of the WEA Mobile Penetration Strategy and factors that influence its availability to the general public. The chapter first reviews the goals of the penetration strategy and then enumerates the challenges that must be overcome to achieve the goals.

The ability to disseminate WEA messages is based on a public-private partnership. Its effective operation requires the cooperation of multiple organizations. Because participation in WEA is voluntary, the majority of relevant public- and private-sector organizations, and the public at large, must adopt it for it to be successful. As described in Chapter One, these are as follows:

- AOs
- CMSPs
- Mobile wireless device manufacturers
- Subscribers of a CMSP.

Figure 2.1. An End-to-End View of WEA

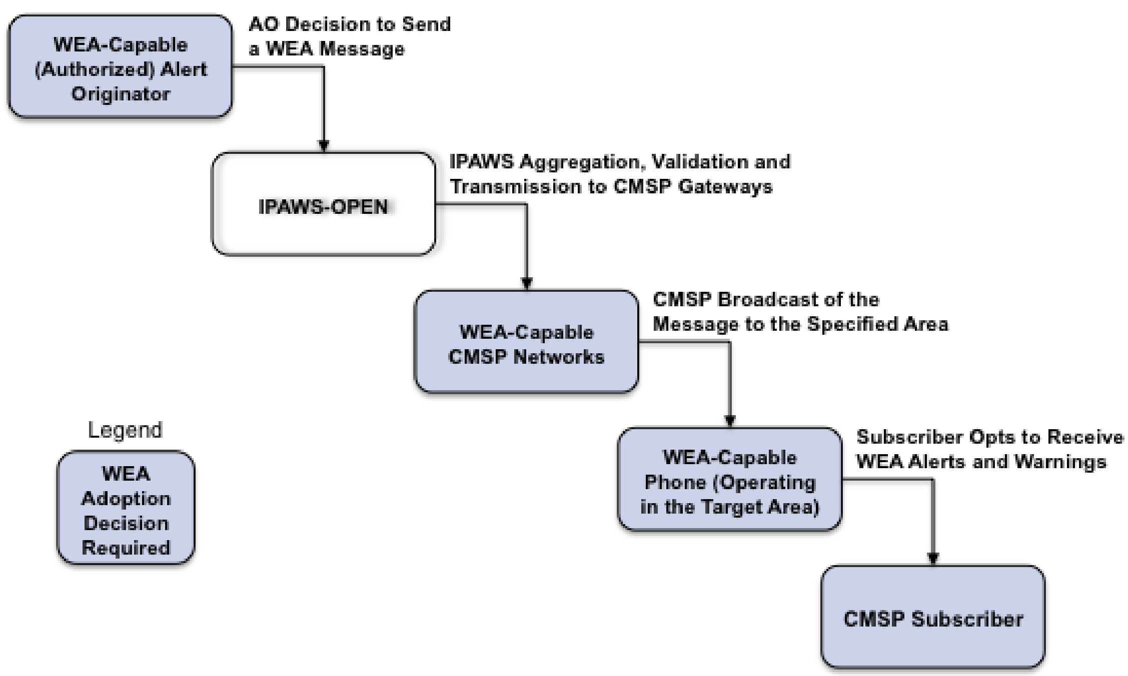


Figure 2.1 illustrates an end-to-end model of WEA adoption that can be used to understand WEA penetration or usage rates at various levels of the public-private partnership. WEA usage and availability can be limited at the AO, wireless carrier, mobile device manufacturer, or subscriber levels. In order for a message to be transmitted from an AO to a CMSP subscriber, each entity in Figure 2.1 must decide to become (or remain) WEA enabled. At each step, a decision to participate must be made. The only element of the WEA for which voluntary adoption is not an issue is the IPAWS-OPEN aggregator, which provides the linkage between AOs and CMSP networks.[9]

It is useful to consider a number of coverage measures to estimate WEA penetration rates and to identify issues that may prevent WEA adoption and ultimately the availability of WEA to the U.S. public.

WEA *coverage* can be defined at the levels indicated in Figure 2.1 (AOs, CMSPs, mobile device manufacturers, and subscribers) as the number or percentage of entities at each level that choose to adopt WEA or act to enable use of WEA by others. For example, if an AO does not take the steps necessary to disseminate alerts via IPAWS-OPEN, then any WEA imminent threat warnings issued by that originator would not be sent to mobile devices. If a carrier does not adopt WEA, its subscribers will never receive presidential alerts, AMBER alerts, or imminent threat warnings. If a carrier's subscriber chooses not to purchase a WEA-capable mobile device, that subscriber cannot receive an imminent threat warning sent by his or her carrier.[10]

The U.S. public, as CMSP subscribers, depends on the public- and private-sector organizations indicated in the figure. If any of these organizations do not adopt WEA, the fraction of the public that cannot receive all or some WEA messages increases. **Thus, WEA *penetration* (adoption) is a critical factor in the system's success and effectiveness.** WEA availability to the U.S. public depends on WEA penetration at the levels indicated in Figure 2.1.

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[9] The only way the IPAWS-OPEN aggregator could reduce WEA availability would be if it were to become disabled or not available for extended periods of time. This analysis assumes the IPAWS-OPEN aggregator is always available and able to process WEA messages.

[10] In addition, if a subscriber has a WEA-capable mobile device, he or she can opt out of receiving AMBER alerts and imminent threat warnings by changing settings on their phone. By opting out, the subscriber will no longer receive these types of alerts.

Even if all the organizations and individuals indicated in Figure 2.1 decide to adopt WEA, important questions still arise regarding the public's ability to comprehend the alert or warning and how the public will respond to such messages. The answers to these questions require understanding of the demographics of the population (e.g., non-English speakers, literacy), behavioral factors (e.g., message fatigue), and how and in what language the alert or warning is displayed on the mobile device. DHS S&T is sponsoring additional research on this topic.[11]

Goals

The purpose of this analysis is to assess existing WEA service coverage and identify measures that would maximize public access to WEA messages. This report provides data that characterize WEA penetration at various levels of the WEA public-private partnership, and it provides analyses that form the basis for a strategy to maximize the participation of AOs, CMSPs, mobile wireless device manufacturers, and the public in WEA.

The sections below describe four specific objectives of the study.

Characterize Expected Levels of WEA Penetration

The first objective is to characterize the WEA coverage achieved at initial capability and later when CMSPs and mobile device manufacturers have fully fielded WEA capabilities. The WEA service is an evolving and complex system of systems. The organizations adopting WEA will do so at different rates, and their adoption decisions can be coupled in ways that are difficult to model and estimate as independent phenomena (e.g., CMSPs, mobile device manufacturers, and subscribers). Most of the estimates and analyses are for the April 2012 initial capability date. Trend data (when available) are used to suggest how rapidly the initial capability estimates may change. Known systematic biases (resulting in an over- or under-estimate) may exist for some estimates and are noted. Assumptions about the independence of variables, made to simplify analyses, are also noted.

The estimates presented in the following chapters include numbers of

[11] *Phase 1 Final Report - Comprehensive Testing of Imminent Threat Public Messages for Mobile Devices,* National Consortium for the Study of Terrorism and Responses to Terrorism, December 27, 2012

- AOs prepared for and/or interested in using WEA and the nature of their coverage, i.e., national, state, county, and municipal
- CMSPs implementing, preparing for, and/or committed to implementing WEA and the nature of their coverage
- WEA-capable mobile devices and other mobile wireless devices in the marketplace
- Percentages of the population that may not be capable of receiving and understanding WEA messages, based on demographic factors.

Identify Barriers to Adoption, Including Demographic Factors

Since participation in the system is voluntary, another objective of the study is to identify the barriers to WEA adoption. *A further objective of this study is to estimate the effects of demographic factors.* If barriers are understood, then DHS can take steps to reduce or eliminate these barriers and thereby improve WEA coverage—allowing more alerts and warnings to reach more citizens.

The effectiveness of WEA is not solely a matter of technology adoption. Even if every type of organization in Figure 2.1 adopts WEA, factors other than adoption decisions may be impede WEA's effectiveness. Physical attributes of the wireless infrastructure (e.g., a subway rider may have trouble receiving a WEA message), and laws restricting its patterns of use (e.g., laws restricting texting while driving) can limit the transmission and receipt of a broadcast WEA message. Demographic characteristics can limit the ability to comprehend and act upon a WEA message, for example, illiterate or non-English speaking populations cannot understand English text messages. Patterns of WEA usage by AOs can also impede effectiveness, as when message fatigue may lead to subscriber decisions to opt out of receiving WEA messages.

Recommend Options for Improving WEA Penetration

The final objective of the Mobile Penetration Strategy is to identify a comprehensive set of options for improving WEA penetration at all levels of the service. As shown later in this report, WEA adoption and coverage estimates are complex. The estimates depend on demography, geography, CMSP network coverage, mobile device capabilities, the public's interest in receiving WEA messages, and the public's understanding of what WEA is and the information that it can convey during an

emergency. Therefore, a one-dimensional strategy based only on one aspect of WEA may not provide the anticipated benefit or improve WEA penetration significantly.

A comprehensive multi-dimensional strategy is needed for increasing WEA penetration. This strategy must address all possible barriers to WEA adoption and incorporate cost-effective measures for implementing improvements to WEA by the many organizations that contribute to the WEA public-private partnership.

The analytical results contained in this report can help government and private-sector decision makers determine how a particular system enhancement could increase WEA penetration (increase the number of citizens who can receive a WEA message).

Challenges

A number of potential challenges exist that may prevent or slow the adoption of WEA. If these challenges are not addressed, then WEA penetration may not increase substantially over time. These challenges are identified in this section. Later in this report, they are addressed in detail and recommendations are made to overcome them.

The first challenge is the small message size of WEA messages. The short message size of 90 characters limits message content and—potentially—the understandability of the message, which may also limit the public's effective response to the alert. The 90-character limit results from the type of communications channel that was selected to transmit WEA messages from the cell tower to the subscriber device. This type of channel is called a cell broadcast channel, and such channels provide an important advantage for transmitting emergency alerts. It is not uncommon in an emergency for individuals to attempt to use their mobile devices to try to obtain more information about the situation. Consequently, subscriber voice and data traffic may increase substantially in an emergency, especially in the specific area where the emergency occurs. This increase in traffic can cause network congestion and dropped calls, and may prevent subscribers from using the CMSP network. Designers of the WEA system took this possibility into account. Cell broadcast channels will remain operational even during times of network congestion because they are one-way broadcast channels and do not require confirmation of message receipt by the CMSP's network, as in the case of SMS text messages.

The WEA message size limitation presents a challenge to AOs, in that they must describe the emergency and the actions the public should take in a message of 90 characters or less. Since many AOs have other alert communications paths available to

them (a factor we expand upon below), they may choose to use these alternative paths because of the WEA message limitation. DHS S&T has already taken an important step to address this challenge. DHS S&T is developing a set of WEA message origination best practices. These will include message templates and examples of how best to use short alert messages. In addition, it should be noted that DHS S&T is also sponsoring research into the public response to short message alerts under the National Consortium for the Study of Terrorism and Responses to Terrorism (START) program. The results of this research will also provide AOs with additional guidance on how to structure WEA messages effectively.

Another potentially important challenge for the emergency management community is the lack of understanding of the alert origination tools needed to originate a WEA message. A wide range of alert origination tools are available to emergency managers and are used to support alert messaging over a variety of communication pathways. However, many existing tools that are already in place in local emergency management centers are not compatible with the WEA architecture. In addition, special security requirements exist for connecting alert origination equipment to the IPAWS-OPEN aggregator. A secure virtual private network (VPN) connection is needed and an approval process is also required to set up such a VPN. Some emergency managers, especially from smaller jurisdictions, may not be aware of the steps, tools, and security procedures that must be followed to disseminate alerts via the aggregator. The above issues represent barriers that emergency managers, and especially those with limited resources, may not wish to address to initiate a connection to the WEA architecture. FEMA recognizes these issues and has an outreach plan to address them.

A third challenge that may limit WEA adoption is that a number of emergency management organizations currently use other methods of communication to alert the public in their jurisdictions. A common method for transmitting such alerts is by using SMS text messages. Another type of alert system is the reverse 911 system. SMS offers some advantages to AOs: they can send alerts to specific subsets of people in their area of responsibility, and there are vendor offerings that can send SMS-based alerts to a large set of alert subscribers all at once. But SMS-based alerting systems also have important limitations that reduce their utility, especially at the national level. WEA is a national system that is intended to be available at any time for the President to send an alert message to the U.S. public. Table 2.1 compares its capabilities and SMS-based alerting systems.

Table 2.1. Comparison on Mobile Alert Messaging Capabilities

Alert Capability	SMS-based Alerts	WEA Cell Broadcast Alerts
Geo-targeting	No. Point-to-point	Yes. Point-to-location
Message latency	Typically < 1 minute	Typically < 30 seconds
Mobile device updates required to support WEA messages	Yes	Yes
Supports notifications to the entire U.S.	No	Yes
Supports notifications to multiple locations in the U.S.	No	Yes
Supports notifications to an individual mobile device	Yes	No
Potential network congestion for WEA messages	Yes	No
Ability to prevent duplicate alerts	No	Yes
Subscriber cost	Yes	No
Text character limit	160	90
Multilingual support	Devices support various character sets for multiple languages; however, English is the standard for U.S. CMSPs.	Devices support various character sets for multiple languages; however, English is the standard for U.S. CMSPs.

Source: Adapted from DHS S&T, 2010.

When comparing WEA with SMS-based systems it is important to point out that no universal or national-level SMS-based alerting system exists today. A federal AO, such as the NWS, would have to use or rely on a collection of local SMS-based systems to transmit alerts to the public. In contrast, WEA offers a single unified capability for federal AOs. Perhaps the most significant advantage for WEA relative to SMS-based systems is bandwidth efficiency. WEA is relatively bandwidth efficient and can scale up to provide an alert message to all possible locations in the United States where WEA CMSP coverage is available. SMS-based systems cannot scale to the national level because they use the primary subscriber bearer channel of the CMSP network and would contribute to network congestion in an emergency, as indicated in Table 2.1. Finally, users and AOs incur SMS message charges, which may reduce system adoption, especially among lower income groups and smaller emergency management agencies. In

contrast, WEA is free. Finally, WEA messages can be targeted to a specific area. The size of the geo-targeted area depends upon the CMSP. Larger, Tier I CMSPs can now geo-target to small polygon-sized areas in much of their network coverage areas, and all WEA-capable CMSPs can geo-target WEA messages to individual counties. SMS messages cannot be geo-targeted.

The above discussion indicates that while competition from SMS-based emergency messaging systems may reduce WEA penetration, WEA offers significant advantages over SMS-based systems. However, SMS-based systems are already widely used in many local areas in the United States.

The fourth challenge for the WEA system that will reduce WEA penetration in the near term is the requirement (for many carrier networks) that the subscriber use a WEA-capable device to receive a WEA message. WEA messages will be disseminated using cell broadcast channels in many carrier networks. However, the majority of mobile wireless devices used by the U.S. public today cannot receive WEA messages. That is, they are not WEA-capable. It will take some time for the majority of the U.S. device population to become WEA-capable. While this is potentially a temporary issue, it is one that could persist for some time. Chapter 6 investigates this issue in more detail and proposes steps to increase the percentage of WEA-capable phones in the United States in the near term.

A fifth challenge relates to the question of how well WEA will work in practice, and whether and how it can be tested. How well will the public be served in an emergency in a dense urban area where many people should receive a WEA message quickly? Or in a large rural area, how many people will receive an emergency alert in a timely fashion? In both cases it is important that the system deliver an alert quickly to the at-risk population, regardless of the size of the area, the environmental conditions present, and the number of buildings or other obstructions that may prevent effective signal propagation. These questions raise a number of issues that can only be answered by testing the system in a variety of environmental conditions. The results of such tests will help to reassure AOs and the public that the WEA service can be used effectively under a wide range of conditions. DHS S&T is charged with conducting such tests. One national and four regional tests are planned that can help address AO concerns about how well and under what conditions WEA can be delivered effectively.

Still another challenge and uncertainty for WEA—which may not be present in larger U.S. cities, but is a concern in rural areas—is how many small CMSPs will adopt

WEA. Subscribers in remote rural areas may be served by small CMSPs only and may not have access to WEA-capable devices or networks. Chapter 4 investigates this issue.

Additional challenges may also arise when one considers how well the system will serve disadvantaged users, or users with hearing or vision disabilities, as well as users who cannot read English or read English only with considerable difficulty. One question that pertains to such users is the percentage of the U.S. population in specific areas that do not speak English or speak it with difficulty. These users may be underserved by WEA or may find that the service is not relevant to them and so they may opt out of the system. This will reduce WEA penetration in specific parts of the United States with high immigrant populations. To address these challenges it is important to identify barriers to WEA adoption that are caused by language or disability limitations.

3. Methodology

This chapter describes the sources and types of data used to estimate WEA coverage, and the methods used in data analysis. The data used to calculate quantitative estimates of coverage consist of both publicly available and commercial for-purchase datasets and are ultimately the best available descriptions of U.S. mobile device infrastructure, industry, and demographics. Government agencies responsible for the oversight and regulation of the mobile device infrastructure and the businesses that comprise the mobile industry tend to use these same datasets. Some of the analyses conducted required forecasts of future behavior, necessitating the development of models to extrapolate from data that describe current market structure or system penetration. Often these models were based on assumptions and abstractions, which are described when used.

The analyses in this report drew on wide variety of data sources. In almost every case, more than one data source was available for specific types of data. Researchers identified the best data source for each dataset based on data samples provided by vendors. In the cases where significant cost was involved, DHS S&T was consulted to coordinate the purchase of the dataset.

To understand barriers to adoption, empirical data were supplemented with qualitative information obtained from AOs and businesses that comprise the telecommunications industry. This qualitative information was gathered opportunistically, not systematically (e.g., by a survey). Therefore, findings generated by reviewing a limited number of responses should be interpreted with caution.

Definitions of Terms Used

No single metric of WEA coverage can be used to understand who a WEA message may reach, why a WEA message will not reach someone, the benefits to a locality of using IPAWS-OPEN to send WEA message, or the benefits of particular strategies intended to improve the number of persons who can receive a WEA message. As a result, the analysis uses a combination of data to estimate WEA coverage, including units of geography, census tracts, cell coverage, geopolitical units, and designated market areas. Each of these terms is defined below.

Units of Geography

The analytic results are portrayed, in part, using a Geographic Information System (GIS). A GIS is used to tie attributes of interest (e.g., CMSP radio frequency coverage) to geography. Geographic areas can be polygons[12] that are either related to the data source being analyzed (e.g., the advertised footprint of a CMSP's radio frequency coverage), or a political boundary meaningful to decision makers (e.g., a county).

Census Tracts

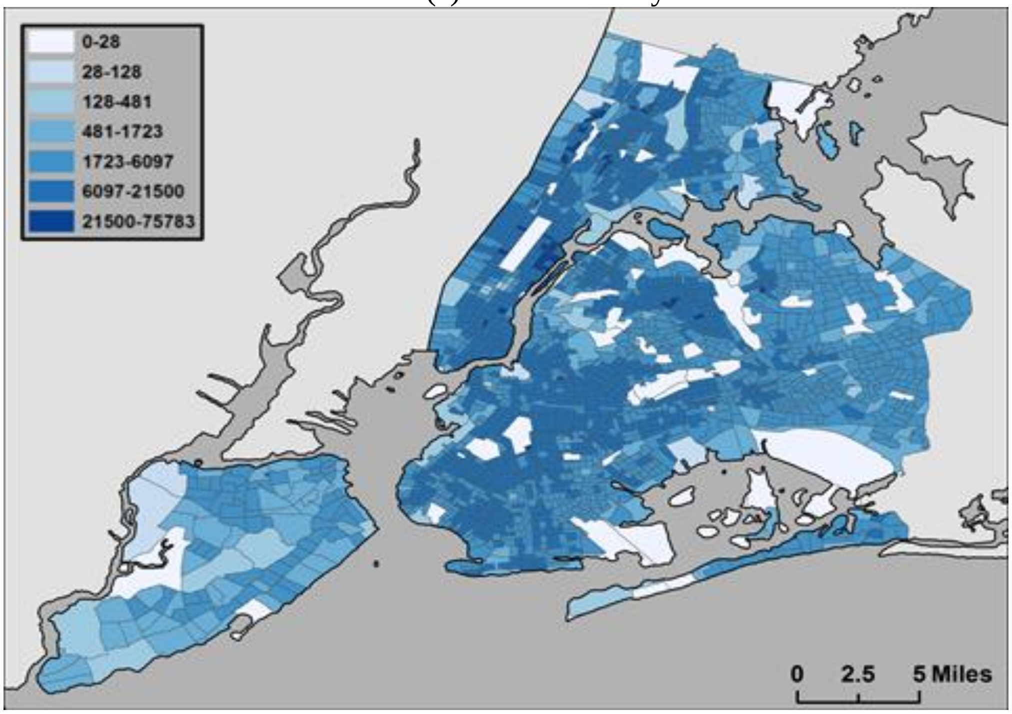
Population statistics fundamental to these analyses are estimated from data at the census tract level. The U.S. Census Bureau uses tracts to "provide a stable set of geographic units for presentation of statistical data" (Rossiter, 2012), recommending them as a level of geographic division of the United States that is less likely to change between decennial censuses. As counties are whole aggregations of census tracts, the boundary of each census tract lies entirely within a single county and therefore also entirely within a single state. A tract typically represents 1,200 to 8,000 people, optimally 4,000 people. The 2010 U.S. Census comprised 72,931 tracts with an average population per tract of approximately 4,200 people.

To illustrate the variations in geographic sizes of census tracts, Figure 3.1 contrasts maps of New York City, NY, and Carson City, NV. The outlines of the census tracts are shown in each city. Because census tracts are designed to represent approximately 4,000 people, the census tracts of rural areas represent physically larger areas than the tracts of urban areas.

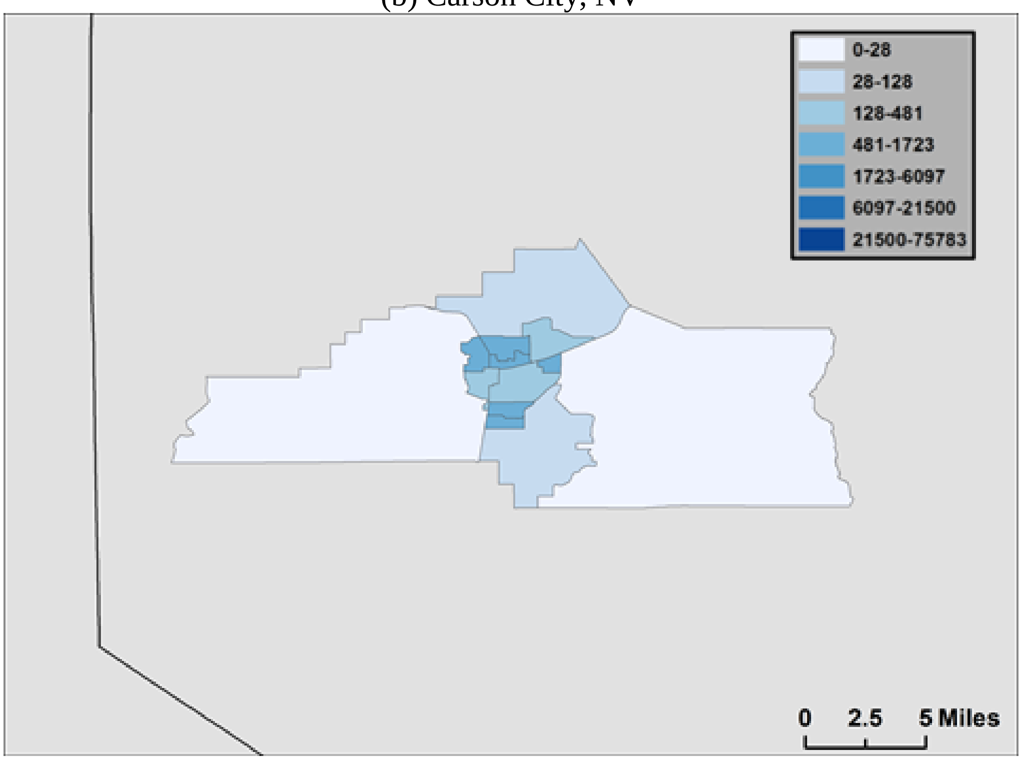
[12] As the term is used in a GIS, a polygon is comprised of one or more discrete bounded areas, which can be of any irregular shape.

Figure 3.1. Census Tracts of New York City and Carson City, NV

(a) New York City



(b) Carson City, NV



Each census tract is colored using a palette that represents its population density (number of people per square mile). With this coloring, low-density features such as Central and Prospect Parks are clearly visible within the boundary of New York City.

Cell Coverage

Data describing the geographic coverage of CMSP signals is represented as polygons. These polygons generally represent the reach of each CMSP's radio frequency (RF) signal. The polygons used in the analysis are based on the infrastructure (of antennas) that the CMSPs have implemented, the signaling protocols they use (e.g., GSM or CDMA), and the capabilities of protocols. Such coverage polygons can span multiple census tracts, or cover only a portion of a census tract.

Geopolitical Units

The coverage analysis combines census tracts with polygons that represent WEA coverage to portray the properties of two-dimensional areas that are meaningful to decision makers. For example, a heat map is used to encode population densities that can and cannot be reached by the WEA service. A color palette is used to encode the number of CMSPs offering coverage in an area to portray areas where competitive forces may play a role in public adoption of WEA.

Designated Market Areas

Data describing the geographic distribution of mobile devices (feature phones[13], smart phones, etc.) is described by Designated Market Areas (DMAs). DMA is a registered trademark of The Nielsen Company. DMAs are defined in the following way:

> Geographic areas in the United States in which local television viewing is measured by The Nielsen Company. A DMA region is a group of counties that form an exclusive geographic area in which the home market television stations hold a dominance of total hours viewed. There are 210 DMA regions, covering the entire continental United States, Hawaii, and parts of Alaska.

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[13] Feature phone is the mobile device industry's term for a phone that does not have the capability to install and run a wide variety of software applications that customize the function and capabilities of the phone.

Data Sources

Each major subsystem of WEA must be considered to estimate the coverage of WEA as of April 2012. The three major WEA subsystems[14] are

- AOs
- CMSPs
- Mobile devices.

The sections below describe the data sources and types of data used to estimate coverage in each of the subsystems.

Alert Originator Data

The analysis of AOs is based on a combination of FEMA data and information provided by individual AOs.

FEMA Data. The FEMA web page listing approved IPAWS-OPEN interconnections (FEMA, 2012) is one basis for the estimates of potential WEA AOs. An authorized connection to IPAWS-OPEN is necessary to use WEA, but it is not sufficient by itself to guarantee that an AO intends to use WEA. For example, one AO explained that, although both their state and county were going through the process to disseminate alerts via IPAWS-OPEN, there were no plans in the state to use the system for public alerting. FEMA's public data provide few insights about the reasons AOs seek IPAWS-OPEN connections, or the barriers to doing so.

State-level Data. Open sources, interviews conducted for DHS, and outreach to state- and territory-level AOs not included in interview data were used to gain a better understanding of the WEA intentions, motivations, and barriers perceived by AOs. This

[14] Note that IPAWS-OPEN is not central to understanding coverage, since its aggregation and dissemination functions are required for any other component of the system to originate or deliver an alert. However, they are important to understanding and evaluating the WEA system. For example, the throughput of IPAWS-OPEN might constrain the rate at which alerts can be aggregated and distributed. Depending on the expected distribution of alerts from a single originator or multiple originators, a rate-based constraint may cause alerts to be overtaken by events, e.g., a tornado warning needs to be timely to have any benefit to the public.

information was typically obtained by calling the state-level authorities. It was possible to obtain information for slightly more than 80 percent of the states. While this is not a complete picture of states, it is a usable sample that can enable users to draw inferences about the overall national picture of AOs. In some cases, state-level AOs could provide insight into the adoption intentions and issues of localities within their states.

National Homeland Security Conference Data. An additional source of qualitative data was the National Urban Area Association's National Homeland Security Conference (May 22–24, 2012, in Columbus, OH). This event provided a sense of the more general awareness of WEA among emergency managers and practitioners, and, where they are aware, their concerns about it. Impressions were drawn from the conference, participating in a forum event focused on WEA outreach, and informal meetings with attendees representing AOs. Because no attempt was made to obtain data systematically at this conference, it provides only impressions, and not statistical estimates.

WEA was discussed with a total of 141 contacts during the conference. Twenty-one (about 15 percent) of these contacts represented states or territories. Eighty-eight contacts (about 62 percent) represented entities below the state-level, including counties (17 people, 12 percent) and city agencies (71 people, 50 percent). The remaining ones were federal agencies, agencies that did not correspond to the state versus local dichotomy (e.g., regional entities such as state public health systems), or whose affiliation remained unknown.

Fourteen contacts made at the conference provided a written response describing their concerns about WEA. The written responses were consistent with what was learned from phone conversations with state representatives.

Cellular Mobile Service Provider Data

American Roamer[15]

American Roamer (AR) produces a dataset known as CoverageRight (CR) (Mosaik, 2012). Updated quarterly and licensed annually, CR data consist of a set of GIS polygons representing advertised coverage of CMSPs; this is the primary dataset used in the analyses to understand the coverage footprints of CMSPs. The license for the CR data used in this analysis is current as of October 2011. While use of October 2011 data is sufficient for the current analysis, and since the estimates of WEA coverage are for a particular point in time (April 2012), it constrains how the data can be used going forward.

AR's dataset was selected for its status as the industry standard: the FCC's regulatory analyses incorporate CR data, which are also used by CMSPs themselves for competitive analyses. The CR dataset is derived from the polygons CMSPs use to characterize their service coverage. Note that CR data is marketing data and do not necessarily correlate to the area served by a single measured signal strength. Since RF signals can be affected by a variety of both urban and rural features, it is an optimistic portrayal of coverage.

The network details, such as tower locations and nominal broadcast strength, which could be used to make a more accurate estimate of CMSP coverage, are proprietary and closely held. The CR dataset represents the best approximation of CMSP network characteristics available.

The AR database had far fewer CMSPs than the FCC election letters indicated, which could yield an incomplete result. An analysis was done to resolve the discrepancies. If paging companies are excluded, the discrepancy becomes less pronounced and does not appear to be significant.

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[15] In 2012, American Roamer changed its name to Mosaik Solutions, reflecting their expanding business model. As the CMSP datasets used for these analyses date from before the name change, they are referred to as American Roamer throughout the document. For more information, see http://www.mosaik.com.

Mobile Device Data

comScore

Mobile phone ownership data are used to characterize WEA at initial capability and to project the rate at which WEA-compatible phones are being adopted. Mobile phone ownership data were licensed from comScore, Inc. for the years 2010–2012 (comScore MobiLens, Jan. 2010–2012). The data from comScore provide insights about the composition of mobile phone devices in the United States. Over 30,000 individuals, representing mobile phone owners over the age of thirteen, participate in the annual comScore survey. In addition to listing the participant's device and carrier, the survey also includes demographic information, such as income, age group, and race. Participants change each survey year, and thus the data are not longitudinal.

Three successive years of data from comScore are used to construct a model estimating the rate at which WEA-capable phones will enter service. The model of mobile device turnover rates and WEA-capable phone penetration is described in Appendix A.

Data from comScore appears to be the best available industry data describing mobile phone ownership in the United States. Most wireless CMSPs and mobile phone manufacturers use comScore's data to understand the U.S. mobile phone market.

Other Mobile Device and Demographic Data Sources

The analysis of demographic features that affect WEA coverage and adoption draws upon several sources of data:

- 2010 Decennial U.S. Census (U.S. Census Bureau, 2010b)
- 2010 American Community Survey (U.S. Census Bureau, 2010a)
- 2003 National Assessment of Adult Literacy (U.S. Department of Education, 2003)
- 2010 Pew Internet and American Life Cell Phone Survey (Pew, 2010b)
- 2010 Pew Teens and Cell Phones (Pew, 2010a)
- 2010 Mediamark Kid's Cellphone Ownership Survey (Mediamark, 2010)
- 2011 Office of Travel and Tourism (U.S. Department of Commerce, 2011).

The analysis of coverage portrays WEA at a single point in time—April 2012. These are widely used sources that are as current to April 2012 as possible. Some of these data are gathered decennially, e.g., the U.S. Census. Some important data (e.g., adult

literacy information) is not gathered on a regular basis, so the most recently available data was used.

The census data provide estimates of the population at the level of census tracts. These estimates can be aggregated to understand geopolitical areas, such as cities, counties, or states. The American Community Survey data provides estimates of populations with attributes relevant to WEA. For example, institutionalized populations such as prisons, schools, and assisted living facilities are identified. The National Assessment of Adult Literacy data estimate populations that will have difficultly reading and comprehending a text alert. The Pew Internet and American Life Project provides estimates of cell ownership rates by age and income, but not by device type. These data are used to estimate cell ownership in geographies for age-, income-, language- and residence-adjusted populations in different geographies.

4. Estimated Alert Originator Coverage and Barriers to Expanding Coverage

This chapter estimates WEA penetration among AOs at its initial capability—April 2012. It does so by focusing on the AOs at the various tiers of the governmental hierarchy. It begins by describing the types of alerts and then describing coverage at four levels: federal, state/territorial, county, and local. The chapter concludes with a summary of the four levels and a description of the barriers that AOs perceive will limit coverage.

Types of WEA Alerts

WEA provides three types of alerts and warnings: presidential alerts, AMBER alerts, and imminent threat warnings. Alerts and warnings can originate at the federal level. Presidential and NWS imminent threat warnings are examples of federal messaging. WEA also supports imminent threat warnings originated by authorized emergency managers at the state and local levels (such as counties and municipalities) and AMBER alerts. As a result, the question of WEA penetration of AOs can—and must—be asked at multiple levels to capture the use of the system for dissemination of alerts at different echelons of government.

FEMA must approve an AO to disseminate alerts via the IPAWS-OPEN alert aggregator and links the originator and multiple alert dissemination pathways—one of which is transmission to mobile devices by means of WEA. The process through which an AO is approved to disseminate alerts via the aggregator includes the following four steps (described in detail in FEMA, 2012a):

1. *Implement IPAWS-OPEN Compatible Software*: To disseminate alerts via IPAWS-OPEN, an AO requires software that is compatible with the system and produces alert messages in appropriate format. A central requirement for software compatibility is that alerts are produced in CAP format. FEMA has put a process in place for developers to test their products for compatibility with the aggregator (FEMA, 2012b).
2. *Apply to FEMA*: To disseminate alerts via IPAWS-OPEN, alerting authorities (often on behalf of a Collaborative Operating Group [COG]) apply for a Memorandum of Agreement with FEMA to allow their COG to send public

alerts via the aggregator. COGs may contain more than one organization, but are led by a sponsoring organization that makes the application to FEMA (FEMA, 2012a).

3. *Document Public Alerting Authority at the State Level:* To ensure that the alerting capability provided through IPAWS-OPEN is consistent with state-level emergency alerting plans, the process for connecting to the aggregator includes review at the state level of COG applications (FEMA, 2012a).
4. *Complete Required IPAWS-OPEN Training:* Finally, before connecting to the system, a web-based training session (provided by FEMA's Emergency Management Institute) is required (FEMA, 2012a).

Because connection to IPAWS-OPEN is necessary for an AO to send messages by way of WEA, a clear indicator for AO adoption of WEA is the connection of entities at each level of government to that system. As described above, that data were available in public FEMA documents (FEMA, 2012), which provide data at the state, county, and city levels regarding in-process efforts to disseminate alerts via IPAWS-OPEN. Because the capabilities of IPAWS-OPEN are broader than WEA, it should be noted that IPAWS-OPEN can be used for exchange of messages among emergency organizations (i.e., not for public alerting), so intention to initiate a Memorandum of Agreement with FEMA for use of IPAWS-OPEN does not necessarily imply intention to send public alerts through WEA. In an effort to go beyond the information available from FEMA, additional information was collected from published information on adoption of WEA and outreach to AOs. Such information provides more detailed insight into the numbers of states and localities going through the process of connection to IPAWS-OPEN and allowed identification of issues and barriers to adoption of WEA by originators.

Alert Originator Adoption

To provide a picture into AO adoption of WEA and gather additional insight into intentions to adopt WEA more broadly, data from a number of sources was combined. FEMA data provided direct insight into AOs in the process of connecting to IPAWS-OPEN and, therefore, able to send WEA messages. These data were combined with information from stakeholder outreach efforts and other open sources to provide additional insight into the plans and intentions of AOs that were not already in the

process of connecting to IPAWS-OPEN.[16] Information from all these sources was available from and about 82 percent of states (using as baseline the 50 states, the District of Columbia, American Samoa, Guam, the Northern Marianas Islands, Puerto Rico, and the U.S. Virgin Islands). From available data, it was possible to characterize the intention to adopt WEA at the state level from 77 percent of states.

At the Federal Level

At the national level, the president and the NWS can originate alerts. Because of the central role of the NWS, acting as a “national alert originator” for severe weather alerts across the country, it accounts for the vast majority of alerts issued under the legacy emergency alert system. Estimates of alert volume on an annual basis vary, but available information places the NWS share of alerts in the range of 80 to 90 percent of all alerts issued in the United States (Partnership for Public Warning, 2003; Federal Emergency Management Agency, 2007; Government Accountability Office, 2009). There is no history of presidential alerts using IPAWS-OPEN predecessors such as the EAS, EBS, etc. This usage pattern is likely to continue for the foreseeable future. As a result, in practical terms, NWS adoption represents substantial WEA AO penetration for most emergency alerts throughout the country..

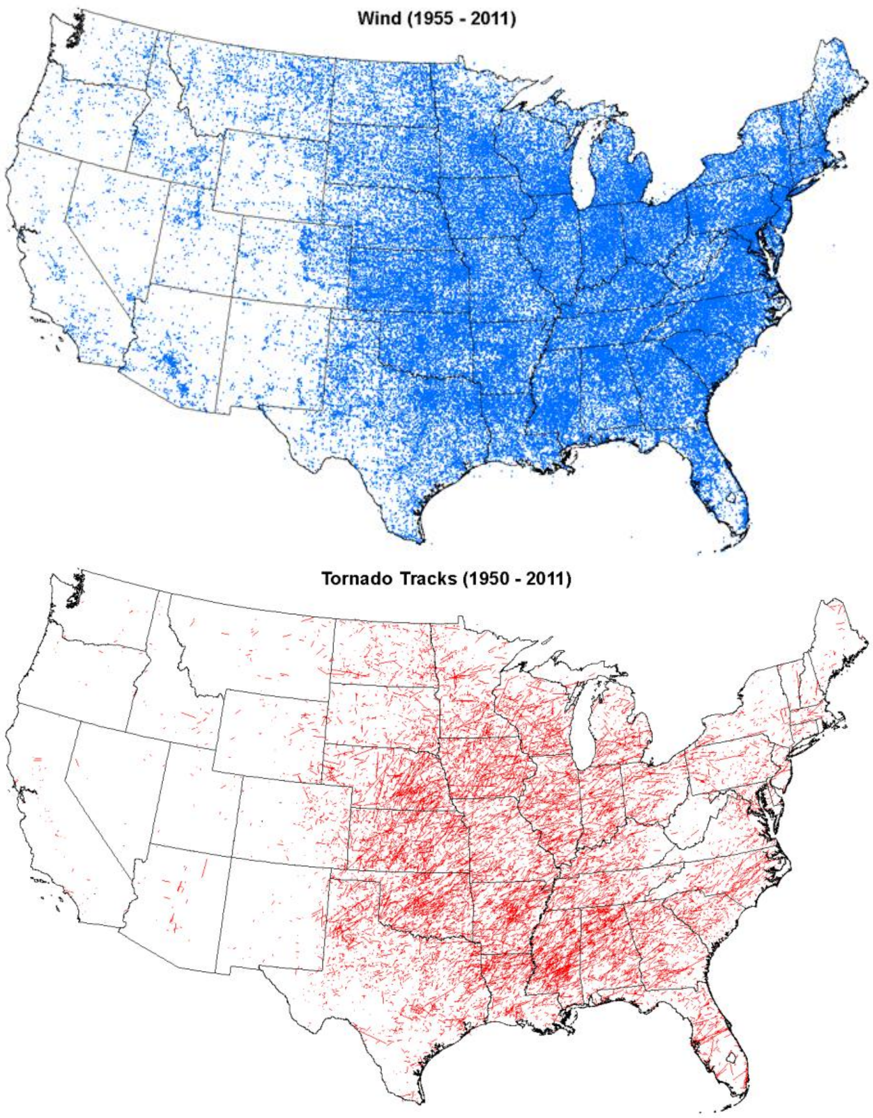
As of May 2012, the NWS is still finalizing its process for categorizing individual weather alerts as imminent threats according to WEA criteria. Until its process for doing so is in place, only a subset of severe weather alerts will be sent from NWS to WEA. The NWS has identified a subset of their warnings that will initially be designed to be transmitted through WEA. They are warnings associated with tsunamis, tornados, extreme wind events, flash floods, hurricanes, typhoons, blizzards, ice storms, lake effect snow, and dust storms (NWS, 2012). Future improvements to NWS systems are expected to allow forecasters finer granularity in grading the severity and imminence of weather events to calibrate which warnings go out through the system (NWS, 2012). This is an important policy decision, since it affects the volume of warnings that WEA may issue in a geo-targetable area and therefore stress the capacity of various system components and affect message fatigue. The adoption issue is discussed in chapter 8.

Figure 4.1 shows historical data for two of these categories of warning, tornados and extreme wind, to illustrate their geographic distribution. Such warnings are not

[16] Additional methodology information is available in Chapter Three.

uniformly distributed geographically. States east of the Rocky Mountains tend to have much higher numbers of such warnings.

Figure 4.1. Historical Distribution of NWS Alerts Likely to Use WEA



Source: NOAA, 2012.

Note: Title spelling corrected in tornado graphic.

At the State or Territorial Level

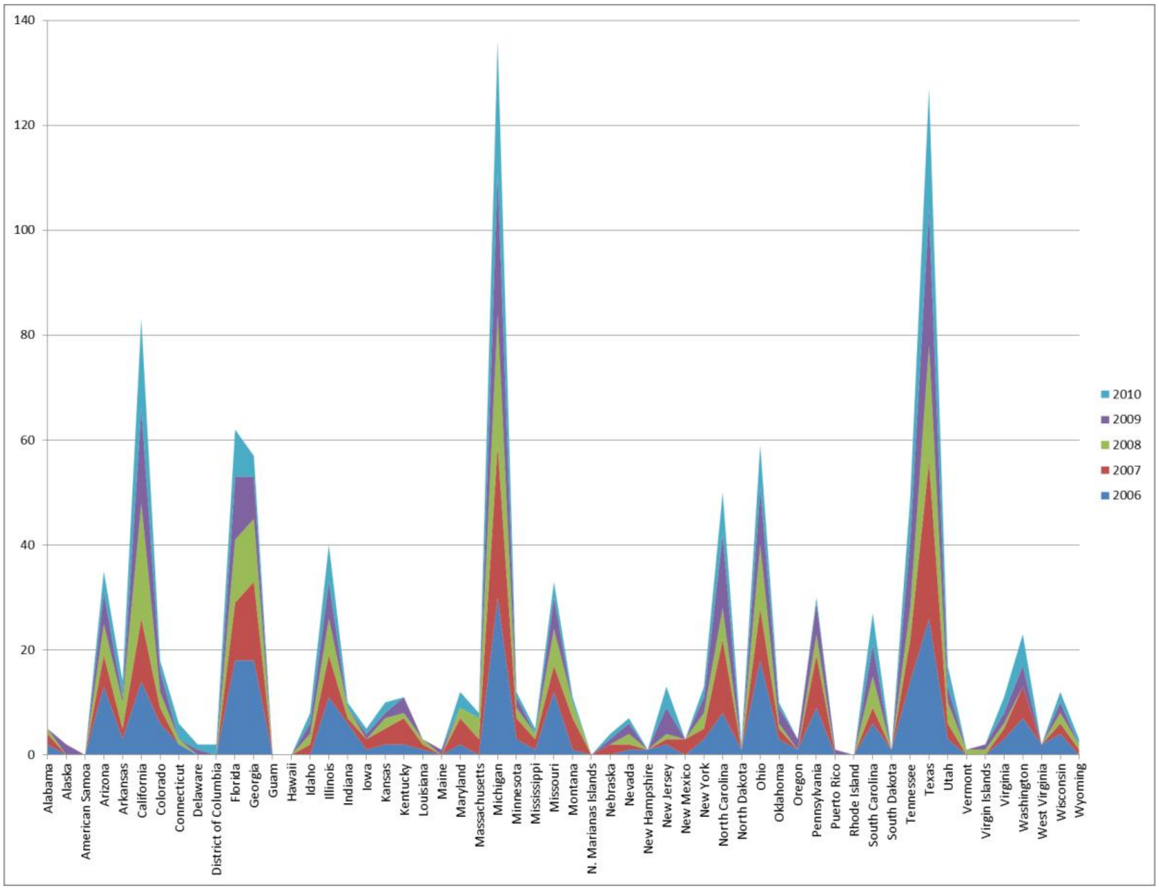
Unlike adoption of WEA at the federal level, where NWS represents the vast majority of alerting done across the nation, use of emergency alerting at the state or

territorial level (hereinafter “state”) varies considerably from state to state. The historical numbers of alerts issued by originators at the state level using the existing EAS system varies, with some states reporting that they never initiate such alerts at all. In outreach to state AOs, the highest estimate for usage by a state was less than 20 alerts per year (among the 20 states out of the larger group of states contacted who provided that information.) Most estimates were in the low single digits. This finding is similar to the only survey data available on this question, from a 2010 data call by the Texas Association of Broadcasters on EAS usage state by state (TAB, 2010).

Because of the change in capabilities provided by WEA, changes in use of emergency alerts could occur at the state level going forward. In our outreach efforts to state emergency management organizations (which were successful for 39 states), representatives expressing an opinion (20 of 39) split approximately evenly between those expecting (seven, yes; three, maybe) and not expecting (ten) changes in alerting behavior after implementation of WEA. Those expecting change suggested there could be significant increases in imminent threat alerts and warnings they issue because of WEA’s versatility compared with other warning systems. In these outreach efforts, information was also sought whether stakeholders believed there would need to be significant changes in alerting procedures as a result of the new capabilities provided by WEA. Only a subset of the 39 states provided insights on this issue, but of those that did (19 of 39), the majority felt procedural changes will or might be needed (seven, yes; eight, maybe; four, no). Concerns about public message fatigue drove concerns about alerting procedures, with a perceived need for improved coordination and control of warnings to avoid that phenomenon. In contrast to the view that WEA could increase use of alerting, the greater capability to geo-target messages and, therefore, reduce the alerting of unaffected areas and cut alert overlap could help address concerns about over-alerting and message fatigue.

AMBER alerts seek public help in stopping a child abduction-in-progress and include transmission of information on the abductee, suspect(s), and other relevant data. Though initiated locally, AMBER alerts are frequently coordinated and issued through state-level law enforcement. Figure 4.2 shows the historical pattern of how AMBER alerts have been distributed between 2006 and 2010. Some states use AMBER alerts significantly more than others. The highest usage was 136 times over the last five years (Michigan), while the low was zero. The average usage was approximately 19, and the median state issued nine AMBER alerts during that five-year period.

Figure 4.2. Distribution of AMBER Alerts



Source: AMBER Alert Reports, National Center for Missing and Exploited Children, 2006–2010.

In some states, there are few, if any, EAS or AMBER alerts. As a result, based on historical alerting data, the practical importance of any specific state's adoption of WEA for originator penetration varies within a relatively narrow range.

As of the end of May 2012, at the state level, FEMA identified nineteen states that were either authorized or seeking authorization to disseminate alerts via IPAWS-OPEN (FEMA, 2012). This connection is necessary to use WEA, but authorization to use it is not sufficient evidence to indicate it will be used, since an IPAWS-OPEN connection might be sought for other purposes. Based on information from stakeholder outreach efforts, there is reason to believe that this was the case for at least one state that was going through the connection process at the time of WEA initial capability. Using progress through this process as a measure, about 34 percent of the states were approved or were pursuing the server connectivity necessary to send WEA messages as of May

2012. Table 4.1 lists the states that were authorized WEA AOs or were seeking authorization for connection to IPAWS-OPEN as of initial capability.[17]

Table 4.1. States Authorized, or Seeking Authorization to Disseminate Alerts via IPAWS-OPEN

Authorized	Seeking Authorization
Hawaii	Alaska
Kentucky	Arizona
Maryland	Idaho
Colorado	District of Columbia
Florida	New York (Three Organizations)
New Jersey (State Police)	Georgia
Minnesota	North Carolina
Maine	Pennsylvania
	Tennessee
	Virginia
	West Virginia

Source: FEMA, 2012.

Adding information gathered from open sources and outreach to the FEMA data made it possible to characterize each state as falling into one of four categories:

- *Almost certain adopter*: When state representatives reported planning to adopt WEA or available public data showed an unambiguous intention to adopt.
- *Possible adopter*: When state representatives indicated that adoption was being considered or was "likely," or a state was going through the FEMA process to disseminate alerts via IPAWS-OPEN but no WEA-specific information was available.
- *Non-adopter*: When a state contact indicated that WEA would not be adopted by the state.
- *Unknown*: When no data could be obtained on the state or when all individuals from the state lacked sufficient information on WEA to project adoption intentions.

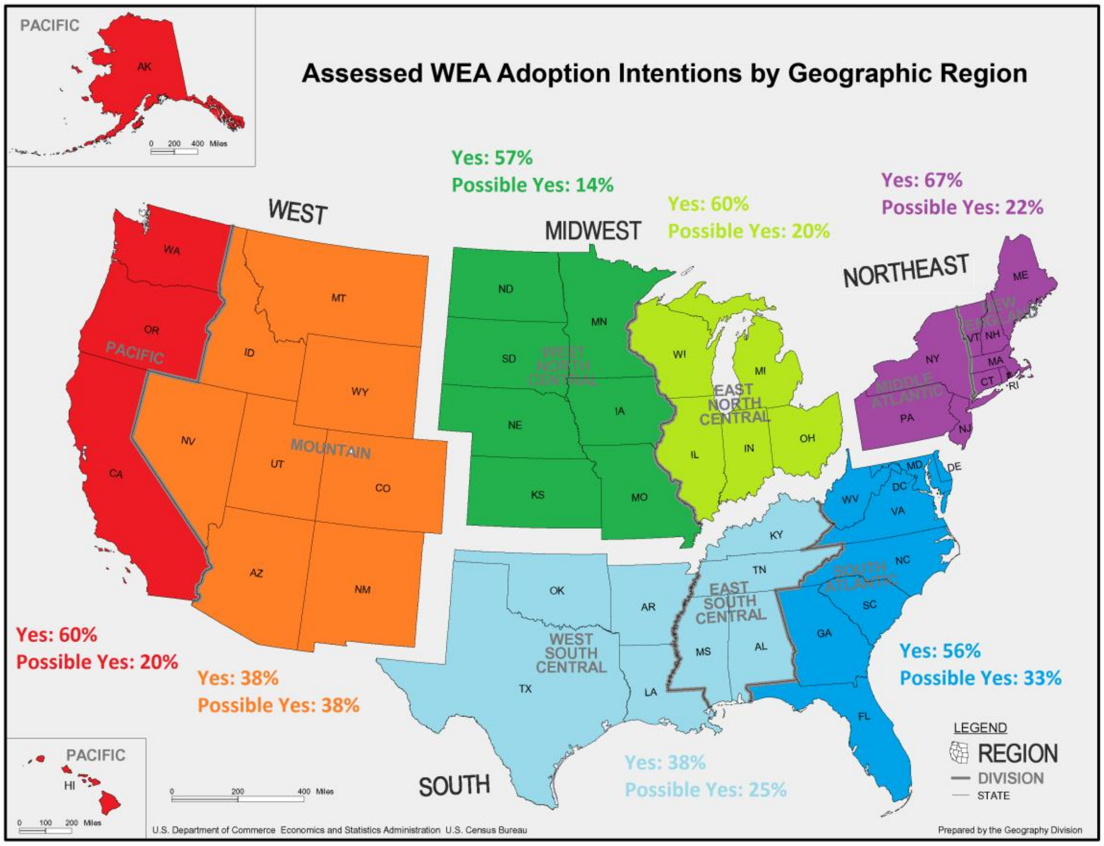
[17] For comparison, by mid-August 2012, this number had jumped to 29 states either approved or going through the process, accounting for just over 50 percent of the total.

Using these four categories, as of WEA initial capability almost three-quarters of states fell into the categories of almost certain or possible adopters of WEA. Of the 43 states for which information was available, 50 percent (28) indicated almost certain adoption and 23 percent (13) were possible adopters. Only two states indicated that they would not adopt (4 percent). The remaining 23 percent (13) of states fell in the unknown category.

Using the regions of the country as defined by the U.S. Census Bureau[18] to break down the states that said they were non-adopters or states whose adoption status could not be assessed (a total of 15 entities), three were Midwestern, two were in the Mountain region, one was in the Pacific region, one was in the South Atlantic region, three were South Central states, four were territories, and one was in the Northeast. Figure 4.3 presents the variation of states assessed as likely adopters by region of the country.

[18] See http://www.census.gov/geo/www/us_regdiv.pdf. To maintain non-attribution as promised to the individuals, questions dealt with state-level adoption intentions, and data were not broken down below a region or sub-region containing fewer than five states.

Figure 4.3. Summary of State-Level Alert Originator WEA Coverage from Stakeholder Outreach



Note: Base map prepared by the U.S. Census Bureau and downloaded from http://www.census.gov/geo/www/us_regdiv.pdf. Subsequently modified, colored, and annotated.

Regions vary somewhat in the percentage of states that appear likely to adopt WEA, with the lowest values in the U.S. territories (not shown in Figure 4.3, where only one of five territories is known to be adopting), the West, and in the South Central states. However, the central driver of the difference is states whose WEA adoption intentions are unknown. This is because state-level officials were not sufficiently aware of the system or because data on their intentions could not be obtained. Only two states/territories were *not* planning to use WEA for alerting at the time data were gathered. At the state level, the data therefore suggest substantial immediate and near-term penetration of WEA among AOs below the national level. A substantial number of the states included in the

almost certain adoption category were already going through the FEMA approval process to use the system at initial capability.[19]

At the County Level

Understanding the extent of originator penetration at the sub-state–level is complicated by differences in the administration of emergency alerts in different states. Though in some states authority to issue alerts is devolved to the county-level[20] (and therefore a full understanding of AO penetration would need to consider the fraction of those counties that adopt WEA), in other states, alerts—even those targeted at single counties—go through state emergency management or law enforcement organizations for reasons of either practicality or policy. As a result, in some states, the concept of county-level adoption of WEA is not a meaningful measure of penetration of the system. Some practitioners spoke on this issue: 10 of the 33 states providing information did not allow localities to originate alerts through the EAS system. However, in other states where alerting authority is devolved to the county or below, availability and use of the system at that level is both relevant and of interest.

As was the case for the state level, the use of the EAS by counties is relatively rare. The only known data relating to this issue are from the Texas Association of Broadcasters (TAB) survey (2010) cited previously, which reports state-level estimates of local-level use. Those estimates spread across a wide range but average in the low single digits. Assessing the use of emergency alerting more generally by county-level agencies is more difficult, since there are a variety of commercial systems (both free and paid) that county government and response organizations use to alert the publics they protect. Others' analyses suggest penetration of these alternative systems is quite broad: in data collected for FEMA for the IPAWS-OPEN Inventory and Evaluation between 2009 and 2011, approximately half of counties reported using emergency telephone-based alert systems (CACI-NSR, 2011). They include systems such as reverse-911 (telephonic systems that call all the phone numbers in a geographic area), social media tools, email, and SMS-based alerting systems, and others.

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[19] This conclusion is supported by the subsequent jump in states connecting to IPAWS-OPEN in the months since initial capability, which increased to 29, or just over 50 percent, by mid-August 2012.

[20] Or other relevant sub-state political or administrative units, hereafter "counties."

FEMA identified 35 counties that were either authorized or seeking authorization to disseminate alerts via IPAWS-OPEN as of May 2012 (FEMA, 2012). These counties appear in 17 states. At the time of initial capability, about 1 percent of the 3,141 counties in the United States was connected to or preparing to disseminate alerts via IPAWS-OPEN (OMB, 2008).[21] Table 4.2 describes the counties that were authorized to disseminate alerts via IPAWS-OPEN or were seeking authorization to do so.[22]

Table 4.2. Counties Authorized or Seeking Authorization to Disseminate Alerts via IPAWS-OPEN

Authorized	Seeking Authorization
Ashtabula County, OH	Alachua County, FL
Contra Costa County, CA	Manatee County, FL
Daviess County, KY	Pinellas County, FL
Kenai Peninsula Borough, AK	Seminole County, FL
Sedgwick County, KS	Delaware County, IN
San Diego County, CA	Geauga County, OH
Siskiyou County, CA	Grant County, IN
Miami-Dade County, FL	Jackson County, IN
Wayne County, IN	Jay County, IN
Madison County, KY	Johnson County, IA
Cecil County, MD	Lexington-Fayette Urban County, KY
St. Mary's County, MD	Ohio County, KY
Camden County, MO	Atlanta-Fulton County, GA
Teton County, WY	Madison County, IN
	Brunswick County, NC
	New Hanover County, NC
	Mercer County, NJ
	Salem County, NJ
	Waco-McLennan County, TX
	Fairfax County, VA
	Dane County, WI

Source: FEMA, 2012.

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[21] By mid-August, the count had jumped to 83 counties, accounting for more than 2.6 percent of the 3,141 counties in the country.

[22] Based on data collected through contacts with potential AOs, it is our understanding that at least one of these counties illustrates the case of an agency seeking to disseminate alerts via IPAWS-OPEN that does not plan to use that connection to initiate WEA messages. Connection to IPAWS-OPEN can be used to exchange messages among organizations (i.e., not for public alerting).

Outreach efforts to state-level AOs sought to identify any insight they had at the time on the WEA adoption intentions of the counties in their state. Most did not have much information on the adoption intent of entities below the state level, even though connection to IPAWS-OPEN by those counties would require state-level approval to verify their alerting authority. When contacts were aware of counties with the intent to adopt, such counties numbered in the low single digits. A small number of states were planning extensive efforts to encourage local-level adoption, with goals of large fractions or even all of the counties in the state being able to use WEA.

Available data therefore suggest that sub-state adoption of WEA will be modest initially, with the exception of states where there are concerted efforts to inform, assist, or incentivize counties to adopt. However, in states where counties (or equivalents) are not authorized to issue alerts, the lack of such adoption says less about WEA penetration than it does about different models for managing alerting across the country (e.g., in a state where counties must issue traditional EAS messages through the state and a similar model will apply to WEA, those counties will be "covered" by WEA, even though they may not achieve the full benefit of being able to issue wireless alerts rapidly within their protected jurisdiction).

In more general outreach at the National Homeland Security Conference,[23] 17 individuals who identified themselves as representing a county-level organization (from both emergency response and emergency management agencies) provided some insight into county-level penetration of WEA. Of those 17, only slightly more than half (nine) were aware of WEA at all. Of those who were aware of the system, two-thirds indicated their county planned to adopt the system.

Available data suggest relatively modest initial penetration of WEA at the county-level, with exceptions for states that are actively promoting adoption within their state. Because historical use of emergency alerts at the county level using the traditional EAS system is relatively limited, slow adoption by counties has a relatively small effect on overall penetration of originators of all alerts, as was the case at the state level. For counties that currently use other tools for alerting, to the extent that WEA becomes a viable replacement for such systems, there could be both financial and other drivers that provide incentive to adopt. As a result, though indications are that initial adoption below the state level is likely to be modest, adoption can be expected to expand as more county-

[23] See additional description in Chapter Three.

level emergency practitioners become aware of the system. The speed of penetration at the county level will be shaped by whether and how rapidly barriers to that adoption (discussed below) are lowered or removed.

At Other Governmental Levels

Although the current WEA system requires that CMSPs be able to geographically target alerts to areas as small as U.S. counties or county equivalents (47 CFR §10.450), entities other than states and counties can and are pursuing connectivity to IPAWS-OPEN. At the time of WEA initial capability, several cities were pursuing adoption, but other entities, including regional or multi-jurisdictional organizations, could do so as well.

As discussed above with respect to counties, some cities use other systems (e.g., telephonic, SMS, email) as alert mechanisms to inform the populations they protect, which WEA could eventually replace.[24] The limited availability of information on the use of alerting at the very local level makes it impossible to make a credible estimate of the extent of alerting by entities in this echelon.[25]

At the time of WEA initial capability, FEMA identified five cities that were either authorized or seeking authorization to disseminate alerts via IPAWS-OPEN (FEMA, 2012). These five cities appear in five states. Though three of the cities currently going through the process fall in the top 1,000 U.S. cities by population, two do not. As a result, the fraction of potential metropolitan/city AOs that were pursuing connectivity to IPAWS-OPEN fell well below 1 percent of the total possible population. Table 4.3 describes the cities that were authorized to disseminate alerts via IPAWS-OPEN, or were seeking that authorization as of May 2012.[26]

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[24] Existing alternative systems provide a range of capabilities, only a subset of which could be replaced by WEA. Different AOs could come to different conclusions about replacing a legacy system with different capabilities and cost than WEA.

[25] The CACI-NSR collected data referenced previously went down to the county level.

[26] By mid-August 2012, this had increased to 15 cities either approved or pursuing approval to disseminate alerts via IPAWS-OPEN.

Table 4.3. Cities Authorized or Seeking Authorization to Disseminate Alerts via IPAWS-OPEN

Authorized	Seeking Authorization
City of New York, NY	City of Kirby, TX
	City of Dyersburg, TN
	City of Alexandria, VA
	City of Lansing, MI

Source: FEMA, 2012.

At the National Homeland Security Conference, 68 individuals who identified themselves as city-level emergency managers or response practitioners provided some insights into their cities' intentions with respect to WEA. Of those 68 people, 41 were unaware of WEA, and therefore had no defined intentions with respect to system adoption. Of the 27 that were aware of the system, ten indicated their city planned to adopt the system.

Of the 68 people, 31 of them duplicated the city affiliation of another respondent (e.g., two or more people from a single city) even though they might not represent the same response or emergency management organization. However, of the ten people who reported that their city was planning to adopt, there was no duplication. Because only a small number of local individuals were contacted and those contacts were made in an opportunistic fashion, it was not possible to generalize to the larger population.

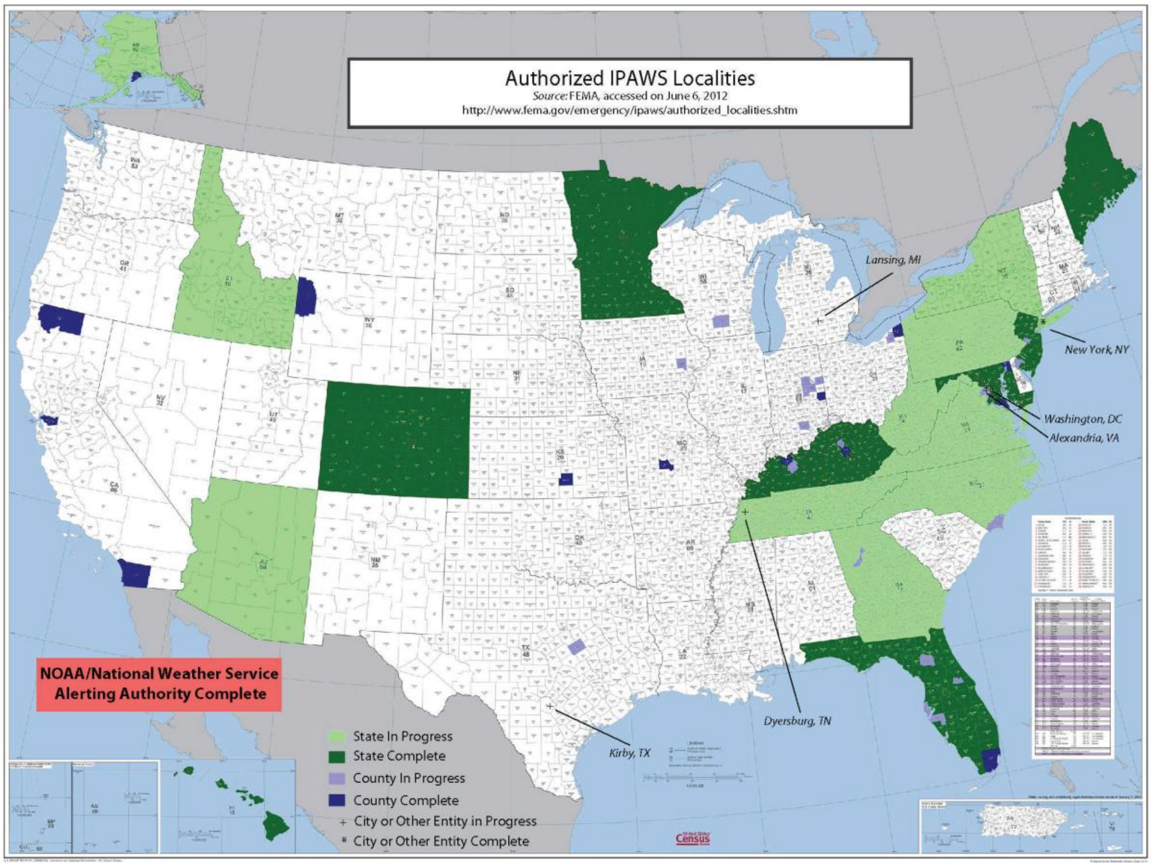
Summary of Alert Originator Coverage

Figure 4.4 illustrates the sub-national (i.e., organizations below the national level) AOs authorized to, or seeking authorization to disseminate alerts via IPAWS-OPEN as of WEA initial capability. While the assumption is that such a connection signals WEA adoption, there are at least two instances (at the state and county level) where it does not appear to do so. The states that have authorization to access IPAWS-OPEN are shown in dark green. The states that are seeking authorization are shown in light green. The counties granted authorization to use to IPAWS-OPEN are shown in dark blue, and the ones seeking authorization are shown in light blue. A city or other local entity authorized to disseminate alerts via IPAWS-OPEN is designated with an asterisk, and the ones seeking authorization are designated with a plus sign.

Based only on these data as a measure of AO penetration, there was a modest number of sub-national AOs (i.e., AOs at the state, county, city, or other non-federal

levels) as of May 2012 —though based on insight gained in outreach to AOs, there was broader intent to adopt the system as time passed.[27]

Figure 4.4. Summary of Sub-National Alert Originator WEA Coverage



Note: Base map prepared by the U.S. Census Bureau and downloaded from http://www.census.gov/geo/www/maps/us_2010_st_cou_wallmap/us_stcou_2010_wallmap.html. Subsequent modifications, coloration, and annotation based on FEMA, 2012.

Issues and Adoption Barriers Raised by AOs

The focus of this penetration strategy is to promote the adoption and use of WEA to achieve the greatest benefit for the resources devoted to the development and implementation of the system. To do so, understanding barriers to adoption—in this case

[27] The increase in entities going through or completed the approval process for access to IPAWS-OPEN between WEA initial capability and mid-August 2012 (during which the total count more than doubled) supports this conclusion.

for AOs at the state, county, and local levels—is a necessary first step. Though adoption at the state level appears likely to increase over the midterm timeframe, available information on adoption intentions below the state level (both from direct interactions with local representatives and indirect information from state-level emergency managers) suggest a slower rate of adoption.

From discussions with state-level contacts, it was clear that there is some uncertainty about the process of WEA adoption—e.g., questions about state-level approval of local applications for alerting authority—and that many states are early in the process of considering the system and developing their processes associated with it. Other states cited “network effects” as the cause their hesitancy to adopt WEA. These states do not want to adopt WEA until they are certain local CMSPs and devices are delivering and receiving WEA messages. Concern about such network effects may resolve over time as initial use of the system by the NWS, as a frequent nationwide AO, demonstrates the functionality of the system in a skeptical originator’s local area. These sorts of “bumps in the road” are unsurprising and will likely smooth out as states develop their processes and approval/connection to the system becomes regularized over time. However, more significant potential adoption barriers for WEA exist that will persist over time if steps are not taken to deal with them.

WEA awareness is an important first barrier. No matter how attractive a new technology or system might be, if potential adopters are unaware of it, they will not take steps to acquire and use the capability. WEA awareness is limited, particularly below the state level. Though relatively few of the individuals specifically identified based on their involvement in emergency alerting were unfamiliar with WEA, those more generally focused (i.e., attendees of the National Homeland Security Conference in late May 2012) were much more likely to be unaware of the system and its rollout. There was also a relatively general belief expressed by state-level contacts that knowledge of the system among emergency managers and practitioners at the local level in their states was limited (which they attributed to shortfalls in information sharing and public information efforts at the federal level). This is consistent with the results of contacts made at the National Homeland Security Conference, where more than half of practitioners and emergency managers at the county or city levels indicated that they were unfamiliar with WEA.

Among those who are aware of the system, it is notable that there are many misperceptions about WEA. Some misperceptions are explained by confusing the features that are incorporated in WEA as of April 2012 (WEA 1.0), and features that are planned for a future release of WEA (WEA 2.0). The misperceptions expressed included

- WEA is (currently) multi-lingual—WEA is not multi-lingual in the current version (1.0)
- WEA is SMS-based—WEA is a broadcast service, not a point-to-(multi)point SMS
- WEA requires a CMSP subscriber data connection—WEA does not, it requires only a subscription to a CMSP voice service.

To the extent that these misperceptions make WEA appear less advantageous compared to other alerting options (which some states and counties have in place already), they represent important factors that could push potential adopters away from doing so.

Cost of WEA adoption is a perceived barrier. In a period when fiscal constraints at all levels of government are broadly recognized, it is not surprising that costs associated with adopting WEA—including acquiring appropriate software or other equipment for alert origination compatible with IPAWS-OPEN—was prominently mentioned as a barrier to adoption. More than a third of the state-level contacts cited cost as an issue for their state-level adoption of the system, and cost was similarly identified as a potential barrier for localities. The effect of cost at the state level was not uniform—some states told us that cost was not an issue. In a few cases, state emergency management organizations planned to or had already purchased software licenses to allow localities to use WEA—essentially removing one element of cost as a barrier to their adoption. Other costs beyond software acquisition that were cited in our discussions were costs associated with forming and gaining approval for COGs to disseminate alerts via the IPAWS-OPEN system and to maintain training for staff. One expressed concern is that the state-level cost of adopting WEA may go well beyond connecting a state emergency management agency to IPAWS-OPEN. State costs will also include "managing" local COG applications using WEA. It is important to note that the state responses listed above are qualitative statements and should not be considered as statistically valid conclusions that can be applied to all states.

Nevertheless, initiatives can be created with the goal of reducing WEA adoption costs and to broaden WEA adoption by alert originating organizations. However, it should be noted that the costs associated with adopting WEA include not only "upfront" costs to acquire compliant software systems, staff time required to set up a COG, and resources to acquire training, but also year-on-year maintenance costs for software licensing (if commercial products are used) and the cost of maintaining staff that is trained to use the system.

The limited functionality of WEA 1.0 is a perceived barrier. Conversations with individual state representatives and participants in the WEA Forum at the National Homeland Security Conference also surfaced concerns about perceived limits in the functionality of WEA 1.0 and whether those limits would be a disincentive to adoption.

- The ***granularity of geo-targeting*** was a frequently cited issue that represents an adoption barrier for many—particularly large counties in western states. Counties that cover large regions are concerned that the county-level granularity of geo-targeting of WEA (as of April 2012) will result in broadcasts of alerts (e.g., weather alerts) that are irrelevant to most county residents. This could result in message fatigue and lead to CMSP subscribers opting out of WEA. Given the relatively broad penetration of telephonic tools for local alerting (e.g., reverse 911 and other systems) discussed above, the geo-targeting available from WEA is actually coarser than currently available to some AOs. Though the technologies underlying WEA potentially provide advantages for reaching larger populations more rapidly than existing SMS- or telephone-based alerts, a perception that WEA is less targeted would nonetheless represent a barrier to adoption by originators with existing alerting systems in place.
- "Border issues" were also a concern given the possibility for broadcasts from towers near the border of one county to transmit to devices in the adjacent one. Counties and states that border Mexico and Canada are concerned about the lack of international coordination for WEA. They note, for example, that Canada is planning to roll out a WEA-like capability in 2015. They do not understand how WEA will interoperate with such international systems.
- Concern about the ***90-character limit for WEA messages*** was raised by a number of AOs. For example, some questioned whether it would be possible to include all the detail needed for an effective AMBER alert in 90 characters. One originator said explicitly he expected to have to send multiple WEA messages for each AMBER alert to transmit the necessary information.
- Cities, counties, and states expressed a ***desire to be able to test WEA locally***, particularly, the message structure and content. This test capability is not provided in WEA as of April 2012. These AOs and emergency managers (Ems) foresee the need to test surge capacity and robustness in both WEA and CMSP networks. They are concerned about how the system will perform when multiple events happen concurrently (at the local level), and whether public

> responses to WEA messages may cause a surge in text and data traffic carried by CMSP networks. The public reaction to WEA and WEA messages is a significant worry that can be reduced by local testing.

Other adoption barriers that were raised by fewer originators included ***cyber-security*** concerns, and ***cross-jurisdictional or cross-agency coordination*** issues.

Some originators were concerned about the ***extent of adoption by network providers*** in their area to transmit messages and of devices to receive them. Though posed in general for all providers in their area, this concern was also raised for specific subsets of CMSPs: In April 2012, the research team found no evidence of current or future planned support for WEA among MVNO-based CMSPs. State and local AOs and EMs note that significant portions of their target populations are comprised of pre-paid MVNO subscribers, who tend to be from low-income populations. These AOs and EMs want to understand how WEA plans to reach such populations so that they can make informed decisions about the value of using WEA rather than other alternatives (such as reverse-911 services). As information is made publicly available about carrier adoption of WEA and resulting coverage, this concern about capability should be resolved.

Concerns about over-alerting are a barrier. Throughout the concerns raised regarding WEA adoption, the issue of over-alerting the public, and leading to citizen frustration and individuals opting out of imminent threat warnings was a common thread. This concern extends beyond AOs to other organizations, including the FCC, FEMA, and wireless carriers. Insufficient geo-targeting will deliver warnings to people who do not need them, and sending multiple messages to deliver complete information for an incident runs the risk of the public feeling bombarded by the system. Though some originators spoken with were excited about the potential for the system to make alerting more effective and to be an important tool in their toolbox for protecting the public, there were reservations about the need to "be careful" of what alerts were sent and by whom to reduce the chance of overuse.

Given its dominance as an AO, for many this was a concern focused on the NWS's use of the system, and whether weather alerts, particularly those that were sent in the middle of the night, would lead to many subscribers to opt out and that the long term utility of the system would be sacrificed. Beyond NWS efforts to be selective in their use of WEA (e.g., the decision not to send severe thunderstorm warnings to the system out of concern that doing so initially would create too many alerts), the potential for NWS-generated WEA messages to cause message fatigue should be monitored over the next several years and as public reactions to it are assessed in practice.

Summary of issues and barriers. Overall, the state, county, and local buy-in to WEA seems to fall short of what is needed to achieve the national alerting capability WEA is designed to provide. Knowledge of the system among response organizations appears to be limited, and where it does exist, there is confusion about what WEA is and how it differs from alternative distribution channels for local alerts. There is also an apparent lack of WEA awareness by elected officials responsible for emergency management, fire, and police based on information gathered in outreach efforts. Their lack of awareness and support is also a barrier for local responders seeking to make use of WEA. Without awareness of the system and its current capabilities, adoption—particularly below the state level—will be impeded.

Beyond issues of WEA awareness, practicalities and performance concerns about WEA in its initial configuration represent additional impediments. Cost was cited by many stakeholders as a concern, though to the extent that potential adopters are currently paying to provide alert capability in their area (e.g., through a dedicated vendor system) adoption of WEA might create cost savings that would spur adoption by that subset of entities. Similarly, to the extent that IPAWS-OPEN connectivity and alert origination functions are integrated into systems that are already in use by emergency management and response organizations, cost could become less of an initial barrier. Questions about the functionality of the system—notably the argument that geo-targeting at the county level is not small enough to be of practical use in many situations and locations—are potentially more serious issues that will shape adoption over a longer term.

5. Estimated CMSP Coverage

The last chapter described the coverage of the AOs at various levels. This chapter turns to the coverage among CMSPs. It begins with a short description of the entities that provide mobile cellular coverage in the United States. It next reviews the trends in CSMP adoption. It then estimates the mobile phone voice coverage in the United States and the WEA coverage. The chapter concludes by discussing the issues surrounding adoption and potential barriers limiting adoption.

Overview of Commercial Mobile Service Providers in the United States

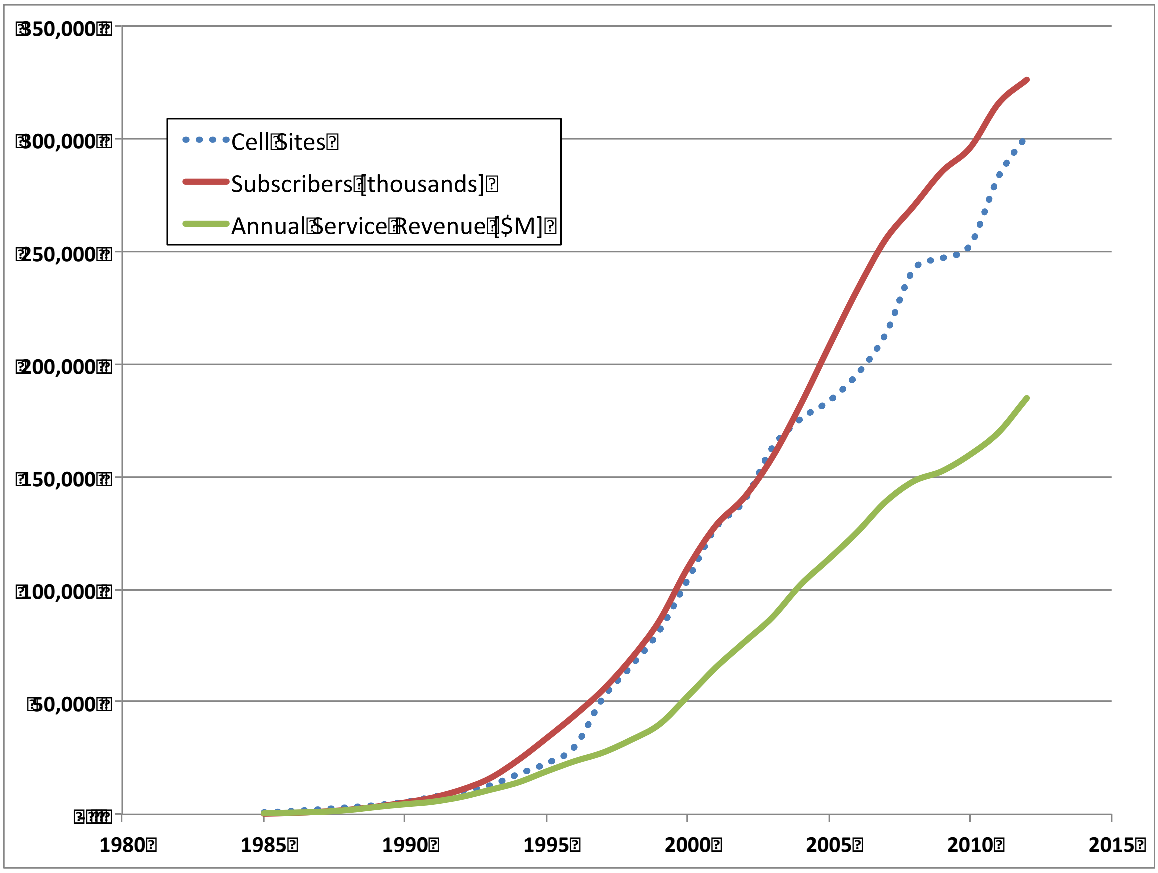
The cellular telephone market is served by hundreds of CMSPs, each with their own coverage areas, service plan options, and line-up of devices. U.S. CMSPs are generally divided into three tiers, based on coverage areas and number of subscribers.

Four Tier I CMSPs have nationwide coverage and have the largest number of subscribers:

- Verizon Wireless, with approximately 100 million subscribers (Verizon, 2012a)
- AT&T, with approximately 100 million subscribers (AT&T, 2012a)
- Sprint Nextel, with approximately 55 million subscribers (SPRINT, 2012)
- T-Mobile USA, with approximately 30 million subscribers (T-Mobile, 2011).

Commercial mobile service has been growing rapidly in the United States, and Figure 5.1 illustrates the explosive growth that has occurred since the mid-1990s.

Figure 5.1. Development of the U.S. Cellular Telephone Market from 1985 to 2012



Source: CTIA, 2012.

The participation of the Tier I CMSPs is important for the success of WEA because they provide coverage for a large percentage of the U.S. population, including the residents of all major metropolitan areas in the United States. If a single Tier I carrier were not to participate in WEA, then WEA would not be available to a significant fraction of the U.S. population.

Smaller in size, Tier II CMSPs focus on regional markets or specialized business models and include the following companies:

- Alltel
- C Spire (focusing on the Southeast)
- Claro (Puerto Rico only)
- ClearWire
- Cricket (owned by and using the network of Leap Wireless)
- MetroPCS (focusing on metropolitan markets)

- U.S. Cellular

Hundreds of Tier III CMSPs, defined as having fewer than 500,000 subscribers, mainly serve rural markets. Most Tier III CMSPs operate in rural areas or states with relatively small populations. Some Tier III CMSPs provide coverage over relatively large unpopulated areas in Alaska or the Midwest.

Of note, there are at least 40 CMSPs that operate as MVNOs[28]—they operate online or physical retail storefronts and have their own lines of branded devices, but they do not own or operate any cellular network infrastructure. Instead, they have agreements with other CMSPs to allow their devices to operate on the licensed CMSPs' networks, in exchange for usage fees.

Another distinction exists at the retail level. This distinction provides some insights into the factors that cause turnover of cell phones (and adoption of new phones more likely to have WEA compatibility). Most CMSPs operate on the subscription model, where a customer contracts for cellular service for a certain period of time (frequently two years), with required monthly service payments that cover a basic allowance of air time, additional billing for any air time overages, and penalties for early contract termination. Intuitively, there should be a propensity to upgrade phones at the end of a subscription, since the cost of the phone is heavily subsidized by the subscription. Some CMSPs offer "prepaid" services, exclusively or in addition to their subscription-based plans, where customers buy a certain amount of airtime ahead of time, and then are free to use these minutes whenever needed, without monthly service payments. Intuitively, such customers are probably more price sensitive and therefore likely to replace their cell phone after a longer period of time, slowing the replacement rate for phones that are not WEA-compatible. Chapter Six presents a detailed analysis of phone replacement rates.

Finally, two wireless network technologies currently dominate the U.S. cellular telephone market. While many U.S. CMSPs use the globally prevalent GSM standard, (European Telecommunications Standards Institute, 2011) others, including Verizon and Sprint, have implemented the CDMA standard (CDG, 2012) for their networks (Cellular Telecommunication Industry Association [CTIA], 2011b).

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[28] The largest MVNO operating in the United States is TracFone, which has 19 million subscribers as of December 2012 (TracFone, 2012). This means that it is the fifth largest "carrier" in terms of subscribers. But since it is an MVNO, it is not licensed as a CMSP and the WEA regulations do not apply.

Different technology is another distinguishing characteristic of the CSMPs. Consistent with FCC's longstanding policy to promote technological neutrality, it did not adopt rules governing the protocols that the CMSPs employ between the CMSP gateway and their internal network, as well as between the cell tower and the mobile phone. These interfaces are entirely within the control of the CMSPs, which are free to choose the alert transmission technology that best meets their needs. The FCC expects that this will allow the CMSP maximum flexibility to innovate and implement WEA cost effectively (73 FR 143, July 24, 2008). Most CMSPs have selected cell broadcast (Cell Broadcast Forum, 2012) as the preferred method for transmitting WEA messages.

Most GSM and CDMA network standards include the cell broadcast capability that will be used for most WEA messaging. However, some older networks will not support WEA messaging using cell broadcast. A few Tier I CMSPs and a number of smaller Tier III CMSPs still employ older network switching equipment in their networks. The prevalence of older networking equipment in Tier I networks is limited and affects coverage in only a few small areas. On the other hand, discussions with Tier III CMSPs indicate some CMSPs, especially those with limited financial capabilities, may have a wider deployment of older networking equipment in their networks. Some older network switches will not be upgraded to support WEA messaging. This limitation of older networks has been cited by some smaller CMSPs as to why they will not implement WEA throughout their entire coverage area. This is not expected to be a significant issue for larger CMSPs because the network equipment suppliers are more responsive to the larger quantities demanded by larger CMSPs. Thus, older switching equipment is a significant concern for some smaller (Tiers II and III) CMSPs.

The wireless industry has been moving to deploy advanced wireless networking systems that are more capable than current GSM- and CDMA-based networks. The wireless industry has converged on new 4G cellular telephone standards that will eventually combine both voice and data communications into one unified architecture—called the Long Term Evolution (LTE) network architecture. The data transmission standards for LTE have been finalized. The LTE voice and cell broadcast standards are still under development and are expected to be finalized soon (Ericsson, 2012). The Tier I CMSPs are or have committed to deploying LTE technology in their networks and devices, and many smaller Tier II and III CMSPs are also deploying LTE. (3GPP, 2012)

The current deployed version of LTE, Release 9, does not include cell broadcast capability, and therefore does not support WEA using cell broadcast. However, industry has committed to including cell broadcast capability in future LTE standards (ATIS,

2010). If the government desires to increase the number of characters or number of languages that can be carried in future versions of WEA, it would be beneficial if government representatives actively participated in the development of the LTE cell broadcast standard. Such representation could ensure that LTE evolves in a manner that maximizes the capability of the WEA system to serve the U.S. public in the future.

WEA Adoption Trends By CMSPs

In 2008, the FCC ordered all CMSPs to submit *Election Letters* declaring their intention to be fully, partially, or non-compliant with WEA, and provided a subsequent opportunity for CMSPs to revise or withdraw their declarations (FCC, 2008b). Declarations of full compliance were not required to detail rollout plans. Declarations of partial compliance were not required to detail areas of non-compliance or rollout plans. In the case of Tier I CMSPs (all of which declared partial compliance), several have sub-networks implemented with technologies incorporated by acquisition or merger, e.g., Sprint (iDEN) and Verizon (GSM). In these cases, portions of the network were deemed to be obsolete technology that would be replaced at some point (presumably with a WEA-capable technology such as a future version of LTE), and are the primary basis for a partial-compliance declaration.

Table 5.1 summarizes the WEA Election Letters filed by the CMSPs with the FCC as of initial capability (April 2012).

Table 5.1. WEA-Compliance of CMSPs Represented in FCC Election Letters

WEA Compliance	CMSP Tier		
	I	II	III
Non-Compliant	0	0	286
Partially Compliant	4	0	6
Fully Compliant	0	5	66

Source: FCC, 2012.

All Tier I and II CMSPs intend to be partially or fully compliant with WEA.

Using data from 2011 and 2012 enabled us to estimate of the rate at which CMSP WEA adoption decisions changed. During this time, 25 CMSPs opted into the WEA program, i.e., a CMSP that changed its election letter to withdraw its intention to be non-compliant and declare its intention to be fully or partially WEA-compliant. During this

same period, 41 CMSPs opted out of the program, i.e., a CMSP withdrew its intention to be fully or partially WEA-compliant and declared its intention to be non-compliant.

The CMSPs that opted in during this 2011–2012 period included many of the largest CMSPs that had previously elected not to implement WEA. The largest included Cellular South, with an estimated 700,000 subscribers (Memphis, 2007) and nTelos with an estimated 424,800 (nTelos, 2012) subscribers. Others included General Communications, Appalachian Wireless, and Alaska Communications.

About a third of the CMSPs that opted out during the 2011–2012 period have "paging," "answering," or "radio" in their company name, suggesting that there are 45 CMSPs in the United States that provide exclusively paging services. Table 5.2 presents a breakdown of the WEA elections for CMSPs deemed to be paging services. Approximately two-thirds, or 31, opted not to become WEA compliant. Of the 14 remaining paging only CMSPs, only twelve stated they intend to implement WEA fully.

Table 5.2. WEA Elections of Paging Company CMSPs

WEA Compliance	
Non-Compliant	31
Partially Compliant	2
Fully Compliant	12

Source: FCC, 2012.

Paging appears to a declining market in which the number of pager-equipped subscribers is falling. For example, AT&T, Sprint, and T-Mobile no longer appear to sell pagers, although Sprint is offering a smartphone with paging capability as a replacement for pagers (Sprint 2012). Consistent with this view, no pager offered for sale has been identified as WEA-capable. However, taking their FCC election letters at face value, a few paging companies appear to remain committed to implementing WEA.

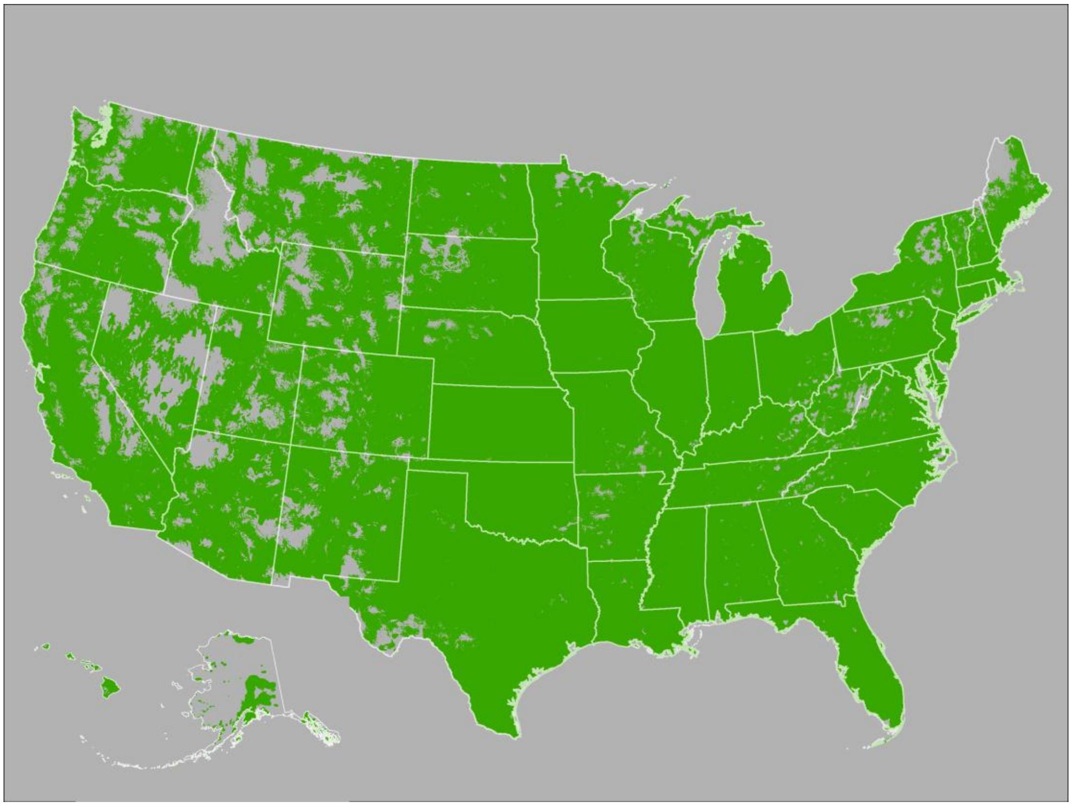
It should be noted that pager limitations were one of the reasons cited for not extending WEA geo-targeting to areas smaller than the county level (Hardman, 2008). If paging companies cannot effectively implement WEA because they lack WEA-capable paging devices, then this barrier to improved WEA geo-targeting accuracy would no longer be a valid reason to limit the geo-targeting accuracy of WEA.

Estimated National Mobile Phone Voice Coverage

WEA operates over wireless networks that are implemented by hundreds of CMSPs. Most wireless networks provide cellular telephone services (as opposed to paging or wireless internet, among other services). However, CMSPs may or may not own and operate their own network. Complex business relationships enable a CMSP to offer service under a different name (i.e., to "operate as") to extend the reach of a branded service, or to provide service as a MVNO (i.e., provide a branded service without owning and operating a cellular network).

Figure 5.2 shows the estimated national mobile device coverage. This figure aggregates all mobile phone voice coverage in the United States from all CMSPs, using any voice communications protocol. It is constructed from the polygons describing CMSP-advertised voice coverage areas in AR's data set.

Figure 5.2. Estimated Gaps in National Mobile Phone Coverage



Source: American Roamer, October 2011.

Green shows where there is at least one CMSP that provides voice coverage. Grey shows where no CMSP advertises voice coverage. These gaps are significant, since WEA coverage is not possible without cellular voice coverage.[29] CMSPs cover an estimated 77.8 percent of the nation's landmass. The estimated percentage of the population covered by at least one mobile device network is 99.5 percent.[30] This number is estimated by allocating the population of a census tract to the fraction of the census tract area that is covered by at least one cellular carrier's service (the green areas of Figure 5.2).

AR data are advertised coverage (rather than measured coverage). Depending on factors such as signal strength, geographic features (e.g., mountains), and interference from high-rise buildings, advertised coverage likely include some areas of poor or intermittent reception. Therefore, the green areas of Figure 5.2 likely include areas of poor or intermittent reception.

Estimated National WEA Coverage

In general, CMSPs are unwilling to share proprietary data describing the details of partial WEA compliance, or the rollout schedule for (full or partial) compliance. The estimate of WEA coverage makes two assumptions:

- WEA compliance is fully implemented by all CMSPs that have declared their intent to be fully WEA-compliant, i.e., no attempt is made to understand the timing of planned rollouts of technology in networks.
- Partial WEA compliance is represented by the full voice network footprint of the CMSP—no carrier is willing to provide a detailed picture of the portions of its network that will not be WEA-compliant.

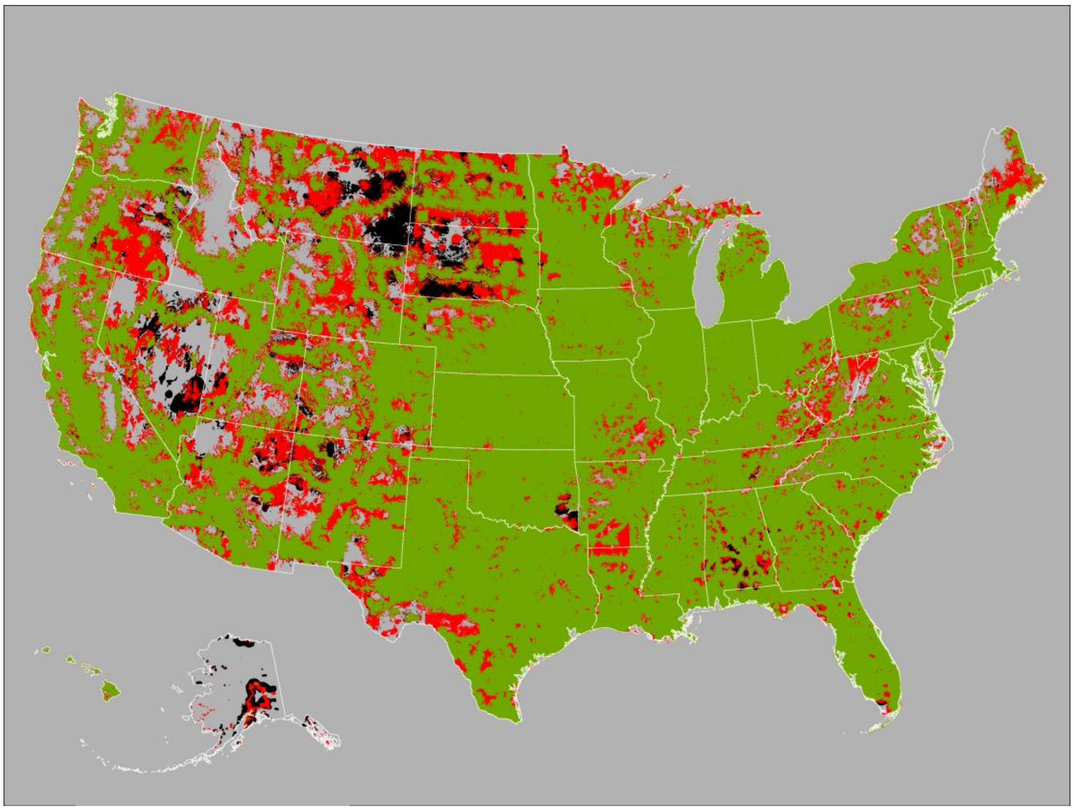
Thus, the estimate portrays what WEA coverage will be, not necessarily what it is at initial capability. These assumptions potentially overstate WEA coverage as of April 2012. Some Tier III CMSPs with the stated intention to be WEA compliant do not appear in AR's data and may offset this overestimate.

[29] AR's dataset may not include some Tier III carriers operating in these regions. This may overstate the gaps in RF coverage.

[30] AR's data set may not include some Tier III CMSPs. This may understate the covered population.

The following discussion examines the availability of WEA-compliant carrier coverage on a geographic basis. Admittedly, the mere existence of a WEA-compliant CMSP in a particular geographic location is only one of a several factors that are needed to successfully transmit a WEA message from an AO to a mobile device. The remaining factors are discussed in the following chapters.

Figure 5.3. Estimated WEA Coverage Areas



Source: American Roamer, October 2011.

Grey areas in Figure 5.3 show areas with no voice coverage, and therefore, no WEA coverage. Black portrays areas with voice coverage, but no WEA coverage (i.e., no CMSP in AR's data has declared its intention to fully or partially implement WEA). An estimated 22.2 percent of the landmass, and the 1.6 million people living in these two regions, has no mobile device coverage whatsoever, and therefore no access to WEA messages. The estimated landmass covered by one or more non–WEA-compliant cellular services is 4.6 percent. An estimated 330,000 people living in these regions have access to mobile device services, but cannot receive a WEA message. The difference between these two views (4.6 percent of the landmass, and roughly 330,000 people) is the

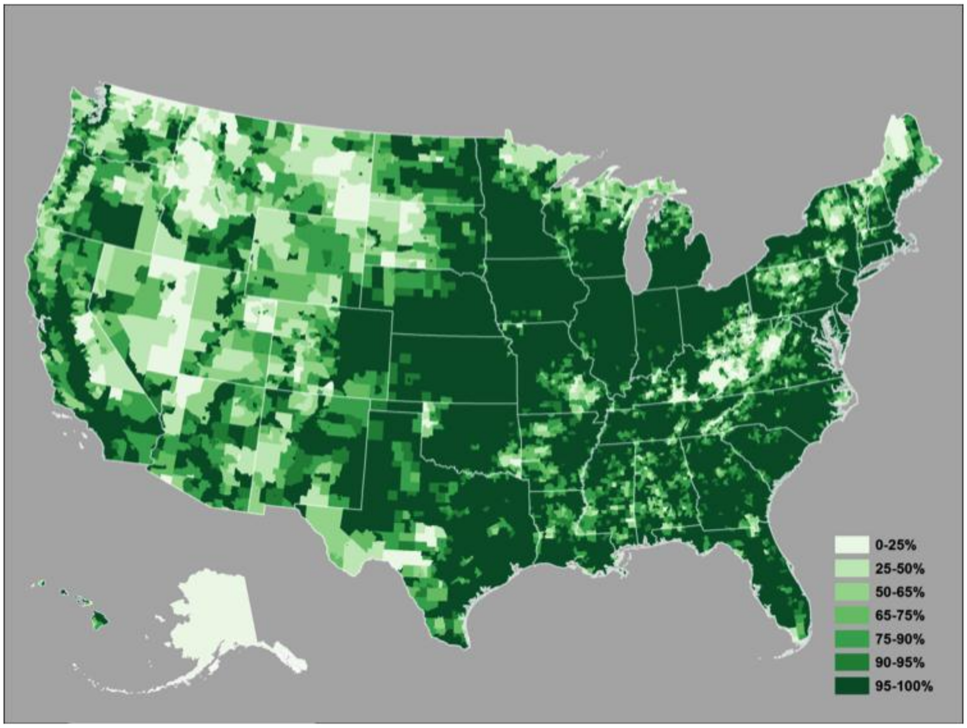
potential amount that an effort to increase WEA compliance can improve WEA coverage. An effort to increase mobile device coverage (and assure that it is also WEA-compliant) could increase WEA coverage even further (an additional 26.8 percent of the land mass, and 1.9 million residents). Red areas in Figure 5.3 have only one WEA-compliant (full or partial) CMSP, i.e., areas in which there is no competitive WEA-compliant service available. These areas are estimated to be 14.0 percent of the nation's landmass with 4.4 million people living in those areas (1.4 percent of the population). Green represents areas with more than one WEA-compliant (full or partial) CMSP. This last category represents areas where competitors provide WEA-compliant services. The competitive picture is important, since the availability of a WEA-capable service may be a differentiator that causes subscribers to change CMSPs to obtain access to the service. These areas in which two or more WEA-compliant CMSPs provide service are estimated to constitute 59.2 percent of the nation's landmass with 302.4 million people living in those areas (98.0 percent of the population).

An estimated 73.2 percent of the nation's landmass is covered by at least one CMSP that intends to fully or partially implement WEA. The estimated fraction of the nation's population that resides in this covered area is 99.4 percent (compared to 99.5 percent with voice coverage). These estimates can be interpreted as measures of the extent to which WEA has penetrated CMSP network coverage.

The size of CMSP networks varies widely. Figure 5.4 visualizes the penetration of the Tier I CMSPs: AT&T's and T-Mobile's GSM networks, and Sprint's and Verizon's CDMA networks.[31] The primary voice networks of Tier I CMSPs provide service to the majority of the nation's mobile device subscribers, covering 72.7 percent of the nation's landmass.

[31] Each Tier I CMSP operates a primary network of either GSM or CDMA protocol coverage. The WEA includes only these networks, which excludes secondary or legacy networks such as Sprint's iDEN network.

Figure 5.4. Estimated National WEA Coverage by Tier I CMSPs



Source: American Roamer October 2011, U.S. Census Bureau.

Figure 5.4 is a heat map[32] showing the fraction of the estimated population, by census tract, that is covered by at least one WEA-compliant Tier I CMSP. The lightest green corresponds to tracts where there is little or no WEA-compliant coverage by a Tier I CMSP. These light colored areas generally correspond to the grey and black areas of Figure 5.3 that have no voice coverage. The darkest green shows tracts where there is nearly complete WEA-compliant service by a Tier I CMSP. Fully or partially WEA-compliant Tier I CMSPs cover an estimated 99.2 percent of the U.S. population.

Figure 5.5 is another heat map, showing the estimated populations (by census tract) not covered by at least one WEA-compliant Tier I CMSP. The lightest red areas have the smallest populations not covered by a WEA-compliant Tier I CMSP. These light-colored areas generally correspond to the red and green areas of Figure 5.3 that have WEA-compliant coverage. The darkest red areas have the largest populations not covered by a WEA-compliant Tier I CMSP. At the national level, the estimate is that 2.3 million

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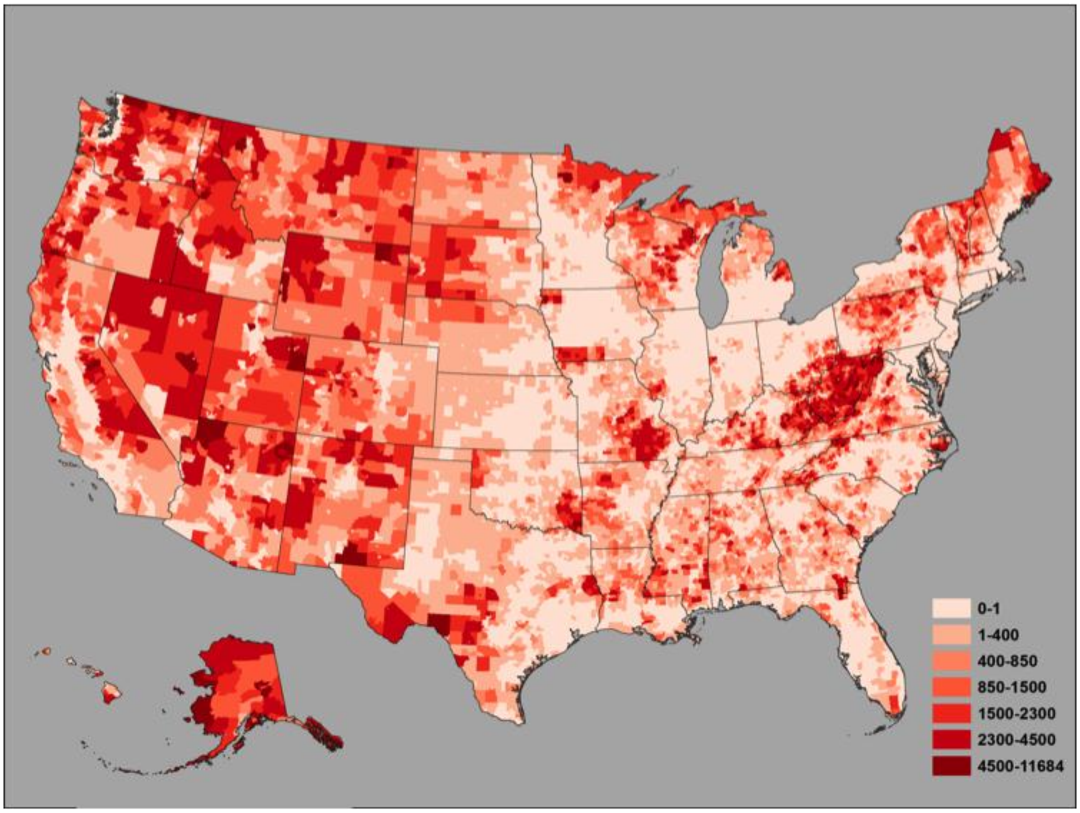
[32] A heat map is a graphical depiction that uses colors to represent data values.

people in the United States live in areas not covered by the WEA-compliant network of at least one Tier I CMSP.

Figure 5.5. Estimated Population Not Covered by a Tier I WEA-Compliant CMSP



Source: American Roamer October 2011, U.S. Census Bureau.

As stated previously, a Tier II CMSP is defined by the FCC as one with over 500,000 subscribers but without nationwide coverage. The FCC Election Letters showed that all U.S. Tier II CMSPs elected to be fully WEA compliant, and so the analyses reflected in Figures 5.4 and 5.5 were also performed for all Tier II CMSPs that operate inside the United States[33], as shown in Figures 5.6 and 5.7. Note that these results reflect the entirety of the coverage of Tier II CMSPs, which share a great deal of overlap with

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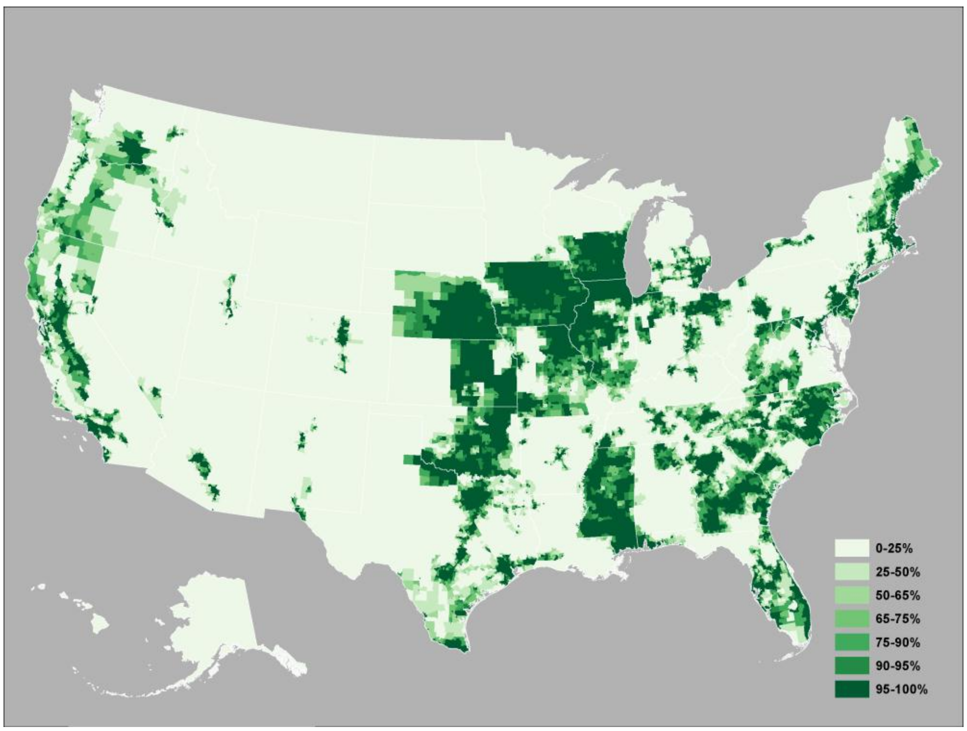
[33] Claro, a Tier II CMSP, operates solely in Puerto Rico, and was excluded from analysis.

the entirety of the coverage of Tier I CMSPs (and also with the Tier III CMSPs). Thusly, there is a corresponding overlap in the numerical results.

Analogous to Figure 5.4, Figure 5.6 is a heat map showing the fraction of the estimated population, by census tract, that is covered by at least one WEA-compliant Tier II CMSP. The lightest green corresponds to tracts where there is little or no WEA-compliant coverage by a Tier II CMSP, and the darkest green shows tracts where there is nearly complete WEA-compliant service by a Tier II CMSP. Fully or partially WEA-compliant Tier II CMSPs cover an estimated 71.7 percent of the U.S. population.

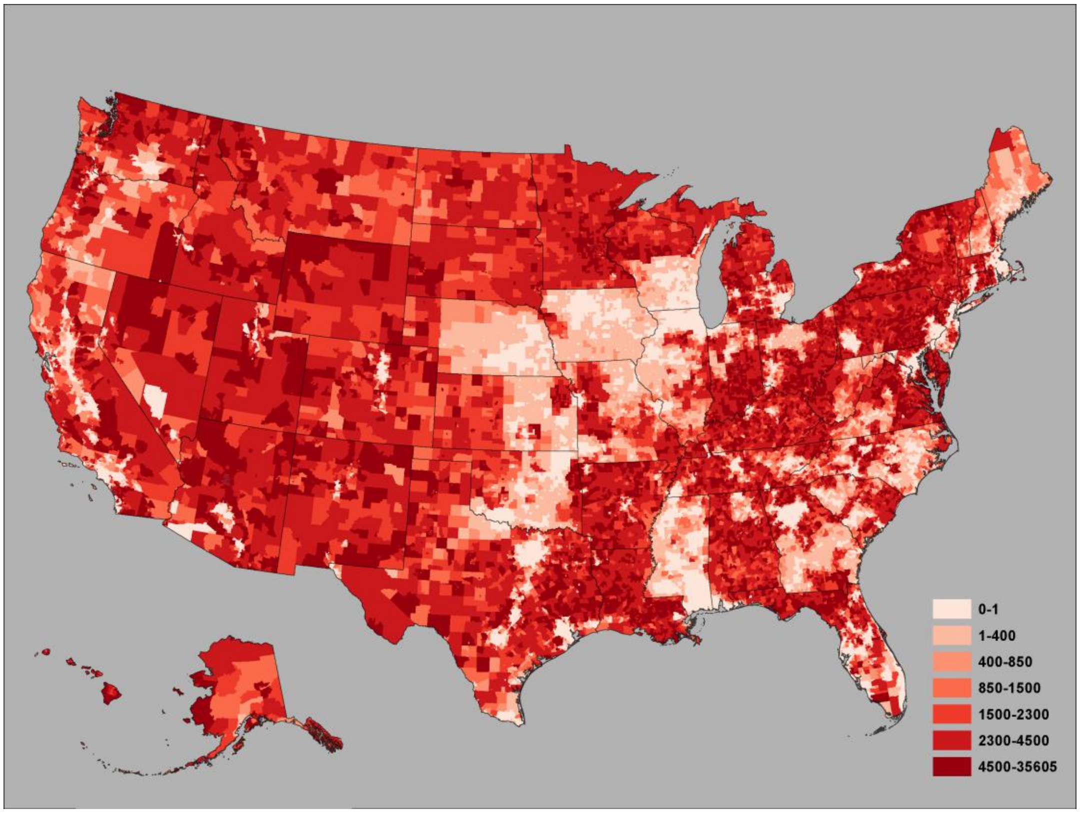
Figure 5.6. Estimated National WEA Coverage by Tier II CMSPs



Source: American Roamer October 2011, U.S. Census Bureau.

Analogous to Figure 5.5, Figure 5.7 is a heat map showing the estimated populations (by census tract) not covered by at least one WEA-compliant Tier II CMSP. The lightest red areas have the smallest populations not covered by a WEA-compliant Tier II CMSP, and the darkest red areas have the largest populations no covered by a WEA-compliant Tier II CMSP. At the national level, the estimate is that 87.4 million people in the United States live in areas not covered by a WEA-compliant Tier II CMSP.

Figure 5.7. Estimated Population Not Covered by a Tier II WEA-Compliant CMSP

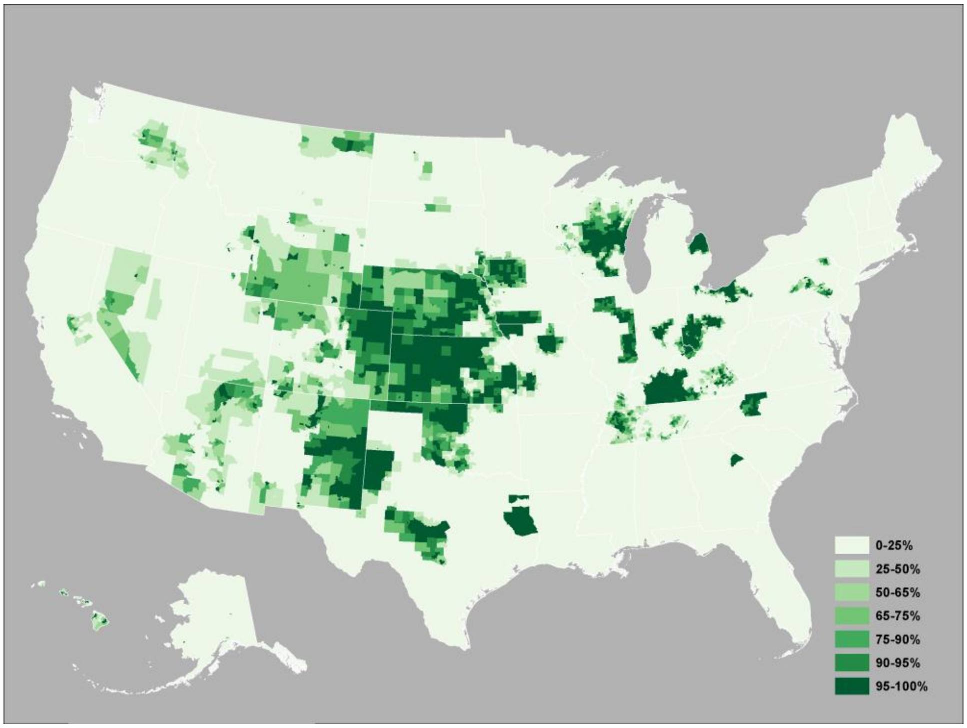


Source: American Roamer October 2011, U.S. Census Bureau.

Finally, the same sets of analyses were performed for Tier III CMSPs which elected either Yes or Partial for WEA compliance, as shown in Figures 5.8 and 5.9. Again, note that the coverage of the collected Tier III CMSPs overlaps that of the Tier I and Tier II CMSPs, and the numerical results should be considered as separate and not additive to the other results given in this chapter.

Figure 5.8 is a heat map showing the fraction of the estimated population, by census tract, that is covered by at least one WEA-compliant Tier III CMSP. The lightest green corresponds to tracts where there is little or no WEA-compliant coverage by a Tier III CMSP, and the darkest green shows tracts where there is nearly complete WEA-compliant service by a Tier III CMSP. Fully or partially WEA-compliant Tier III CMSPs cover an estimated 9.1 percent of the U.S. population.

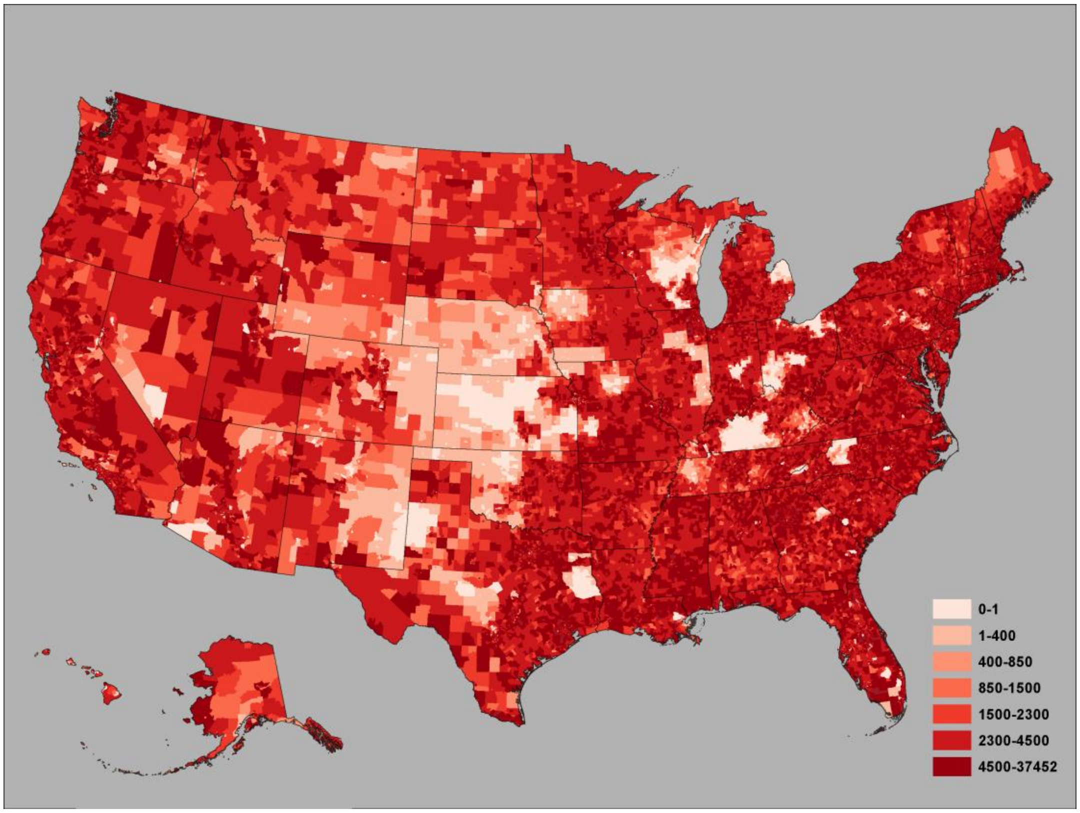
Figure 5.8. Estimated National WEA Coverage by Tier III CMSPs



Source: American Roamer October 2011, U.S. Census Bureau.

Figure 5.9 is a heat map showing the estimated populations (by census tract) not covered by at least one WEA-compliant Tier III CMSP. The lightest red areas have the smallest populations not covered by a WEA-compliant Tier III CMSP, and the darkest red areas have the largest populations no covered by a WEA-compliant Tier III CMSP. At the national level, the estimate is that 280.5 million people in the United States live in areas not covered by at least one WEA-compliant Tier III CMSP.

Figure 5.9. Estimated Population Not Covered by a Tier III WEA-Compliant CMSP



Source: American Roamer October 2011, U.S. Census Bureau.

As stated previously, the WEA-compliant networks of Tier I CMSPs cover an estimated 99.2 percent of the U.S. population. Despite the significant results shown by Tier in Figures 5.6–5.9, fully or partially WEA-compliant Tier II and III CMSPs, when added to the existing Tier I coverage, add only .2 percent of additional WEA-compliant coverage, for an estimated grand total of 99.4 percent of the U.S. population living in an area served by at least one WEA-compliant CMSP. Thus, while Tier II and III CMSPs may play an important competitive role, they extend WEA coverage a modest amount.[34]

While it is possible to relate WEA coverage to population, it was beyond the scope of this work to relate areas of known risks to WEA coverage. Such areas would include statistical profiles of NWS events (e.g.,"Tornado alley") and known areas of hazards

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[34] A tenth of a percent of the U.S. population represents roughly three hundred and nine thousand people.

(e.g., California's Contra Costa county—the home to refineries and chemical manufacturing facilities). In principle, these data can be overlaid on the CMSP coverage maps illustrated in Figures 5.2–5.9 and the maps of AO participation discussed in Chapter Four. Doing so would help to identify specific areas where it would be helpful to encourage additional AO participation at the locality level, and possibly additional CMSP participation (e.g., an county with an identifiable hazard with a significant fraction of its population served by a non–WEA-compliant Tier III CMSP).

Unfortunately, this study is unable to estimate WEA coverage for MVNOs. As noted previously, MVNOs do not operate a physical network, are not licensed by the FCC, and are not considered CMSPs for the purposes of WEA. Consequently, MVNOs were not required by the FCC's order to declare whether or not they would participate in disseminating WEA. Some of these CMSPs have extensive subscriber bases. Tracfone Wireless, a subsidiary of America Mobile, has over 19 million subscribers (Tracfone, 2012), more than half the reported subscribership of T-Mobile USA (T-Mobile, 2011). Hence, the inability to estimate WEA coverage for MVNOs represents a potentially significant gap in this analysis.

Adoption Issues and Barriers

CMSP networks evolve through mergers and acquisitions, technology change, upgrade cycles, and in response to changes in demand. A CMSP merger or acquisition could result in a combined network implemented with two technologies, only one of which can be made WEA-compliant at reasonable cost. Many of the largest network operators anticipate upgrading their networks to LTE—technology-driven change aimed at improving data services and reducing operating costs,—however, no major carrier has explicitly committed to providing WEA on its LTE networks. In fact, AT&T explicitly excluded its LTE networks from their WEA election until such time as the LTE standard is WEA ready. At that time they anticipate amending their WEA election with the FCC. This will probably be a minor issue in the future because the majority of wireless CMSPs will be motivated to maintain their current 3G networks for some time to provide their subscribers and roaming customers equipped with older non–LTE-capable devices a network connection. Furthermore, currently deployed LTE networks will continue to evolve as more capabilities are added to the LTE standard (for example voice calling). These additional capabilities will be added most likely by means of a software upgrade to

LTE network hardware, which is increasingly based on software-defined radio technology.

The longer-term LTE concern for the government sector is the timely selection of a WEA cell broadcast standard for LTE. This may make it more difficult to ensure that the majority of LTE-capable devices will be WEA compatible in the future, when 3G network availability starts declining. To reduce the risk of this occurring it may be prudent for the government to play an active role in the development of a WEA cell broadcast standard for LTE, or at least to monitor these developments to ensure that industry remains committed to developing such a standard.

AT&T was also careful to specify that its "partial" WEA election on September 8, 2008, did not include technologies such as WiFi or small-cell technologies.[35] All other CMSPs' election letters were silent on the inclusion of small cells and WiFi-based systems in their WEA message dissemination footprints. If AT&T's pattern holds true for all small-cell installations, then many subscribers who are connected to CMSP networks via small cells will not receive a WEA message if one is sent to their geographic area. Due to a growing shortage of spectrum for mobile device networks, it is likely that small and large CMSPs will increase their use of Wi-Fi and small cells. All indications are that these extensions of CMSP networks will not be WEA-capable. Therefore it is possible that a significant WEA coverage gap could occur and grow over time if these systems are not made WEA-capable.

To summarize the analysis of this chapter, all Tier I CMSPs and the majority of Tier II CMSPs plan to implement WEA in their networks. Some of these CMSPs have indicated they will only partially implement WEA. Interviews with selected CMSPs and discussions with cellular infrastructure providers and mobile device manufacturers indicate that partial implementations will likely be temporary—at least for Tier I and Tier II CMSPs. However, decisions to not implement WEA or to implement it only partially by smaller Tier III CMSPs may not be decisions that are quickly reversed. The data presented in this chapter indicate that only 23 percent of Tier III CMSPs intend to implement WEA, or only 28 percent if paging companies are removed from the total CMSP population. In 2012, researchers attended a number of wireless carrier industry

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[35] Femtocells and other small cells are used by some carriers to extend their networks into areas that are not being covered well by larger towers (macro cells). Frequently, these are locations inside of buildings or in other hard-to-reach urban areas.

conferences and interviewed representatives of Tier III CMSPs. These interviews indicate that 22 of 42 Tier III CMSPs sampled intend to implement WEA. This 52 percent indicates a much higher WEA implementation rate than the FCC election letters. However, this sample could be biased in favor of larger Tier III CMSPs—and probably is—as they had the resources to attend a national conference. It is likely that the smallest Tier III CMSPs are the ones that are constrained most by limited financial resources and the most likely not to implement WEA.

Conversations with smaller CMSPs that will not implement WEA indicate that they are very concerned about cost and affordability, and also that they have concerns about obtaining WEA-capable devices even several years from now, when their availability will likely be higher than it is today. A review of WEA election letters are consistent with these observations and provide the following reasons for partial- or non-WEA compliance:

- A portion of a network uses a technology that cannot be made WEA-compliant or is not cost-effective to upgrade in the CMSP's estimation[36]
- A portion of the network is expected to be retired and replaced by newer technology that is WEA-compliant, but the remaining usable lifetime of the non-compliant portion of the network does not justify upgrading it to be WEA-compliant
- A CMSP expects that some or all of its device offerings cannot be upgraded to WEA-compliance.

Perhaps the most important WEA adoption issue at the CMSP level is the uncertainty regarding whether MVNOs will implement WEA. On one hand, there is some reason for optimism, in that these companies do not own or operate their own network infrastructure. They effectively lease the network infrastructure of larger CMSPs and probably in most cases the infrastructure of Tier I CMSPs who are or will eventually implement WEA. However, for MVNO subscribers to receive WEA messages they must

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[36] Several pager companies initially opted-in (2008) and then later opted-out (2012) due to the non-availability of equipment for disseminating WEA messages over their networks.

Sprint-Nextel does not plan to bring its legacy iDen network into WEA compliance before it is retired in 2013.

Verizon (predominantly CDMA carrier) has several legacy GSM networks that it is essentially a caretaker for but does not intend to upgrade.

use WEA–capable devices. It is not clear whether MVNOs will plan to or be capable of offering WEA-capable devices in the near future.

Representatives from a number of MVNOs were interviewed to try to learn more about their WEA implementation plans. Representatives from these companies were unable to explain their company plans regarding WEA. They had relatively little awareness regarding WEA in general and appeared to have difficulty obtaining such information from inside their companies. This raises the possibility that a significant fraction of the U.S. public that receives wireless service via MVNOs will not be able to receive WEA messages.

6. WEA Compatibility of Mobile Devices

This chapter examines the population of mobile wireless devices in the United States and the fraction of that population that is currently WEA-compatible and that may be WEA-capable in the future. It begins by charting the current adoption trends. Many cellphone users do not have a WEA-capable device, but they can acquire compatibility in two ways: by upgrading a current device or by purchasing a new, more capable device. The chapter analyzes the potential effect of each method in turn.

At least three types of mobile wireless devices in use today connect to CMSP networks. These are mobile or cellular phones, tablet computers with cellular capability, and cellular modems that provide data communications for users with laptop computers. This chapter considers only mobile phones.

Current Adoption Trends

In addition to a WEA-compliant CMSP, a WEA-capable device is also required to receive an alert or warning. It is, therefore, important to estimate the number of WEA-capable phones that are expected to be in service as of April 2012 (initial capability for WEA). To construct this estimate, survey data from comScore (January 2012) were supplemented with data from the websites of the four largest CMSPs (Verizon Wireless, 2012; AT&T, 2012a; SPRINT, 2011; and T-Mobile, 2012). Data from comScore were used to estimate the prevalence of mobile phone models currently in use. Data from the carrier websites helped identify which mobile phone models are WEA-capable. It was impractical to review every carrier's website to determine which of their phones are WEA-capable. In fact, many small CMSPs do not list the phones they offer on their websites, making it difficult to determine WEA-compatibility. Although WEA-capable phone offerings for smaller CMSPs were not surveyed, many smaller CMSPs offer some of the same mobile phones offered by the largest four CMSPs. For phones offered by smaller CMSPs that are not offered by the four largest CMSPs, the subsequent analysis assumes that these phones are not WEA-capable. This assumption is conservative, and the number of phones that are actually WEA-capable is higher. However, it is reasonable to assume that the smaller CMSPs will be slower to offer WEA-capable phones and less likely to be able to induce device manufacturers to make WEA-capable phones due to limited market power.

Table 6.1 shows the estimated number of WEA-capable devices being used in the top metropolitan areas of the United States. These roughly correspond to the DMAs that comScore uses to report its survey data.

Table 6.1. Percentage of WEA-Capable Phones in the Top U.S. Metropolitan Areas

DMA	Num. Phones	WEA-Capable Phones
NEW YORK	16,248,733	600,021 (3.7%)
LOS ANGELES	11,595,767	501,970 (4.3%)
CHICAGO	7,113,016	158,134 (2.2%)
PHILADELPHIA	6,259,937	245,009 (3.9%)
DALLAS-FT. WORTH	5,456,990	178,199 (3.3%)
SAN FRANCISCO-OAKLAND-SAN JOSE	5,209,462	113,261 (2.2%)
WASHINGTON, D.C.	4,957,852	88,678 (1.8%)
ATLANTA	4,882,983	122,986 (2.5%)
BOSTON	4,755,012	211,871 (4.5%)
HOUSTON	4,423,352	79,159 (1.8%)
DETROIT	3,644,901	193,697 (5.3%)
MINNEAPOLIS-ST. PAUL	3,391,057	129,170 (3.8%)
MIAMI-FT. LAUDERDALE	3,360,128	107,722 (3.2%)
TAMPA-ST. PETERSBURG (SARASOTA)	3,337,985	132,301 (4.0%)
SEATTLE-TACOMA	3,273,179	79,170 (2.4%)
PHOENIX	3,188,695	142,148 (4.5%)
SACRAMENTO-STOCKTON-MODESTO	3,167,254	94,148 (3.0%)
ORLANDO-DAYTONA BEACH-MELBOURNE	3,065,061	102,468 (3.3%)
DENVER	2,881,466	115,152 (4.0%)
CLEVELAND	2,719,311	143,332 (5.3%)
ST. LOUIS	2,366,781	35,294 (1.5%)
CHARLOTTE	2,240,326	113,609 (5.1%)
INDIANAPOLIS	2,191,671	95,099 (4.3%)
PORTLAND	2,188,856	69,483 (3.2%)
PITTSBURGH	2,169,149	97,856 (4.5%)

Source: comScore

As Table 6.1 shows, the numbers of mobile phone subscribers using a WEA-capable phone in major metropolitan areas are a single-digit percentage of all mobile phone subscribers in those areas. Furthermore, some fraction of these subscribers will opt out of receiving WEA messages, even though their mobile phones are WEA-capable, therefore further reducing the number of people who will receive a WEA message. Although the estimated coverage of the WEA-compatible CMSPs (measured as geographic area or population) is comprehensive, most of the covered population appears to be unable to receive a WEA message at the initial capability date because their phone is not yet WEA-capable. Thus, the adoption (penetration) of WEA-capable mobile phones appears to be the most important technical barrier to overall WEA penetration at initial capability.

Another view of the national picture of WEA-capable phone adoption is the estimated number of WEA-capable phones in use by each CMSP. Table 6.2 shows the estimate for April 2012. The estimate is derived from comScore data as of January 2012. Unsurprisingly, only single-digit percentages of the subscribers of these major CMSPs have phones capable of receiving a WEA message. This estimate may be overstated, since an unknown fraction of subscribers with a WEA-capable phone may opt out of receiving WEA messages. Among Tier I CMSPs, AT&T has the lowest number of subscribers with WEA-capable phones.

Table 6.2. Number of WEA-Capable Phones, by CMSP

Operator	Num. Phones	WEA-Capable Phones
AT&T (Cingular)	61,538,944	215,697 (0.4%)
Cricket	4,342,745	0 (0.0%)
MetroPCS	7,536,289	0 (0.0%)
Other	6,506,254	14,701 (0.2%)
Sprint	24,655,165	2,038,120 (8.3%)
Sprint Prepaid	11,831,459	235,036 (2.0%)
T-Mobile	22,217,400	1,010,943 (4.6%)
Tracfone	16,669,393	0 (0.0%)
U.S. Cellular	4,828,809	0 (0.0%)
Verizon	73,873,541	4,715,855 (6.4%)

Table 6.3 shows the estimated percentages of WEA-capable mobile phones available in each state at WEA initial capability, based on comScore data. ComScore survey data have limitations when used to analyze adoption trends at the state level. For instance, from 2011 to 2012, the percentage of WEA-capable phones drops in small states such as Montana, Vermont, and Wyoming. States with low population densities reduce the sample size comScore uses for DMAs in these states. This is an inherent limitation of the way comScore collects its data. Nevertheless, the overall picture portrays very low coverage of the United States by WEA-capable phones at WEA initial capability. Currently, even though much of the nation is covered by WEA-compatible CMSPs, only a small portion of CMSP subscribers will actually receive a WEA message.

Table 6.3. comScore Estimates of WEA-Capable Phone Market Coverage As of April 2012

State	WEA-Capable Phones in 2011 (%)	WEA-Capable Phones in 2012 (%)
Alabama	1	4
Alaska	0	8
Arizona	3	4
Arkansas	0	2
California	1	3
Colorado	1	4
Connecticut	1	4
Delaware	2	4
District of Columbia	0	0
Florida	1	3
Georgia	1	3
Hawaii	1	4
Idaho	2	3
Illinois	1	2
Indiana	1	4
Iowa	0	1
Kansas	2	4
Kentucky	0	3
Louisiana	0	2
Maine	0	1
Maryland	1	3
Massachusetts	1	4
Michigan	1	4
Minnesota	1	4
Mississippi	1	4
Missouri	1	2
Montana	5	2
Nebraska	3	4
Nevada	2	4
New Hampshire	5	5
New Jersey	2	4
New Mexico	2	3
New York	2	3
North Carolina	2	3
North Dakota	1	3
Ohio	2	5
Oklahoma	0	2
Oregon	1	3
Pennsylvania	2	4
Rhode Island	1	3

State	WEA-Capable Phones in 2011 (%)	WEA-Capable Phones in 2012 (%)
South Carolina	1	5
South Dakota	1	3
Tennessee	2	5
Texas	1	4
Utah	1	4
Vermont	2	0
Virginia	2	4
Washington	1	3
West Virginia	0	2
Wisconsin	1	3
Wyoming	12	0

Sources: comScore, 2012 and NDRI analysis.

WEA Penetration and Software Upgrades

Given the current limited offerings of WEA-capable mobile phones, one strategy to increase penetration is through operating system and firmware upgrades, particularly for smartphones. Table 6.4 shows an estimate for the number of mobile phones in major metropolitan areas that might be made WEA-capable through an upgrade.

Table 6.4. Estimated Effect of a Software Upgrade to Achieve WEA-Capability on Metropolitan Areas

DMA	Install Base	Existing WEA Enabled	Existing +All iPhone Enabled	Existing + All iPhone + All BlackBerry	Existing + iPhone + BlackBerry + Android + Windows Phone
New York	16,248,733	3.7%	18.1%	31.0%	51.5%
Los Angeles	11,595,767	4.3%	20.5%	28.2%	52.3%
Chicago	7,113,016	2.2%	16.5%	24.0%	46.8%
Philadelphia	6,259,937	3.9%	20.3%	25.6%	47.3%
Dallas-Ft. Worth	5,456,990	3.3%	24.4%	28.6%	53.5%
San Francisco-Oakland-San Jose	5,209,462	2.2%	23.3%	30.0%	49.8%
Washington, DC	4,957,852	1.8%	15.1%	20.6%	43.5%
Atlanta	4,882,983	2.5%	17.8%	26.0%	48.7%
Boston	4,755,012	4.5%	21.1%	25.7%	49.0%
Houston	4,423,352	1.8%	15.5%	26.5%	50.5%
Detroit	3,644,901	5.3%	15.3%	23.9%	51.8%
Minneapolis-St. Paul	3,391,057	3.8%	15.0%	21.8%	45.5%
Miami-Ft. Lauderdale	3,360,128	3.2%	12.2%	27.0%	54.5%
Tampa-St.Petersburg (Sarasota)	3,337,985	4.0%	14.1%	19.4%	40.6%
Seattle-Tacoma	3,273,179	2.4%	16.0%	18.5%	44.8%

Phoenix	3,188,695	4.5%	12.5%	17.8%	44.7%
Sacramento-Stockton-Modesto	3,167,254	3.0%	20.4%	25.9%	40.9%
Orlando-Daytona Beach-Melbourne	3,065,061	3.3%	14.9%	19.5%	39.1%
Denver	2,881,466	4.0%	18.1%	24.5%	51.2%
Cleveland	2,719,311	5.3%	12.8%	20.0%	37.9%
St. Louis	2,366,781	1.5%	16.4%	23.7%	46.4%
Charlotte	2,240,326	5.1%	16.7%	26.6%	49.0%
Indianapolis	2,191,671	4.3%	16.5%	21.1%	45.3%
Portland	2,188,856	3.2%	14.6%	17.0%	40.5%
Pittsburgh	2,169,149	4.5%	18.1%	22.0%	39.9%

Source: comScore

In developing this estimate, only phones that can be made WEA-capable by means of a software upgrade are considered (iPhone, Android, Blackberry, and Windows phones). *If such a software upgrade were possible, it would significantly improve the estimated percentage of subscribers in major metropolitan areas (to double digit percentages) that could receive a WEA message.*

Table 6.5 provides estimates of the effect of a software upgrade of the smart phones on major CMSP networks to incorporate WEA-capability. These estimates are optimistic and assume that all of the smart phones listed are capable of receiving software and firmware upgrades that would make them WEA-capable. Given this assumption, the effect of such an upgrade is substantial and consistent with the estimate for major metropolitan areas. Note that Tracfone, an MVNO, is the notable exception. Tracfone serves low-income subscribers with inexpensive feature phones (as opposed to smart phones). As with Table 6.4, these estimates likely overstate the effect, since subscribers may opt not to receive WEA messages or not to upgrade their software. *This view of the data suggests that a Mobile Penetration Strategy based on software upgrades may have a diminished effect for low-income segments of the population.*

Table 6.5. Estimated Effect of a Software Upgrade to WEA-Capability on CMSP Network

Carrier	Install Base	WEA Enabled	WEA Enabled + iPhone	WEA Enabled + iPhone + BlackBerry	WEA Enabled + iPhone + BlackBerry + Android + Windows Phone
AT&T (Cingular)	61,538,944	0.4%	34.2%	41.1%	51.8%
Cricket	4,342,745	0.0%	0.0%	4.8%	34.6%
MetroPCS	7,536,289	0.0%	0.0%	5.4%	35.4%
Other	6,506,254	0.2%	4.5%	10.8%	26.4%
Sprint	24,655,165	8.3%	11.6%	22.1%	61.1%
Sprint Prepaid	11,831,459	2.0%	2.0%	7.2%	35.0%
T-Mobile	22,217,400	4.6%	7.0%	15.4%	49.3%
TracFone	16,669,393	0.0%	0.1%	0.1%	1.4%
US Cellular	4,828,809	0.0%	0.0%	4.2%	26.3%
Verizon	73,873,541	6.4%	16.2%	22.5%	46.6%

Source: comScore

As mentioned previously, these calculations are optimistic because it may not be possible to upgrade some phones to receive wireless alerts over cell broadcast. For a phone to be WEA-capable on most CMSP networks, it must be able to process the cell broadcast information arriving on the cell broadcast channel. This functionality depends on the baseband modem chip having cell broadcast-ready firmware. For device vendors that exercise significant design control over both the hardware and the device's operating system (e.g., Apple's iPhones, RIM's BlackBerries), a software update has the potential to give the device cell broadcast and WEA capability. However, for device vendors that do not have significant control over the device and the operating system, an update alone may not be sufficient to ensure a device is ready to receive wireless alerts over cell broadcast.

Mobile Device Turnover Rates

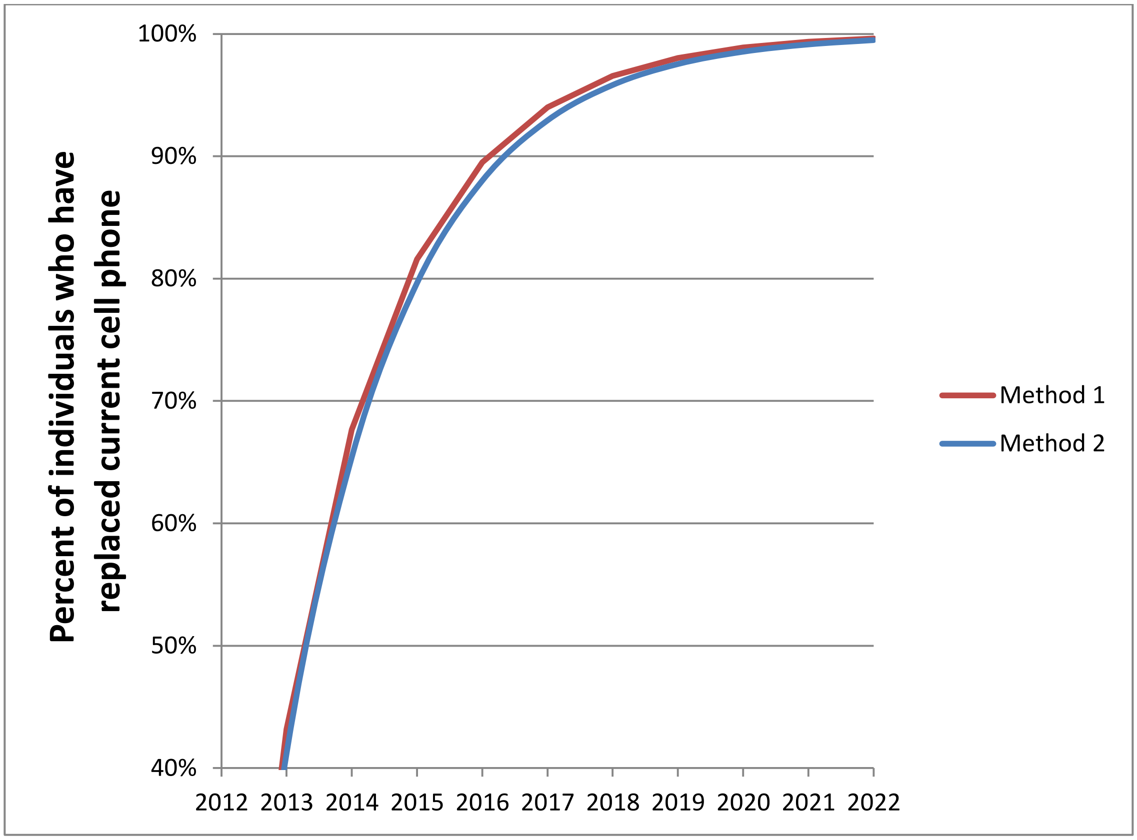
Another strategy to promote the proliferation of WEA-capable phones is to increase the percentage of new mobile phones that are WEA-capable. In implementing this strategy, it is essential to assess how frequently individuals purchase new mobile phones, especially since WEA-capability is unlikely to be achieved through software upgrades to existing phones. The data for estimating turnover rates are sparse, so we

estimated rates in different ways to ensure that results are generally consistent. A model developed using comScore data indicates that the current stock of mobile phones will not be replaced until about 2022. Breaking out the data by income level does not indicate significant difference across income groups. Analyzing the data by CMSP suggests that the replacement rate varies somewhat more, with MVNO and Lifeline subscribers replacing their mobile phones at a somewhat lower rate. Note, however, that our analysis assumes that all Tier 1 phones will be WEA-capable in 2013. Analyzing data by DMAs as a proxy for metropolitan area indicates that small DMAs have a somewhat lower replacement rate. While not in itself an issue of concern, when coupled with the weaker coverage for these areas, it may suggest that access to WEA messages might be somewhat more problematic.

Because there are few reliable forecasts of mobile device turnover rates, a model estimating the turnover rate of mobile phones among subscribers is required. The model developed for this analysis, which relies on three years of comScore data, is described in detail in Appendix C.

Two approaches can be used to estimate the turnover rate from the comScore data. The first approach uses an average annual turnover rate based on two, one-year observations of phone turnover rates derived from comScore data. The second approach uses an annual rate based on a single, two-year observation of phone turnover rates derived from comScore data. The weights used are proportional to the sample size of each income level. Figure 6.1 compares the time to replace the current stock of mobile phones predicted by the two alternative approaches. The graph indicates that the two methods produce similar results.

Figure 6.1. Estimated Time to Replace the Current Stock of Mobile Phones



Source: comScore

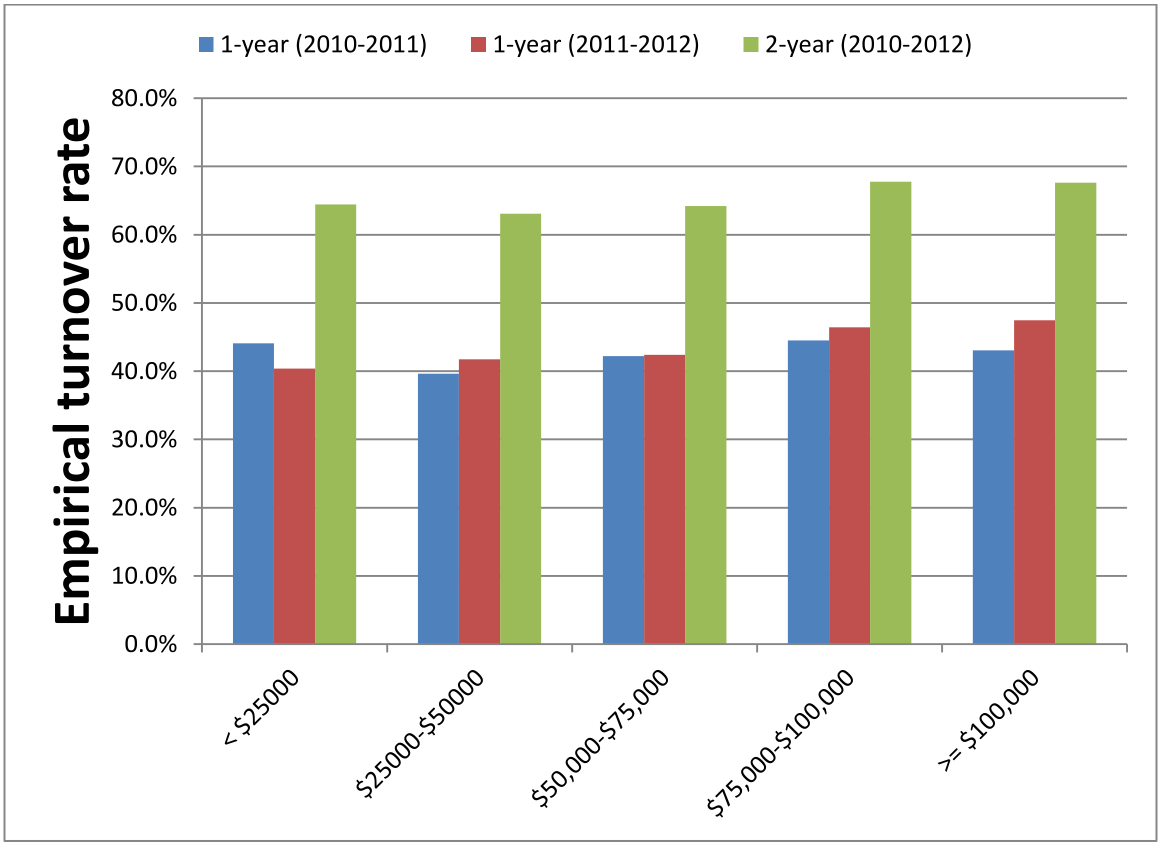
Both Table 6.6 and Figure 6.2 show data on cellphone turnover rate by income. Analyzing the relationship between mobile device turnover rate and income may be helpful in understanding the effects of a strategy to improve penetration that provides incentives to a particular income group. Each uses three estimates of turnover rates: two one-year annual rates of change based on 2010 and 2011 comScore survey data, and a third annual rate based on average annual rates of change over two years (2010–2012). In Table 6.6, observe that the two one-year estimates for the percentage of phones replaced are reasonably close. Table 6.6 also suggests that the mobile device turnover rate is not very sensitive to income. The figure shows a slight increase in turnover with income, but it appears that the relationship is not that strong.

Table 6.6. Estimated Annual Turnover Rate

Annual Income	One-Year (2010–2011) Percentage of Phones Replaced	One-Year (2011–2012) Percentage of Phones Replaced	Two-Year (2010–2012) Percentage of Phones Replaced
< $25,000	44.1	40.4	64.4
$25,000–$50,000	39.6	41.7	63.1
$50,000–$75,000	42.2	42.4	64.2
$75,000–$100,000	44.5	46.4	67.8
>= $100,000	43.1	47.5	67.6
Weighted total	42.5	43.9	65.4

Source: comScore

Figure 6.2. Estimated Mobile Device Turnover Rate, by Income

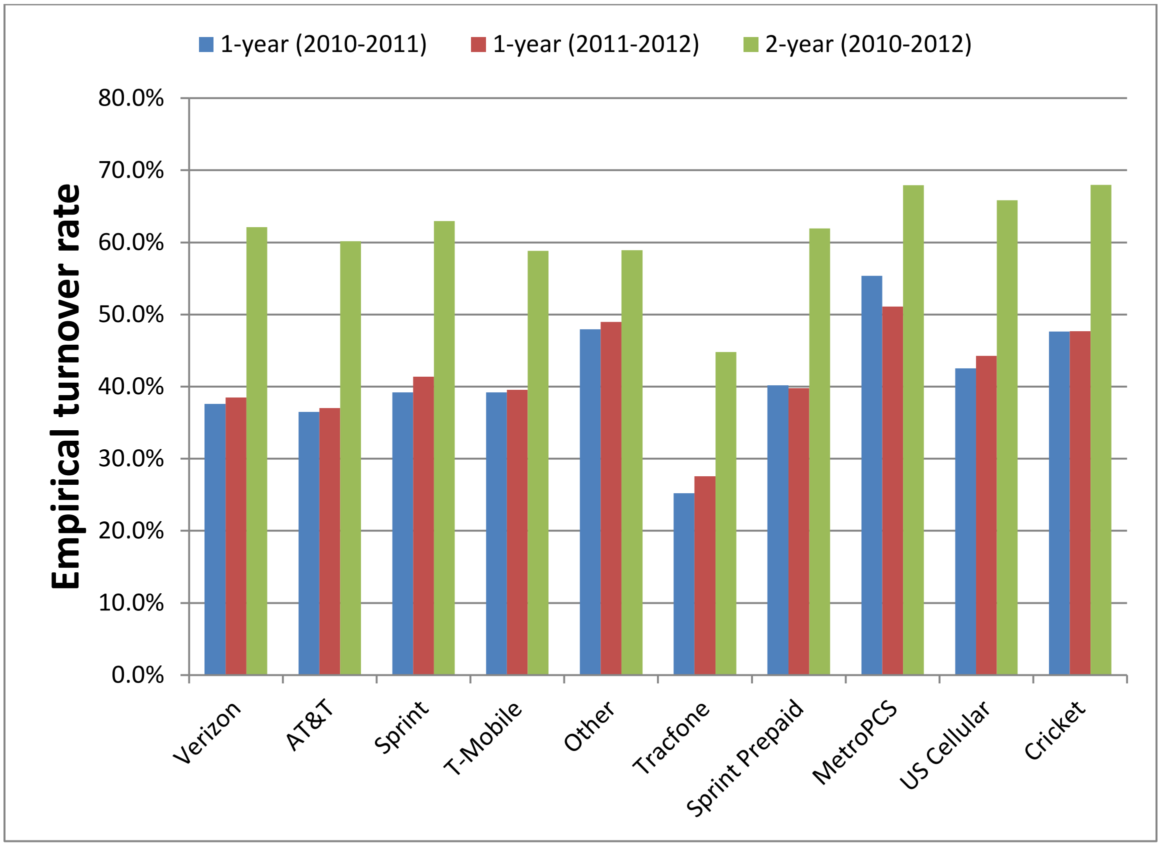


Source: comScore

The turnover rate does appear to vary in a more pronounced manner by CMSP, as shown in Figure 6.3. Note that Tracfone, an MVNO featuring no-contract plans and basic mobile phones (feature phones), has a much lower turnover rate than the other CMSPs.

The comScore data are somewhat limited for the smaller CMSPs, so the figures should be interpreted with caution.

Figure 6.3. Estimated Mobile Device Turnover Rates, by Carrier

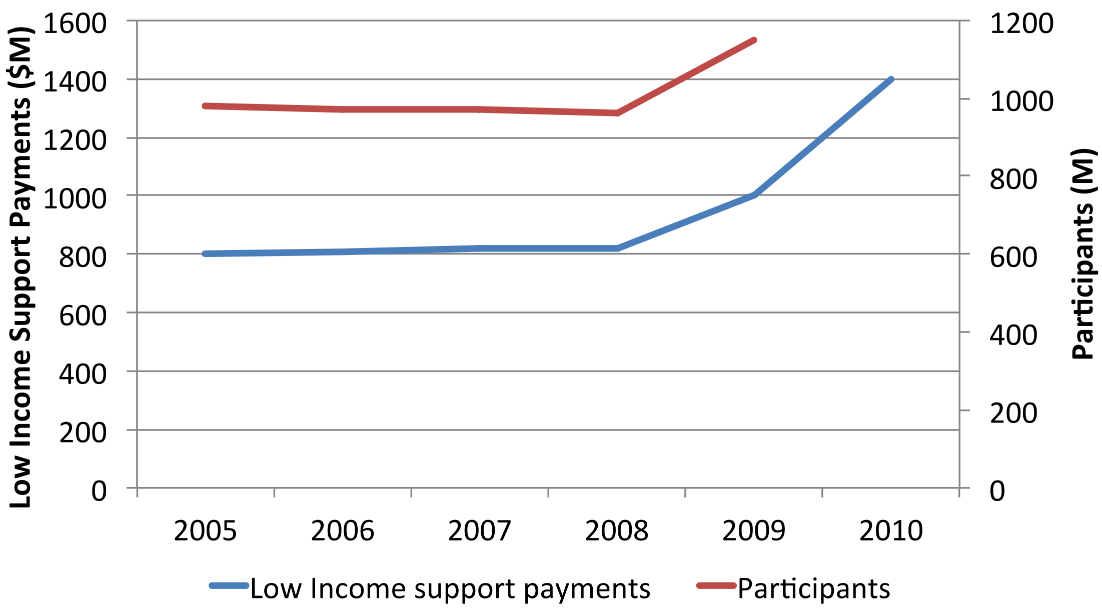


Source: comScore

Recall that Figure 6.2 did not indicate a significant difference in turnover rates by income. By contrast, Figure 6.3 suggests that Tracfone, an MVNO, has a lower turnover rate. There are several explanations for this apparent contradiction. First, Tracfone does not offer its subscribers a free upgrade or any other incentives to purchase a new phone, in contrast with the Tier I CMSPs. Given limited resources, a low-income family must decide how to spend its disposable income. Some will value mobile phone service highly and may subscribe to a major carrier, where mobile phone replacement is encouraged. Others might simply want basic voice communication, and thus elect a carrier such as Tracfone. Furthermore, Tracfone's customer base is still a relatively small fraction of all low-income subscribers. Consequently, the Tracfone subscriber base only represents a subset of the low-income population.

The slower turnover rate among Tracfone's subscriber base raises important issues for policymakers trying to promote the proliferation of WEA-capable phones. Through its Safelink brand, Tracfone is one of several providers of Lifeline services to low-income individuals. An estimated ten million mobile phones are provided under the FCC's Lifeline program, based on trends taken from a Government Accountability Office (2010) analysis. The growth of this program is shown in Figure 6.4. Phones provided by this program are low-cost feature phones, with a slower than normal turnover rate and reduced likelihood of being WEA-capable than more expensive smartphones.

Figure 6.4. Growth in Mobile Phones Provided Under the FCC's Lifeline Program



Source: Government Accountability Office analysis of USAC data

In addition to income, potential penetration-improvement strategies might also be based on variations observed between turnover rates depending on the size of metropolitan areas. comScore DMAs can be used as a proxy for metropolitan areas to test whether there are significant variations in turnover rates by geographic location. The comScore data weighted the survey population by DMA; hence, using DMAs in the analysis is the most reliable way of comparing urban to rural settings. DMAs are placed in one of three bins, based on the size of the population of the DMA:

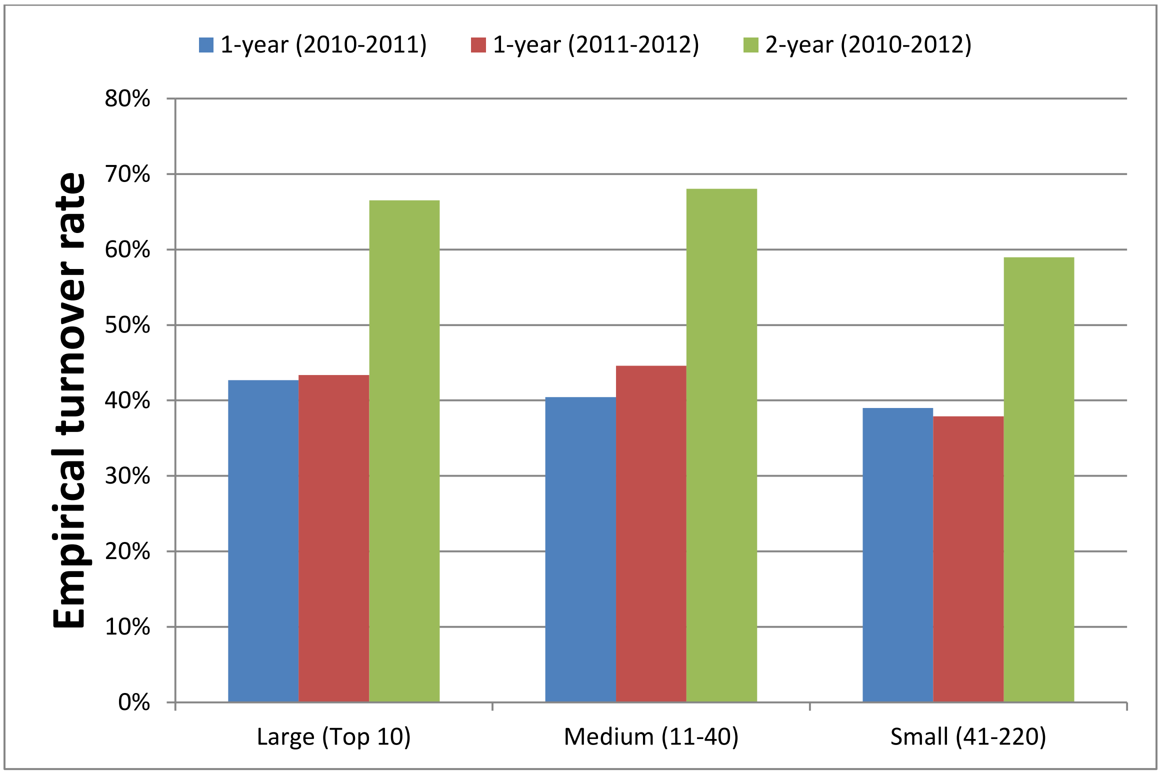
1. Large: the ten largest DMAs
2. Medium: the eleventh through the fortieth largest DMAs

3. Small: the remainder of DMAs.

The total populations in each of the three bins are approximately equal.

As shown in Figure 6.5, large- and medium-sized DMAs have similar mobile device turnover rates. By contrast, small DMAs have a somewhat reduced mobile device turnover rate. By itself, the lower mobile device turnover rate in the small DMA category is not striking and may not raise concerns about whether individuals living in these areas will acquire a WEA-capable mobile phone. However, when the lower mobile device turnover rate is compounded with the typically less robust mobile phone coverage, access to WEA messages may be somewhat less in smaller markets.

Figure 6.5. Mobile Device Turnover Rate, by DMA



Source: comScore

Using the predicted mobile device turnover rates, it is possible to estimate the proliferation of WEA-capable phones in the U.S. population. Table 6.7 summarizes the predicted penetration of WEA-capable mobile phones by income level for the years 2014, 2017, and 2021. This forecast assumes that 100 percent of newly offered mobile phones are WEA-capable starting in 2012, a highly optimistic estimate.

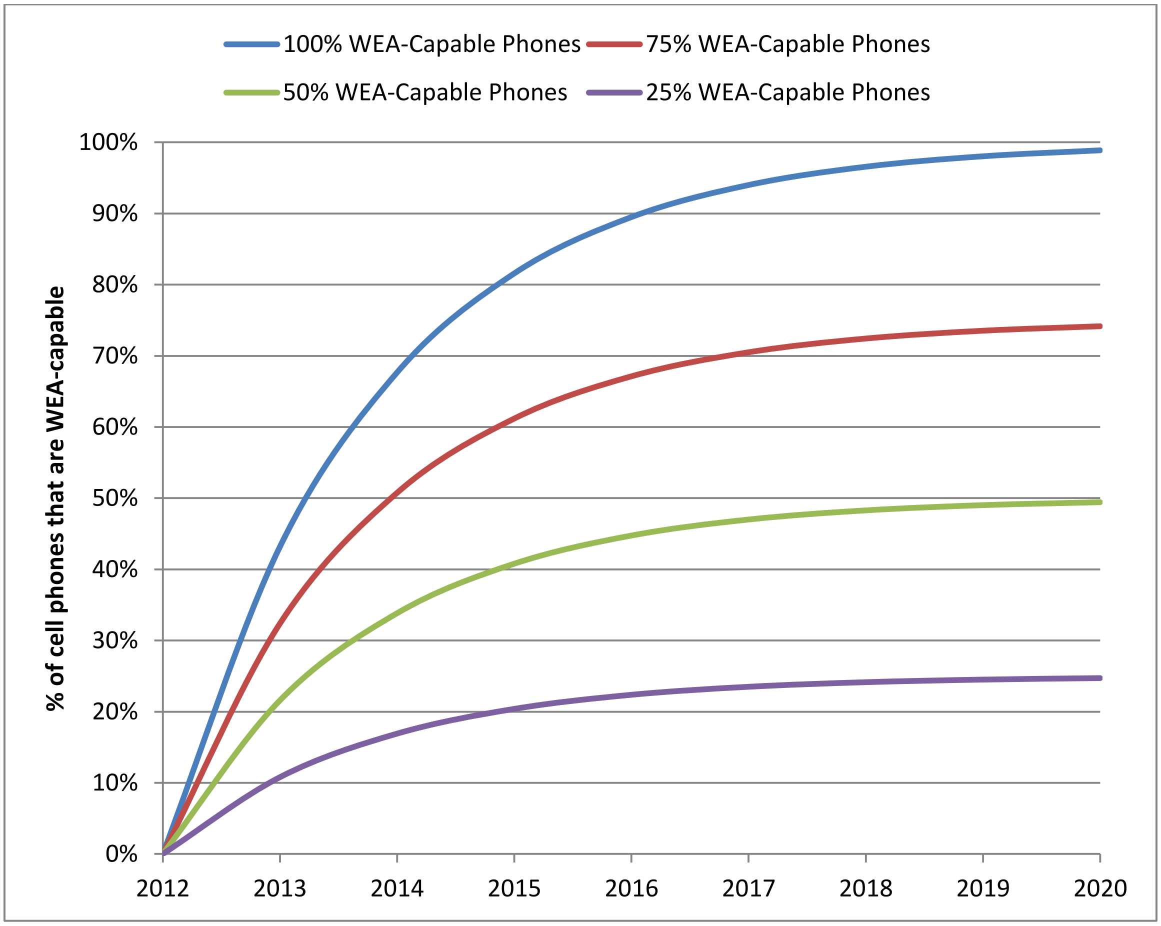
Table 6.7. Estimated Market Penetration of WEA-Capable Phones

Income Level	2014 Percent Penetration	2017 Percent Penetration	2021 Percent Penetration
< $25,000	66.6	93.6	99.3
$25,000–$50,000	64.8	92.7	99.1
$50,000–$75,000	66.7	93.6	99.3
$75,000–$100,000	70.3	95.2	99.6
>= $100,000	70.0	95.1	99.6
Weighted total	67.7	94.0	99.4

Source: comScore

All newly offered phones are not likely to be WEA-capable for some time. Figure 6.6 varies the assumed percentage of newly offered phones that will be WEA-capable to estimate the proportion of WEA-capable phones that would be in use over the next eight years. Over the eight-year period, the percentage of WEA-capable phones is assumed to remain constant in Figure 6.7. To model the turnover of mobile phones, an average one-year turnover rate derived from comScore's data is assumed. If only 25 percent of newly offered phones were WEA-capable over the eight-year period, the WEA proliferation rate is sluggish, resulting in less than 10 percent of mobile phone users having access to a WEA-capable phone after eight years. By contrast, if all newly offered phones are WEA-capable, over 90 percent of mobile phone users will have a device capable of receiving WEA messages within five years.

Figure 6.6. Estimated WEA-Capable Phones in Circulation Over Time



Source: comScore

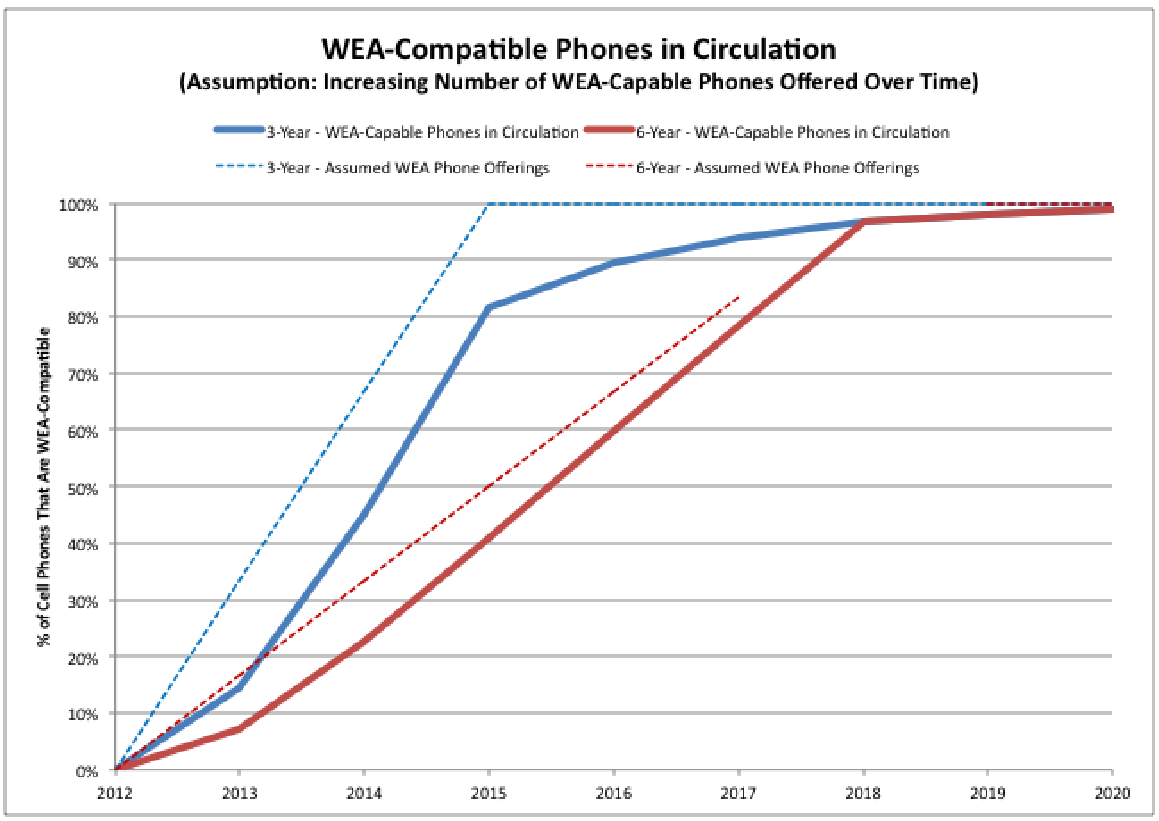
Note: Assume constant number of WEA-capable phones offered over time.

However, it is likely that the percentage of newly offered WEA-capable phones would increase over the next five years, rather than remain constant (as this estimate assumes)[37] Such an occurrence would moderate the "leveling-off" effect present in Figure 6.6. In Figure 6.7, the percentage of WEA-capable phones is allowed to vary over the same time frame shown in Figure 6.6. It considers two estimated cases: (1) a fast

[37] While the percentage of WEA-capable phones *purchased* would provide a better estimate of the WEA-capable phones in circulation, these market data are proprietary. As a result, the percentage of WEA-capable phones *offered* is used as a proxy for the percentage of WEA-capable phone in circulation.

growth rate in which WEA-capable phones offered saturate the market in three years (dotted blue line) and (2) a slow growth rate in the percentage of WEA-capable phones in which the market is saturated in six years (dotted red line). Put another way, the two dotted curves show when the supply of WEA-phones meets the possible demand. The other two curves show the demand, which is the rate at which the population acquires a WEA-capable phone. In the three-year growth rate scenario, ownership of WEA-capable mobile phones exceeds the 90-percent level by 2016. In contrast, the percentage of WEA-capable mobile phones does not exceed 90 percent in the six-year growth rate scenario until 2018, at which point all newly offered mobile phones are WEA-capable in both cases. Compared with Figure 6.6, Figure 6.7 may give a more realistic depiction of the proliferation of WEA-capable phones.

Figure 6.7. Estimated WEA-Capable Phones in Circulation Over Time



Note: Assume increasing number of WEA-capable phones offered over time.

This chapter examined available data on WEA adoption in mobile phones and estimated future WEA compatibility. The wireless industry went through an analogous

transition in the previous decade when the FCC mandated that mobile phones be compatible with Enhanced-911 (E911) geolocation standards. The FCC's final rule was issued in 1998 and mandated 95-percent penetration of E911-capable mobile devices by the end of 2005 (47 CFR §20.18). During the transition, many CMSP's reported their E911-capable device penetration in quarterly reports to the FCC.[38] Many CMSPs met the target penetration rate of 95 percent by 2005, but several others, including some Tier I CMSPs, did not (Telecompaper, 2007). In other words, it took at least seven years, if not longer, for E911-capable device penetration to reach 95 percent.

In contrast to the E911 transition, the FCC has not mandated WEA device penetration targets and dates for CMSPs. Note that the results in Figure 6.7 show a WEA-capable device penetration rate that is marginally faster than that mandated for E911. Using relatively pessimistic assumptions, we estimate a 95-percent penetration rate for WEA-capable phones within six years of system introduction, as opposed to seven years to reach an approximate penetration rate of 95 percent for E911-capable devices. This comparison indicates that our device replacement model may still be somewhat optimistic, even if we assume it takes six years to saturate the market with WEA-capable devices. The experience of the E911 transition indicates it may take one to two additional years (until 2018) to reach a WEA-capable mobile device penetration rate of 90 percent.

In the concluding sections of this report, the reader will find future WEA penetration estimates that are based on several assumptions for each major component of the system. One of these assumptions is that Tier I CMSPs will offer only WEA-capable devices by 2018, according to the penetration curve shown in Figure 6.7.

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[38] E911 – Carrier Quarterly Reports, available at http://transition.fcc.gov/pshs/services/911-services/enhanced911/phase2-waiver.html (Accessed April 30, 2013)

7. Estimated Population Adoption

The report so far has described data and analyses related to AOs and CMSPs. This chapter presents factors related to subscribers, beginning with a recap of the U.S. population covered by at least one CMSP participating in WEA, and then focusing on phone ownership and the ability to comprehend a WEA message. The first section considers demographic characteristics affecting possession of a WEA-capable mobile device. The second section describes factors affecting awareness or understanding of a WEA message.

U.S. Population with WEA Coverage

As stated in Chapter Five, CMSPs in the CR dataset were matched to WEA Election Letters submitted to the FCC to determine the geographic prevalence of WEA-compatible CMSP coverage. Results indicate that approximately 73.2 percent of the U.S. landmass and 99.4 percent of the U.S. population are covered by at least one CMSP that either elected to participate fully or partially in WEA.

Factors Affecting Possession of a WEA-Capable Mobile Device

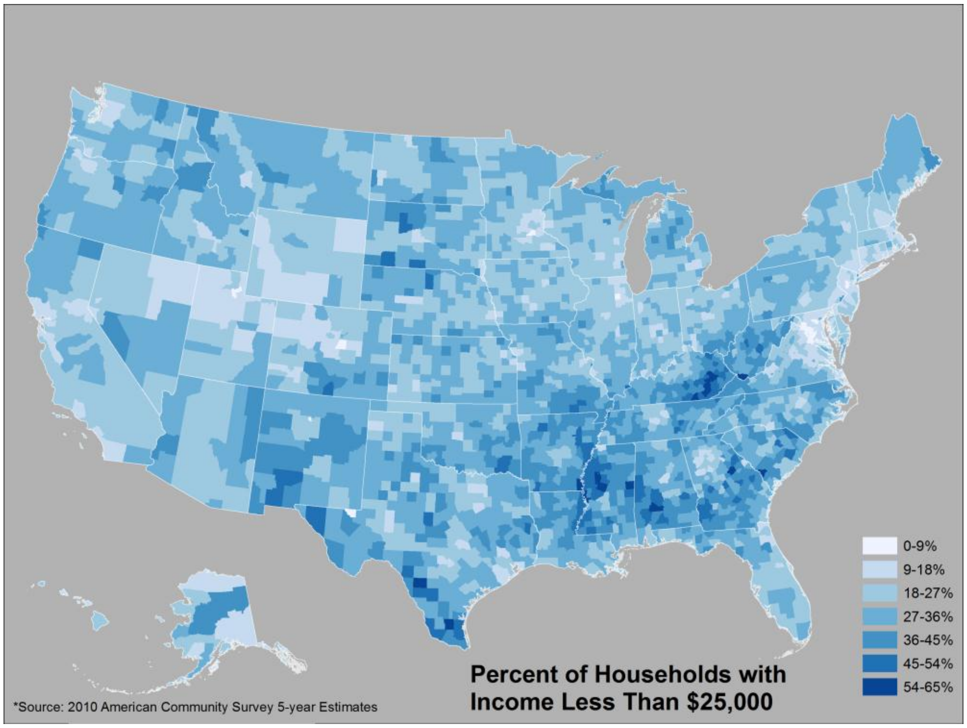
To be able to receive a WEA message, subscribers must have a WEA-capable mobile device. The previous chapter focused on the proliferation and adoption trends of WEA-capable phones among both CMSPs and subscribers. This chapter describes demographic characteristics that affect possession of a WEA-capable mobile device, including

- income
- age
- institutionalization
- being a foreign visitor to the United States.

Low Income. Individuals with lower income have limited disposable income and may not have funds available to maintain a mobile device. Figure 7.1 shows the prevalence of U.S. households with less than $25,000 annual income. Nationally, 25 percent of U.S. households have an annual income of less than $25,000, but the

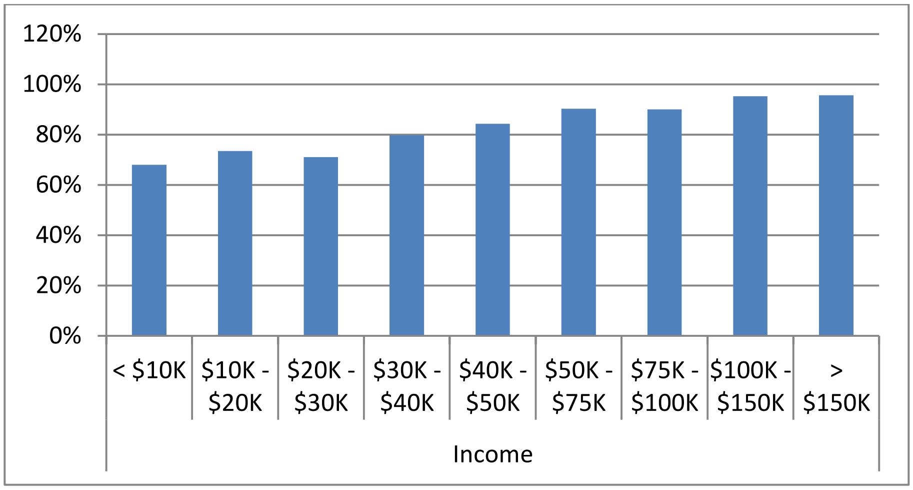
prevalence of lower-income populations varies county-by-county from 0 percent to over 64 percent. Some states, such as Mississippi, have more low-income households, whereas other states, such as Maryland and New Jersey, have relatively few such households.

Figure 7.1. Prevalence of Low-Income Households, by County



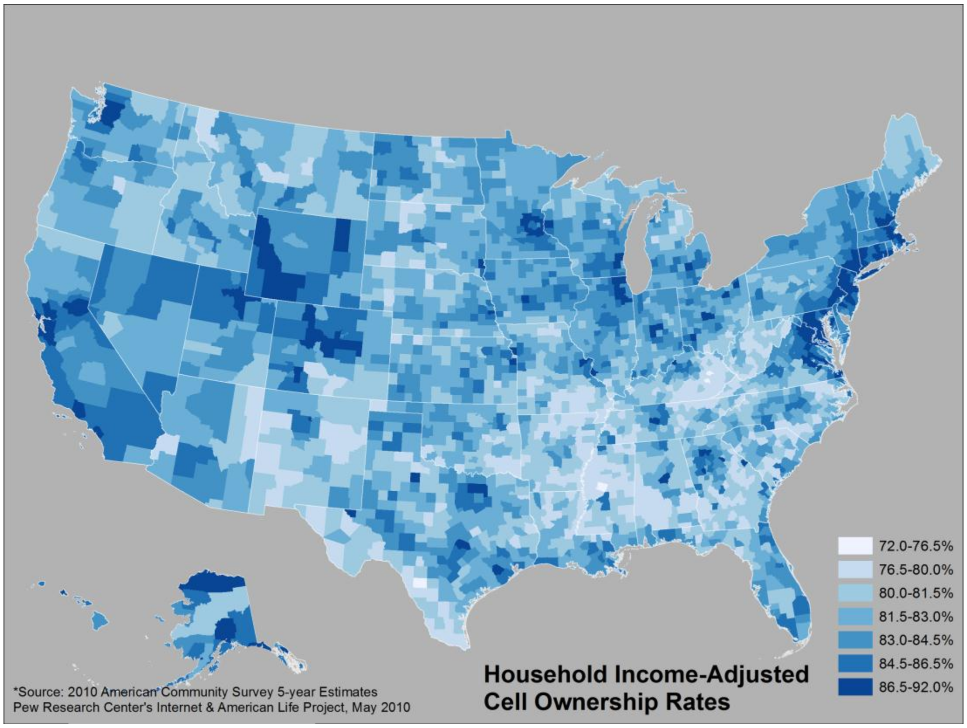
As shown in Figure 7.2, mobile phone ownership increases with income, such that those with the very lowest incomes have the lowest ownership rates. As of 2010, 81.7 percent of all U.S. adults own a mobile phone, but only 71 percent of those with annual incomes of $30,000 or less report owning a mobile phone (Pew, 2010b).

Figure 7.2. Mobile Phone Ownership, by Income



Combining these two sources of information, Figure 7.3 adjusts the national rate of adult mobile phone ownership by each county's income distribution. Income-adjusted rates vary by approximately 15 percent county-to-county. In particular, income-adjusted mobile phone ownership rates in the northeast tend to be higher than those in West Virginia and the Ohio and Mississippi river valleys.

Figure 7.3. Income-Adjusted Mobile Phone Ownership Rates, by County



For WEA test planners and emergency managers, these data illustrate the likelihood that a WEA message will reach the individuals in their jurisdictions. In areas with high concentrations of low-income households, where mobile phone ownership is likely lower, using other dissemination methods for alerts and warnings may be even more critical. Other methods of alerts and warnings will especially be needed in isolated low-income communities with low mobile phone ownership.

A federal government program, Lifeline, already exists to help ensure that all Americans have the opportunities and security that phone service brings. While Lifeline started off as a program for landline service, Lifeline discounts were extended to pre-paid wireless service plans starting in 2005. The program, which varies from carrier to carrier, typically provides a free or reduced-cost mobile phone, 250 free minutes per month, and text messaging (note that WEA messages are free and do not rely on an SMS text messaging plan) to qualified low-income households. The Universal Service Fund fee on telephone bills funds Lifeline. To qualify, subscribers must have a household income below 135 percent of federal poverty level (up to 150 percent in some states) or participate in another federal or state assistance program (e.g., Medicaid, food stamps).

They must also have a valid U.S. mailing address (not a P.O. box) and are limited to one Lifeline account per household.[39]

The Lifeline program has grown significantly since 2008. Lifeline subscribers increased from 6.7 million subscribers in 2008 to 13.7 million subscribers in 2011 (FCC, Universal Service Monitoring Report 2012). While these numbers reflect both landline and wireless subscribers, competitive eligible telecommunication carriers (CETCs) have received a growing share of total low-income support over the past ten years and now receive substantially more support than incumbent local exchange carriers (ILECs).[40] Support received by CETCs increased from $147 million in 2008 (18 percent of total) to $1.23 billion (69 percent of total) in 2011 (FCC, Universal Service Monitoring Report 2012). Data on the breakdown of landline and wireless Lifeline subscribers are not available, but the decrease in subsidies to ILECs suggests that a larger portion of the Lifeline program funds wireless subscribers than landline subscribers.

Age. Phone ownership also varies by age, as might be expected. Minors have less control over phone ownership and generational differences may limit phone ownership among the elderly. According to a national survey in 2010, 57 percent of adults age 65 or older reported owning a mobile phone and just 36 percent of adults age 80 or older (PEW, 2010b). On the other end of the age spectrum, 75 percent of U.S. teens (age 12–17) reported owning a mobile phone (PEW, 2010a), and only 20 percent of U.S. children (age 6–11) had a mobile phone (Mediamark, Kid's Cell Phone Ownership, January 2010). Figure 7.4 combines these data to give a sense of the overall distribution of ownership rates by age.

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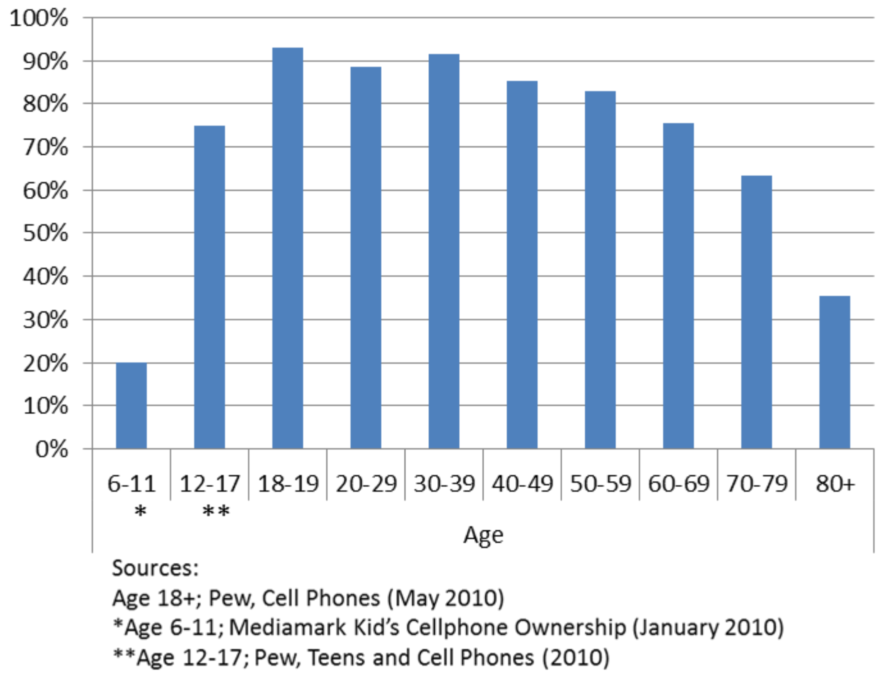
[39] For details, see http://www.fcc.gov/lifeline/.

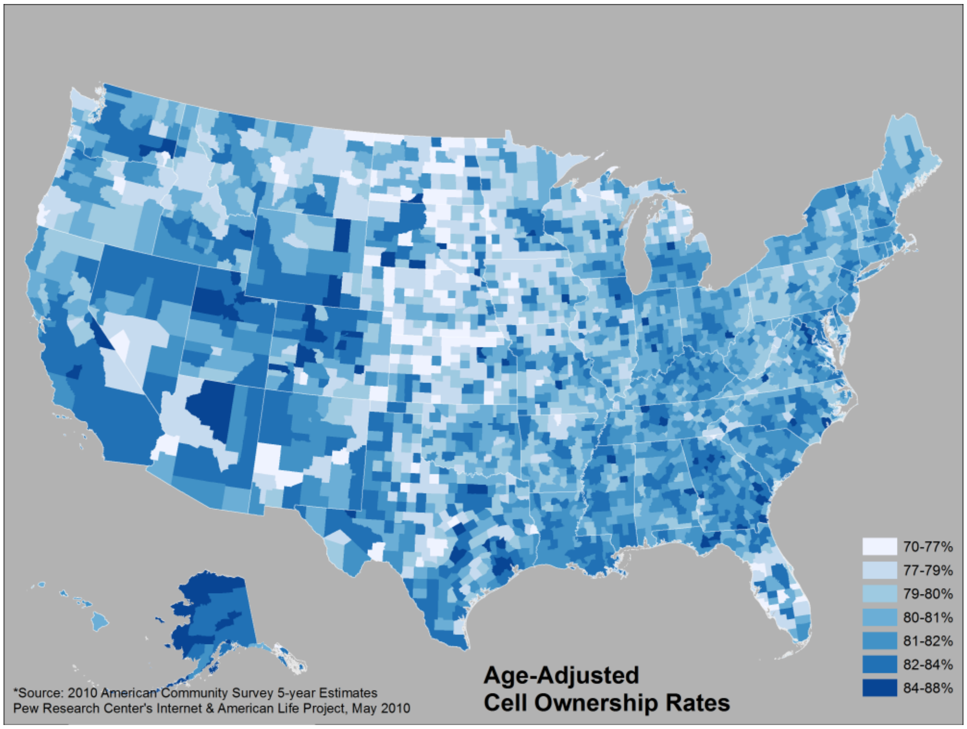
[40] CETCs include both wireless and landline carriers. ILECs include only landline carriers.

Figure 7.4. Mobile Phone Ownership Rates, by Age



Like income, age distributions also vary considerably across geographic regions. Figure 7.5 presents a similar analysis to that done by income, where the age-based mobile phone ownership rates are applied to county-by-county age distributions, providing an age-adjusted mobile phone ownership rate for each county.

Figure 7.5. Age-Adjusted Mobile Phone Ownership Rates, by County

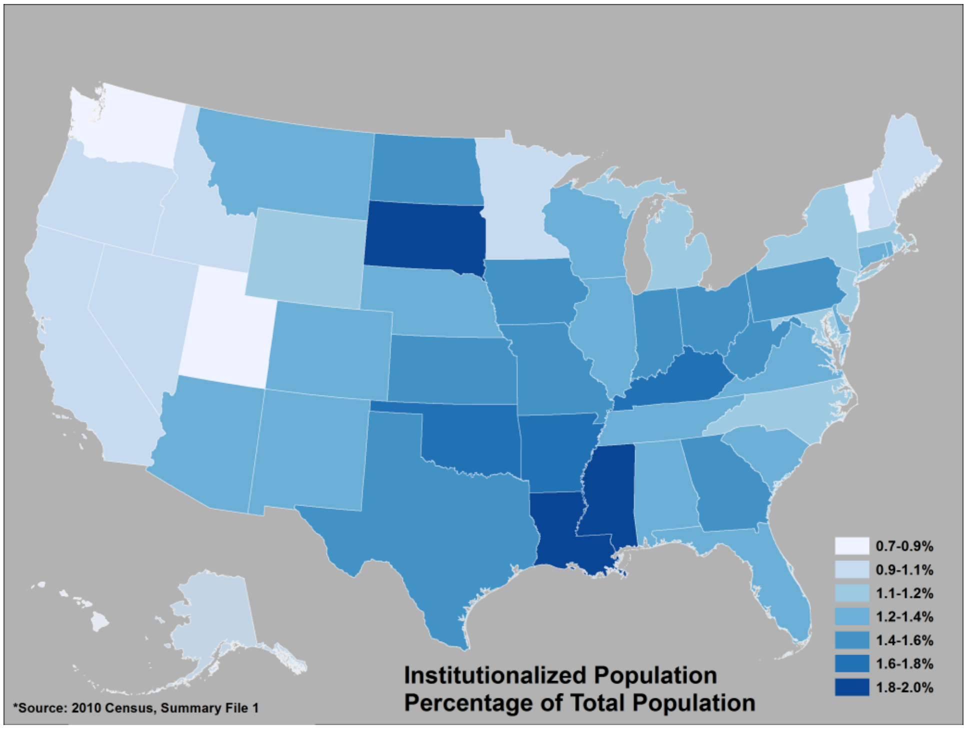


As with low income, age distributions in a given geographic area can help inform emergency alert planning, since these populations could represent a significant gap in WEA coverage. In many instances, assisted living facilities and retirement communities may provide concentrated locations to target alerts, and WEA test planners may want to take such factors into account. For example, if a locality contains a major assisted living facility, it might be informative to test reception of a WEA test message at that location. Furthermore, while residents may not receive a WEA message, it might be more important for the operators of the facility to do so, since their responsibility to care for the residents amplifies the importance of their successfully receiving the alert. Also, there are certain carriers and MVNOs that market their product specifically to low-income and elderly populations. Ensuring that these carriers are WEA-compliant will improve penetration in these populations.

Institutionalization. Institutionalized populations include individuals in correctional facilities, juvenile detention facilities, and nursing and long-term care facilities. These populations may be of significant size, and typically do not have access to mobile phones. The proportion of U.S. residents (age 5 or older) that are institutionalized varies across state, with Louisiana, Mississippi, and South Dakota

having rates approximately twice that of Utah, Washington, and Vermont (see Figure 7.6).

Figure 7.6. Prevalence of Institutionalized Populations, by State.

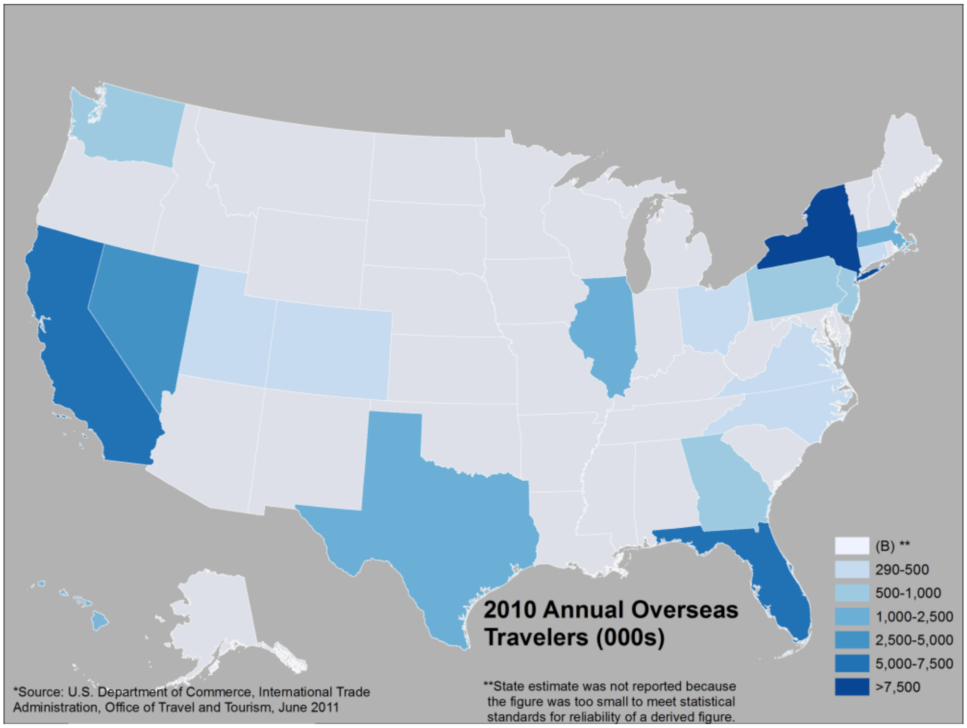


Of course, institutionalized populations are, by their very nature, concentrated in those institutions. Hence, their distribution will vary within a state, with specific counties (e.g., those housing major prisons) having much greater prevalence. Because of this, it may be less important for WEA message to reach specific institutionalized individuals than to reach the operators of those facilities. Indeed, test planners may want to consider institution management as an important (if small) sub-population, where reliability of alerting is particularly critical.

Foreign visitors to the United States. Nationally, on an average night, there are estimated to be 1.9 million foreign visitors in the United States, including 1.2 million overseas visitors, 0.4 million Canadian visitors, and 0.3 million Mexican visitors. There are also roughly 80 million annual day trips from Canada and Mexico or overseas pass-throughs, which amount to approximately 220,000 per day (U.S. Department of Commerce, 2011). Foreign visitors do not represent a segment of the U.S. population missed by WEA, but rather an addition to the existing resident population. Furthermore,

overseas visitors concentrate on the coasts and in more populous states, as shown in Figure 7.7, which amplifies their importance in these areas.

Figure 7.7. Prevalence of Annual Overseas Travelers, by State.



Many international travelers have mobile devices (ITB Berlin, 2010), and a few European countries are implementing cell broadcast–capable emergency messaging systems (e.g., Netherlands has NL Alert). However, even European mobile phones' are unlikely to be compatible with WEA. One solution may be to seek ways to facilitate use of temporary, U.S.-based phones by overseas visitors.

Factors Affecting Awareness or Understanding of a WEA Message

Even if someone owns a WEA-capable device and receives a WEA message, he or she may not comprehend the message. One of the most challenging issues for user acceptance and risk communication more broadly, is ensuring that alert messages provide actionable information to the public in a comprehensible manner. Poorly constructed WEA messages can cause confusion and be counterproductive to penetration/adoption. While concern about over-alerting can be addressed through better geo-targeting, poorly

designed messages cannot be improved by better technology. The content and format of alert messages must consider the social science of message understanding.[41] as well as demographic factors of the population. This section focuses on the demographic factors that can limit owners' ability to notice and understand a WEA message:

- Hearing and vision disabilities
- Cognitive disabilities
- Difficulty with English.

Hearing and vision disabilities. Nationally, 3.6 percent of the U.S. population age five and older are deaf or have hearing difficulty, while 2.2 percent are blind or have vision difficulty (one-year estimates, American Community Survey, 2010). Mobile device ownership rates for these populations are unknown. However, device manufacturers and CMSPs have made efforts to ensure that their devices and networks include accessible features so that these populations can make use of them.

Those with hearing problems may have difficulty noticing that a WEA message has been received if they do not hear the alert tones. The unique vibration alarm provides an alternate alerting avenue, but hearing difficulties may increase the likelihood that a WEA message will go unnoticed. The Wireless Rehabilitation Engineering Research Center

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[41] The U.S. Department of Homeland Security's Science and Technology First Responders Group/Office for Interoperability and Compatibility contracted the National Consortium for the Study of Terrorism and Responses to Terrorism (START) to provide research-based messaging guidance. The project will determine the content and form of optimized public alert and warning messages of various lengths for distribution over new and emerging public alert and warning technologies. It has three phases:

- Phase 1 (June 27, 2012–December 26, 2012) was just completed and culminated with a workshop of 23 agency, practitioner, and research experts. This report details the findings from that workshop held on November 13, 2012 in Washington, D.C., and the subsequent changes to the project's research design.
- Phase 2 (December 27, 2012–June 26, 2013) will test varied alert and warning message lengths by using Internet and laboratory experiments followed by focus groups.
- Phase 3 (June 27, 2013–June 26, 2014) will test Phase 2 conclusions in the "real world." The research team will select an actual public alert/warning event, and will conduct a survey on a representative sample of the population that experienced the event. In doing so, the optimized message conclusions reached in Phase 2 will be re-examined in the context of the "real world."

(Wireless RERC, 2009), a research organization focused on wireless technology and disabilities, recommends customizable attention signal volume and vibration strength (Wireless RERC, 2009). Furthermore, deaf individuals often rely on American Sign Language for effective communication. At this point, American Sign Language videos cannot be embedded within WEA messages, but programs such as Deaf Link are working to bridge this gap.

Vision difficulty, on the other hand, limits the ability of an individual to receive a text-based message. Text-to-speech technologies can be used to fill this gap, but their accuracy should be tested within the actual WEA system. This will be particularly true when dealing with special characters, acronyms, and other unusual text (Wireless RERC, 2009).

Both hearing and vision disabilities are in greater concentration in areas with more elderly populations. Figures 7.8 and 7.9 show state-by-state rates of hearing and vision difficulty, as reported on the 2010 American Community Survey.

Figure 7.8. Prevalence of Individuals with Hearing Difficulties, by State

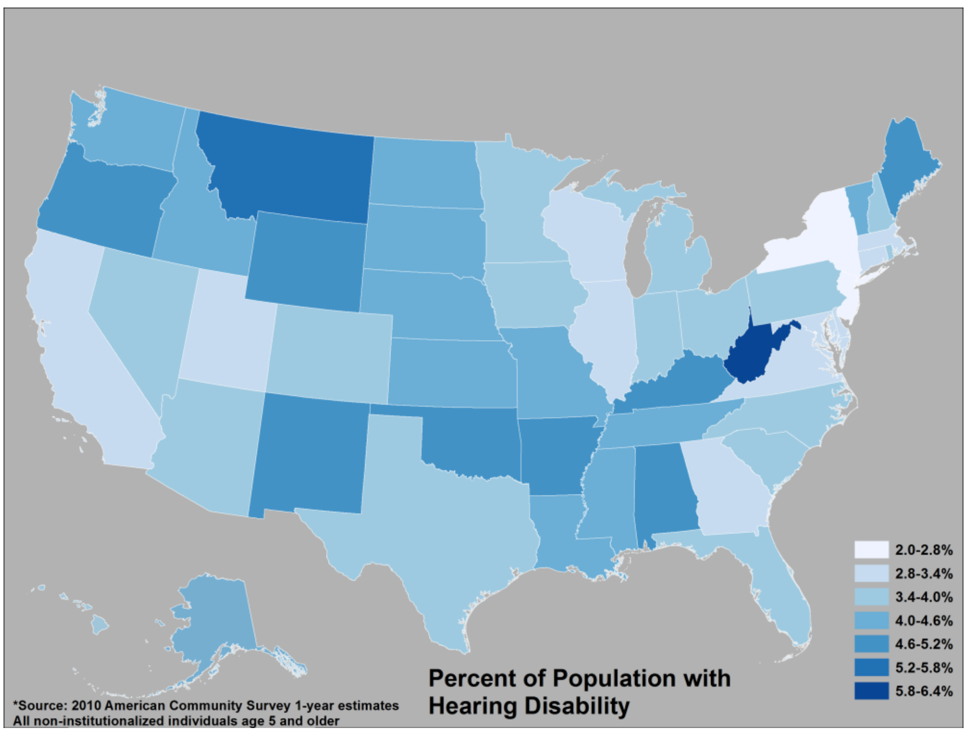
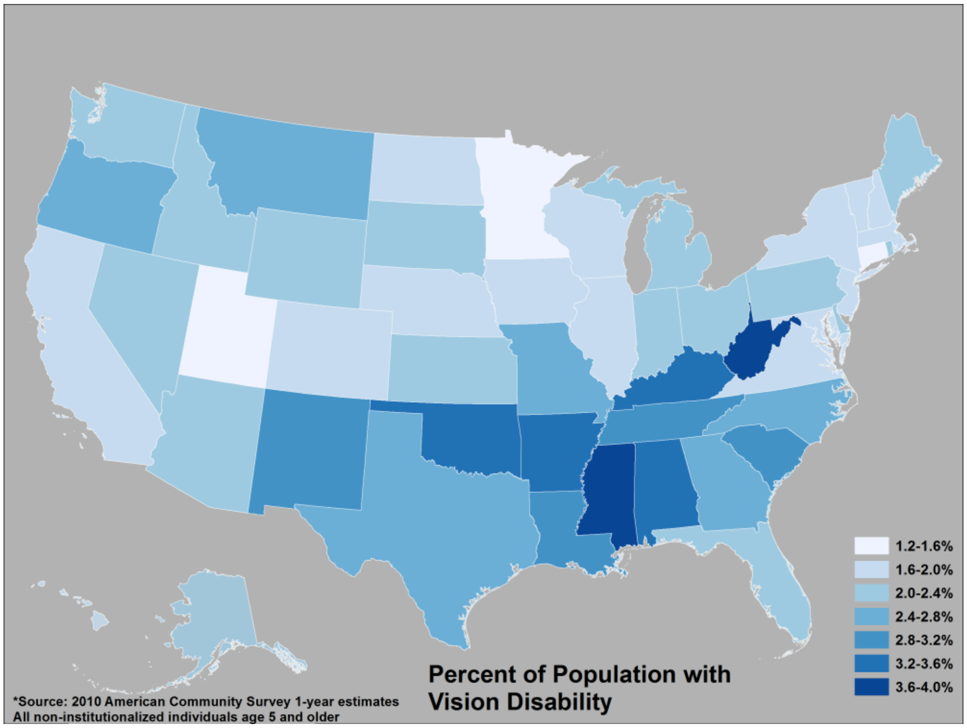


Figure 7.9. Prevalence of Individuals with Vision Difficulties, by State



The greatest rates of disability are in West Virginia, Mississippi (vision), and Montana (hearing).

A series of field trials focusing on EAS and WEA, conducted by Wireless RERC[42] in 2006–2009, highlighted the value of testing messages and the WEA system for those with disabilities. The purpose of the trials was to examine the accessibility and effectiveness of EAS and WEA messages to wireless devices. Some 119 individuals with diverse sensory limitations and technical skills participated in trials where three to four simulated emergency alerts were sent to each participant's mobile phone during a 90-minute test period. In both EAS and WEA tests, the mobile devices were loaded with client software capable of presenting alert content with accommodations for blindness or low vision (text-to-speech) and hearing-impaired users (specific vibrating cadences).

[42] Wireless RERC is funded by the National Institute on Disability and Rehabilitation Research under the U.S. Department of Education to conduct research and development projects dealing with accessibility of emergency communications and emergency alerting.

Findings from the WEA trials suggest that 83 percent of vision-impaired participants and 70 percent of hearing-impaired participants found the accessible WEA system an improvement over their current source of emergency alerts. Participants liked the convenient receipt of messages, saying that it helped them feel safer, but desired the ability to replay the message and adjust volume and vibration strength (Wireless RERC, 2009). These findings highlight the potential of WEA to be an added resource to populations that are already at a disadvantage in other alerting channels.

Programs, such as Deaf Link,[43] offer solutions for targeting hazard alerts to individuals who are deaf, blind, and/or hard of hearing. The system, known as the Accessible Hazard Alert System (AHAS), sends accessible alerts to Internet and video-capable devices such as computers, mobile phones, iPads, and wireless Braille readers. Alerts are offered in American Sign Language and English voice and text.

Cognitive disabilities. Cognitive disabilities may limit the ability of an individual to understand the content of a text message, rather than perceive the message at all. Terse messages, jargon, or unfamiliarity with text messages or the WEA system may exacerbate these challenges. Therefore, a systematic program for testing messages, which can ensure maximum comprehension with a wide range of recipients of diverse abilities, will be particularly important. Awareness campaigns and regular system testing (involving end users) may also help increase familiarity and comfort with the system.

Nationally, 4.9 percent of the U.S. population over five years old has some level of cognitive difficulty (2010 American Community Survey). Figure 7.10 displays the variation in this rate across states.

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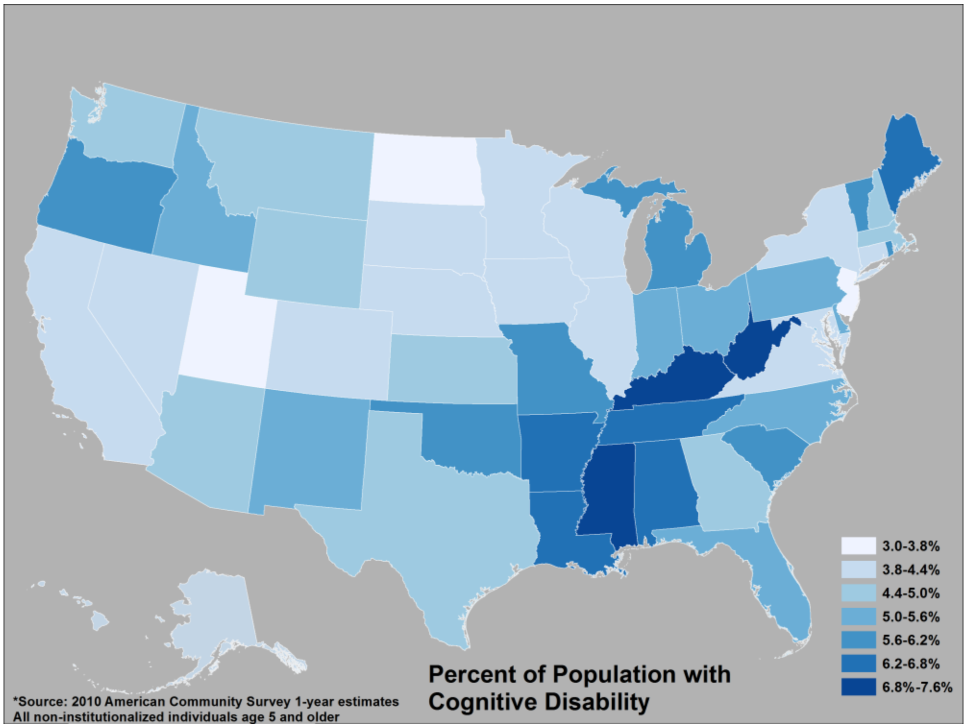
[43] For more information, see http://www.deaflink.com/.

Figure 7.10. Prevalence of Individuals with Cognitive Disabilities, by State



Difficulty with English. As a text-based system, WEA relies on recipients' ability to read and understand the messages sent. Given that WEA is currently English-only, an individual's lack of comfort with written English clearly limits the messages' effectiveness for that individual. The National Center for Education Statistics conducts the National Assessment of Adult Literacy (NAAL), an in-depth national test of individuals' ability to read and comprehend written English. Due to the complexity of the survey, it is administered infrequently and was last conducted in 2003. Nevertheless, it remains the most comprehensive assessment of adult literacy in the United States to date. According to the NAAL, in 2003 approximately 15 percent of the U.S. population read at "below-basic" levels, which includes no more than the most simple and concrete literacy skills (National Center for Education Statistics, 2006).[44] As shown in Figure 7.11, illiteracy rates were greatest in New York, California, Texas and Florida, but were also relatively high throughout the south and Mid-Atlantic States.

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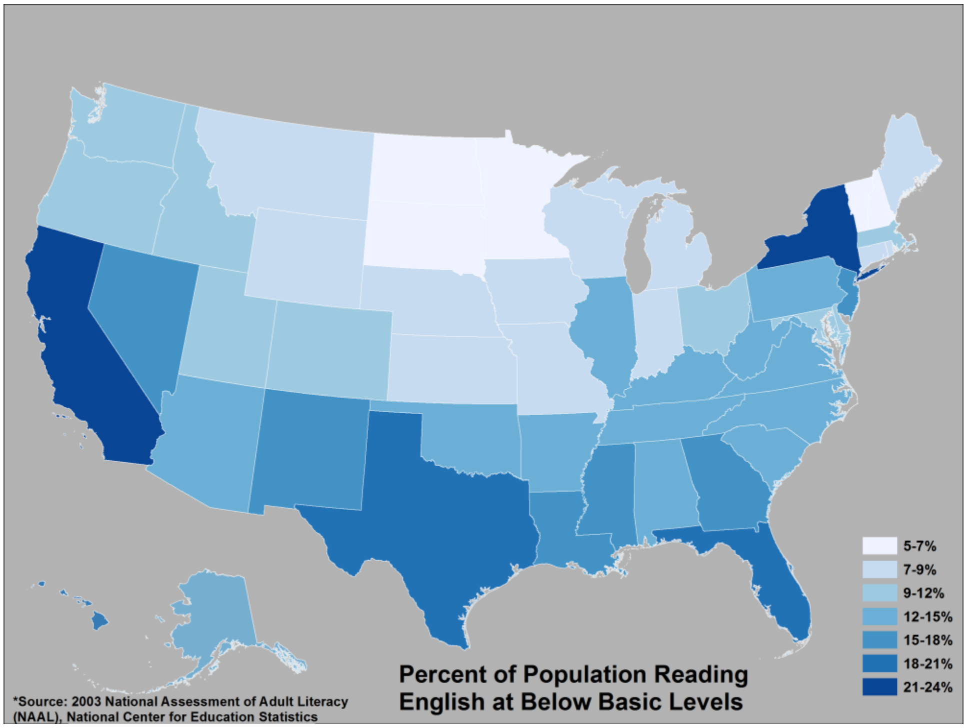
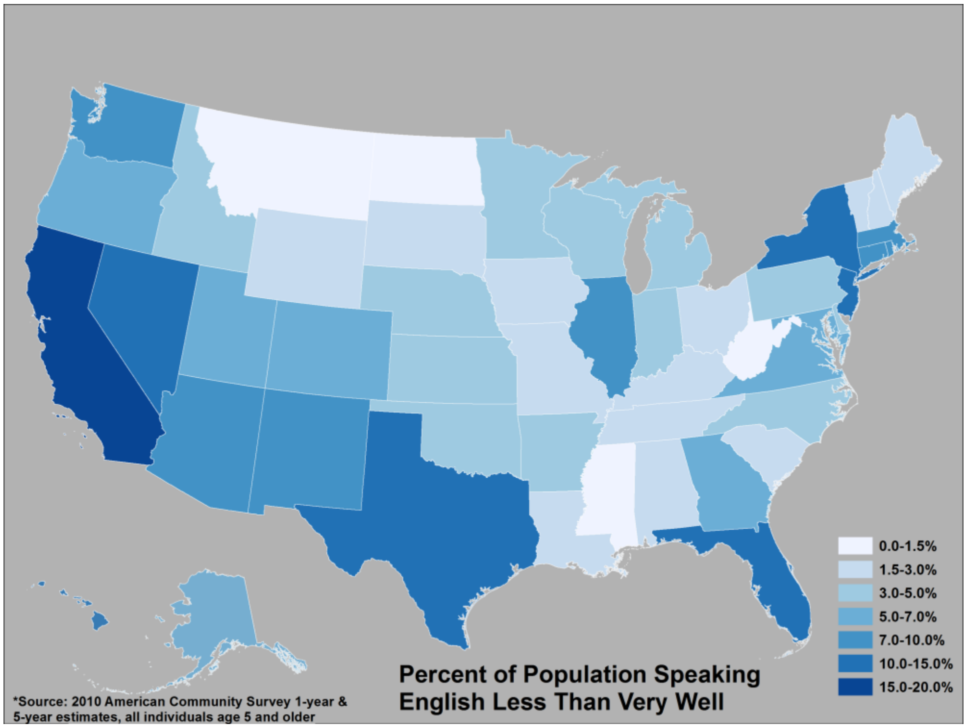
[44] Specifically, individuals in this classification range from being illiterate to "locating easily identifiable information," but not "reading and understanding information in short, commonplace prose texts" (see National Center for Education Statistics, Table 1.1, 2006).

Figure 7.11. Prevalence of Below-Basic Reading Ability, by State



The issue of illiteracy closely relates to that of English proficiency, and data on the latter are more recent. Specifically, the American Community Survey, available as recently as 2010 (American Community Survey, 2010), estimates prevalence of non-English speakers who do not speak English very well. As shown in Figure 7.12, the rates of individuals who read and speak English poorly correlate highly across states. Changes in demographics between 2003 (Figure 7.11) and 2010 (Figure 7.12) may be one cause of differences between the two maps. However, there is a large population of English speakers who do not read, particularly in the Mississippi and Ohio river valleys, as well as Appalachia. West Virginia, for example, has a 13.5-percent rate of below-basic reading, but only a 0.7-percent rate of non-English speakers speaking English less than "very well."

Figure 7.12. Prevalence of Non-English Speakers Who Speak English Less Than Very Well, by State.



At the aggregate level, a lack of spoken English proficiency may act as a proxy for a lack of written English proficiency. Table 7.1 lists the six languages with the greatest number of speakers who speak English less than very well. Spanish is by far the most commonly spoken non-English language, with over 35 million speakers and over 16 million of those speaking English less than very well. It is important to note that the two columns are not perfectly correlated. In particular, while Tagalog is more commonly spoken in the United States than Vietnamese, Vietnamese speakers are more likely to have difficulty speaking English than are Tagalog speakers.

Table 7.1. Incidence of Non-English Speakers Who Speak English Less Than Very Well, by Language Spoken at Home

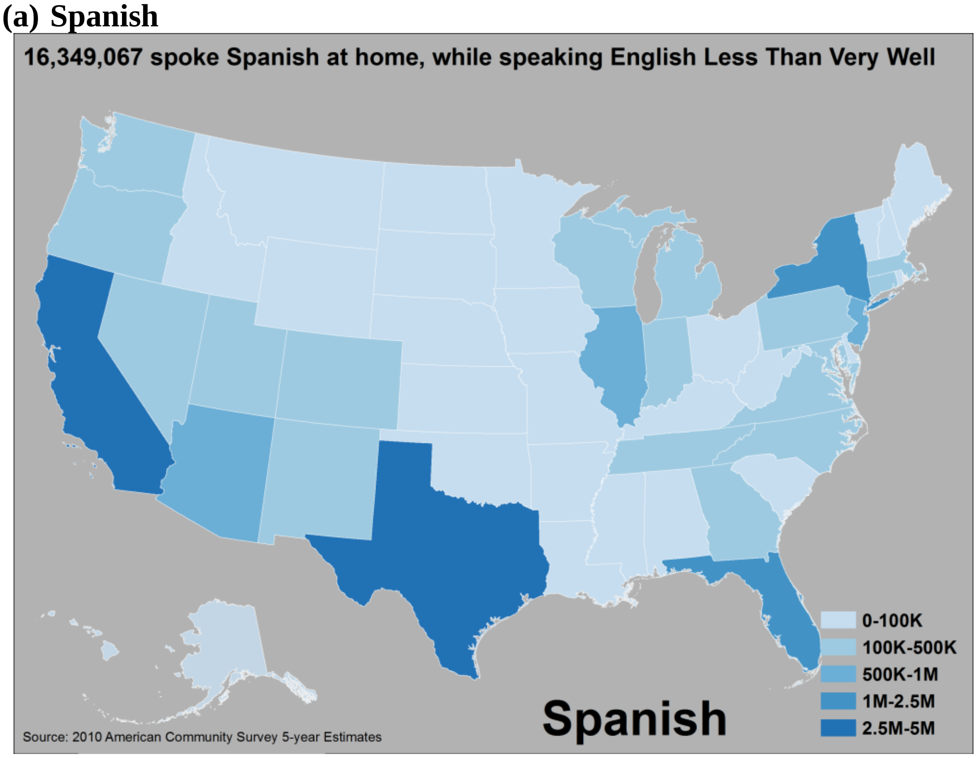
Language	Number of Speakers	Number Speaking English Less Than "Very Well"
Spanish and Spanish Creole	35,470,765	16,349,067
Chinese	2,656,309	1,459,433
Vietnamese	1,292,672	776,595
Korean	1,104,243	630,118
Tagalog	1,535,585	479,523
Russian	830,456	413,107

Source: U.S. Census Bureau, 2010; American Community Survey 5-year Estimates; Age 5 years or older.

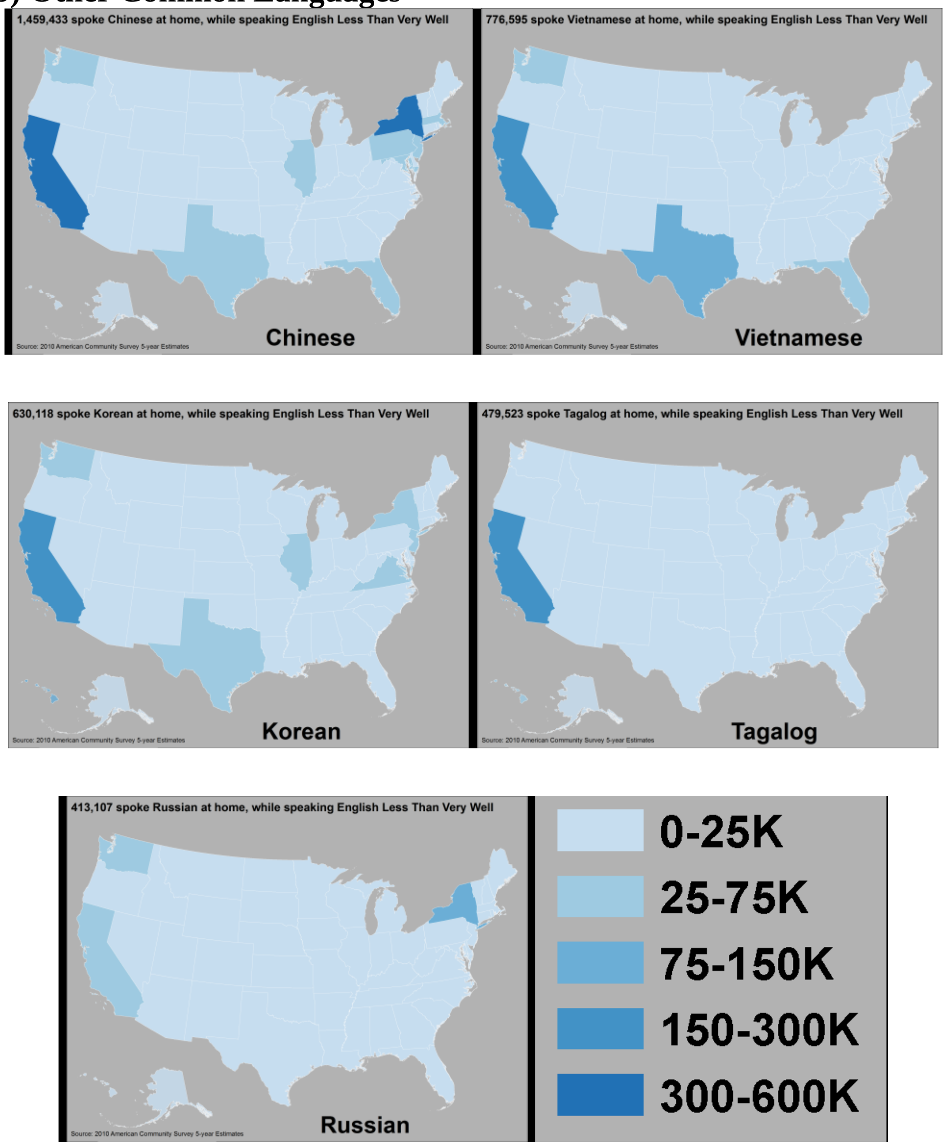
Whereas Spanish is typically the most common non-English language regardless of location in the United States, the prevalence of other languages varies geographically. For example, Chinese and Russian are particularly common in New York, whereas Vietnamese, Chinese, and Korean are more common in Texas. Figure 7.13 displays the geographic variation for the six languages listed in Table 7.1.

Figure 7.13. Incidence of Non-English Speakers Who Speak English Less Than Very Well, by Language Spoken at Home and State

(a) Spanish



(b) Other Common Languages



From a policy perspective, both illiteracy and lack of English proficiency pose challenges to a written, English-only WEA system. Potential solutions include originator-based strategies, such as translating and broadcasting WEA messages in multiple languages, or user-based strategies, such as multi-lingual text-to-speech settings on mobile devices. Additionally, WEA messages should be subject to a rigorous program of pilot testing to assess comprehension of the message across languages, in terms of both content and structure.

How Disadvantaged Populations Cluster Across States

As described in the previous sections, there is substantial geographic variation in the prevalence of each disadvantaged population. This begs the question as to whether there are commonalities in this geographic variation, particularly since many of these groups may be related to underlying forces, such as socio-economic or cultural factors. Using a statistical method called cluster analysis, the research team identified four “clusters” of states that are more similar to each other (in this case, on the prevalence of disadvantaged populations) than to other cases.[45]

These clusters (shown in Figure 7.14) highlight how different locations face different population-based challenges, with respect to achieving full WEA utility. The commonalities within clusters, however, could provide the basis for collaborative efforts (e.g., resource sharing), regional tests targeting specific solutions, or engagement of regional CMSPs to address local issues (e.g., low literacy in Appalachia).

The first cluster, located largely in the south and southeast, is relatively high in disability, illiteracy, institutionalization, and poverty rates. The second, comprising most of the north, is relatively modest in all categories. The third, which includes the southwest, Texas, Florida, Illinois, New York, and New Jersey, primarily faces language-related challenges. Finally, Washington, D.C., is a cluster unto itself.

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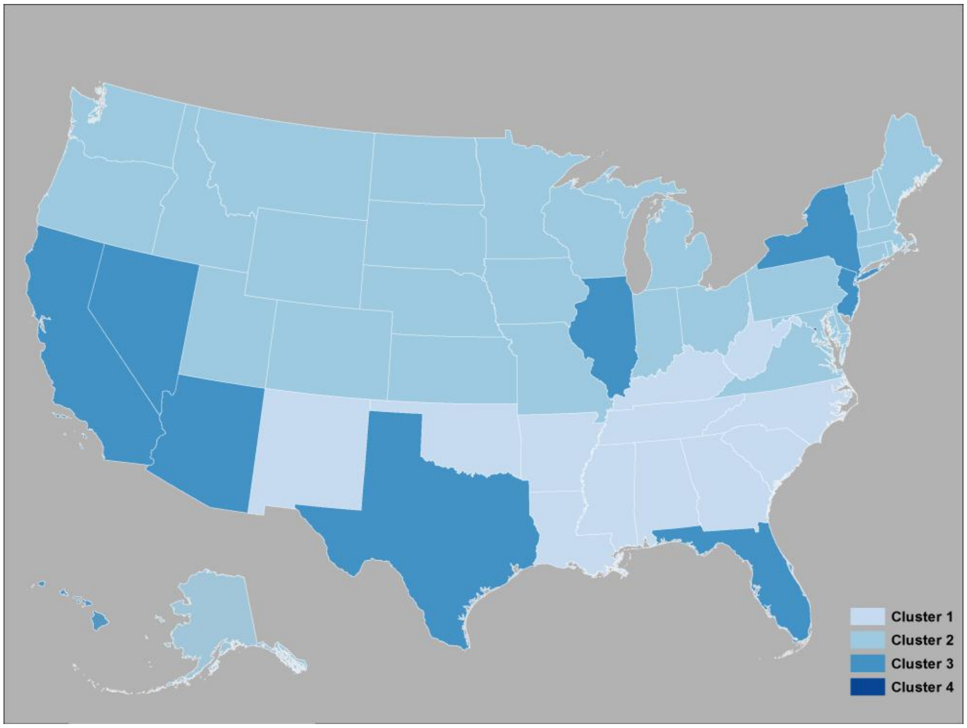
[45] Specifically, a hierarchical cluster analysis was conducted using between-groups linkage and interval (squared Euclidian distance) measures, using SPSS 14.0 statistical software. A dendrogram provided the basis for identifying the four-cluster solution. Solutions with more or fewer clusters were qualitatively similar.

Figure 7.14. Four Clusters of Disadvantaged-Population Profiles



Note: Cluster 4 consists solely of Washington, D.C.

Table 7.2 describes the clusters themselves in more detail. It presents the mean rank, across states, for each cluster (column) and disadvantaged population (row). Higher numbers indicate that the states in that cluster are more disadvantaged, on average, relative to other states.

Table 7.2. Cluster Size and Mean Rank on Each Disadvantaged Population

	Cluster 1 (Percentage)	Cluster 2 (Percentage)	Cluster 3 (Percentage)	Cluster 4 (Percentage)
N	12	29	9	1
Mean Rank				
Hearing Difficulty	38.1	27.2	12.6	1.0
Vision Difficulty	46.3	20.5	20.8	9.0
Cognitive Difficulty	42.9	23.6	13.1	34.0
Low Literacy	37.5	15.1	43.4	48.0
Speak English LTVW	18.3	22.7	47.0	25.5
Institutionalized	38.8	22.6	20.4	21.0
Below Age 18	30.7	24.3	28.1	1.0
Age 65 or Over	24.5	28.2	23.1	6.5
Household Income < $30K	45.2	20.8	18.2	18.0

Note: Higher mean ranks indicate greater mean disadvantage. LTVW = less than very well.

8. User Acceptance and Public Awareness

Once a user has a WEA-capable mobile device and is connected to a WEA-capable network, the final step for WEA penetration (see Figure 2.1) involves user acceptance of both the WEA system and the sent message (which includes taking appropriate action based on the message). This chapter has three parts. The first section of this chapter describes user acceptance of the WEA system, focusing on the opt-out choice. The second section presents findings and theories from behavioral research about public response to alerts and warnings. The chapter concludes with a discussion of the low rate of public awareness of the WEA system, a factor that affects both acceptance of the system and whether users take the action recommended in the WEA message.

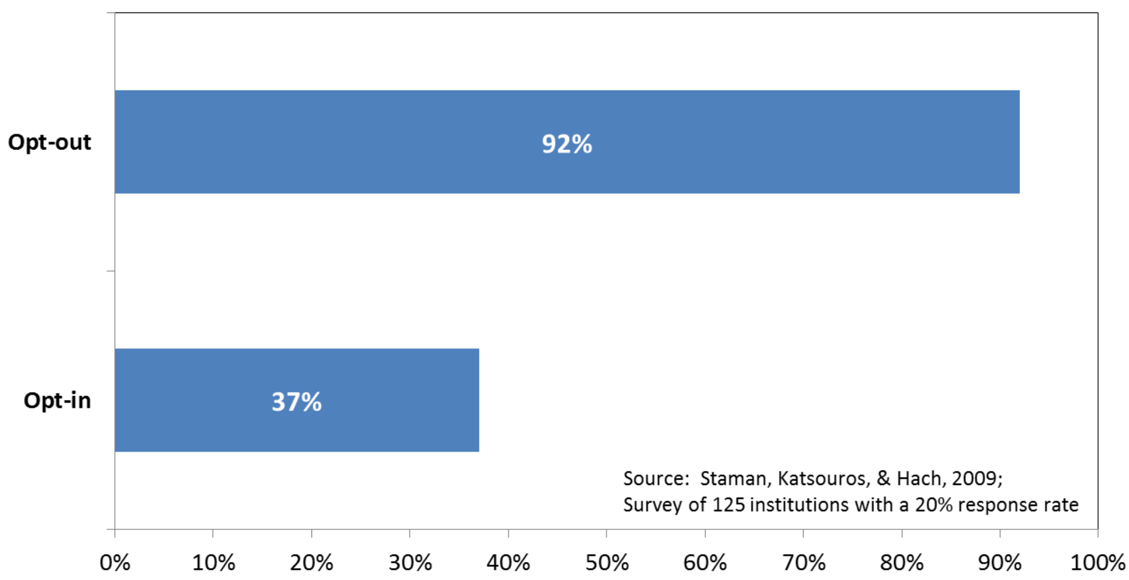
User Acceptance of the WEA System

One of the central characteristics of the WEA program, from the end-users' perspective, is that users are automatically opted in to the system. If they wish, they may opt out of the imminent threat and AMBER alert portions of the system (not the presidential alerts), but the default is participation. Past behavioral research strongly demonstrates that opt-out programs (i.e., those that require an explicit action to leave the program) typically have much higher participation rates than opt-in programs (i.e., those that require an explicit action to join the program; Loewenstein, Brennan, and Volpp, 2007; Madrian and Shea, 2001). This is, in large part, due to a general tendency of individuals to stick with an established status quo or default option, rather than switch from that status quo (Johnson, Bellman, and Lohse, 2002; Samuelson and Zeckhauser, 1988). The opt-out design of the WEA system ensures greater program participation by taking advantage of this aspect of human behavior. One benefit of the opt-out system is that failure of an individual to opt-out of the system (e.g., if they planned to, but forgot) is preferable for both the individual and society, than failure of that same individual to opt-in to such a system (Staman, Katsouros, and Hach, 2009; Thaler and Sunstein, 2009).[46]

[46] Even requiring an "active" decision about enrollment, rather than opt-out, has been shown to increase participations rates over opt-in (by 28 percent in one study of retirement plans; Carroll et al., 2009)

Unlike SMS-based reverse-911 systems, WEA does not provide a direct means of collecting information about how many people participate in the program. And whereas direct evidence on opt-out rates for WEA does not yet exist, lessons may be learned from other similar systems. A survey by EDUCAUSE (Staman, Katsouros, and Hach, 2009) of colleges and universities focused on emergency notification systems. The authors report that, among the institutions they surveyed, systems in which individuals are automatically included and must deliberately opt-out have much higher participation rate (over 92 percent, on average), than do institutions where individuals must deliberately opt-in (37 percent participation, on average; see Figure 8.1).[47]

Figure 8.1. Campus Alert System Participation Rates



For example, Notre Dame increased its SMS emergency messaging system's participation rate from 62 percent to 90 percent by switching from an opt-in to an opt-out policy (as reported in Latimer, 2008). And Virginia Tech, which has an opt-out system,

[47] The survey participation rate for this study was rather low, with responses from only 20 percent of 125 institutions contacted. If it is presumed that responding institutions may also be higher-performing, then these rates may expected to be biased upward. However, given past behavioral research on other types of systems and the fact that this bias would affect both rates, it is unlikely that this substantively changes the overall contrast between opt-out and opt-in participation rates.

reportedly has participation of about 85 percent among students, faculty, and staff (National Research Council [NRC], 2011). In contrast, users must actively opt-in to the DC Alerts system, which has a much lower participation rate, reportedly between around 30,000 to 70,000 users (out of several million in the D.C. area; NRC, 2011). Wireless AMBER alerts, a national program that is also opt-in, reportedly has an enrollment of about 600,000 users nationwide.[48]

Of course, all of these systems use SMS, which entails a greater risk of unwanted messages, and hence greater risk for message fatigue. Message fatigue was a frequently cited concern among potential AOs, noting that it would reduce the potential utility of the system by encouraging users to opt-out.[49] WEA's tight regulation of the types of messages to those that pose a near-term threat to life or property largely eliminates the risk of unwanted messages. Other features of the system, such as increased geo-targeting capabilities (another frequent request of AOs), also hold the promise of reducing message fatigue.

Given that user participation in the WEA program is a necessary condition for a WEA message to help that individual in an emergency situation (see Figure 2.1), and because all evidence suggests that an opt-out policy will result in dramatically greater participation rates than would an opt-in system, it follows that keeping the program opt-out will result in the greatest protection of the public. Furthermore, systematic data collection on who opts out of WEA, how many opt out, and under what circumstances they opt out would facilitate program management decisions designed to ensure that the system is effective and remains effective over time.

User Acceptance of a WEA Message

Once people receive an alert message and understand what it means, they typically must still take steps toward acting on the message (Mileti and O'Brien, 1992; Mileti and Sorensen, 1990; NRC, 2011; START, 2012). These steps include the following:

- Belief that the warning is credible
- Confirmation of the threat

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[48] Personal communication with Bob Hoever, Associate Director, National Center for Missing and Exploited Children, at the WEA Forum in Las Vegas, NV, February 21, 2012.

[49] Personal communications, WEA Town Hall in Columbus, OH, May 22, 2012.

- Personalize the threat
- Determine whether protective action is needed
- Determine whether protective action is feasible.

Users may fail to take any one of these steps, which results in their not taking protective action. The sections below briefly explore each of these steps in detail.

Believe the warning is credible. People must recognize the source of the message (i.e., the messenger), trust that source, and believe that the threat described in the message is real. It is particularly important to identify the source of the alert. If the source of a message is not given, people are likely not to trust the message as valid (NRC, 2011). Other factors that affect the public's trust of a message include perceptions of whether the source has appropriate expertise and whether it has a protective responsibility for the particular event. Given that condition, different sources may be viewed as more credible in different situations (e.g., NWS for weather events, DHS for terrorist events). Other factors that influence perceived credibility include consistency in messaging, perceptions of accuracy and honesty, clarity, certainty with which the message is delivered, sufficiency of the information provided, clear guidance for action, and repeated messaging across multiple channels (Fitzpatrick and Mileti, 1991; Mileti and O'Brien, 1992). Messages available in a users' native language may also lend credibility (as well as increase comprehension), since the messages will appear more targeted to the specific users. Finally, all things being equal, local authorities possess local expertise and responsibility, and so may be viewed as more credible. Hence, engaging local authorities in messaging may be beneficial (NRC, 2011).

Confirm the threat. After receiving a message, people naturally try to seek out information about the threat and risk, including accessing other media (e.g., radio, television), conducting online searches, consulting social media, calling people they know, or having conversations with others in their vicinity (see, e.g., Dow and Cutter, 1998; Drabek, 1969, 1992; Fitzpatrick and Mileti, 1991; Mileti and Darlington, 1997). Current WEA 1.0 guidelines prohibit inclusion of web links in messages, which could be used to provide confirmation of the threat. Absent this, individuals will likely seek out confirmation in the ways that are most natural or convenient for them. As noted in a recent NRC report (NRC, 2011), this very likely could include using their mobile devices to make phone calls or access web content. If enough people do this, it may bring down the networks in the same way that the prohibition on web links was designed to prevent. Hence, consideration should be given to managing this information-seeking process. While web links are not allowed in WEA 1.0, messages can still reference secondary

sources such as radio, television, or other sources that place minimal burden on already stressed networks.

Furthermore, different racial or ethnic groups may seek out information in different ways, may differ in their trust of authorities, and may seeking multiple confirmations from informal sources and delaying protective action (Fothergill, Maestas, and Darlingon, 1999; NRC, 2011). Awareness of these tendencies, along with engagement of local leaders who may be tied into social networks, is necessary to address the potential gaps in risk communication that can result.

***Personalize the threat and determine whether protective action is needed*.** People must determine whether the threat is relevant to them, believe that it can potentially affect them, and decide whether they need to take protective action. Past experience can be a powerful factor (see, e.g., Mileti and O'Brien, 1992; Perry, Greene, and Lindell, 1980), as has been shown in a wide variety of protective and health behaviors (Institute of Medicine, 2002). For example, research suggests that near misses (e.g., from hurricanes that were predicted to affect a given location) can actually *reduce* perceived risk among those lucky enough to experience the near miss (see, e.g., Dillon, Tinsley, and Cronin, 2011). On the other hand, past vaccination behavior was one of the strongest predictors of vaccination during the H1N1 pandemic (Gidengil, Parker, and Zikmund-Fisher, 2012; Maurer, Parker, Harris, and Lurie, 2009; Seale et al., 2010).

***Determine whether protective action is feasible*.** People need to decide whether they are able to take action and if they have the resources to do what is required. This step is of particular concern for several of the disadvantaged population characteristics described in Chapter Seven. For example, low-income households may have fewer resources, lower access to transportation, and other limitations on their ability to act. Individuals with disabilities may face other challenges, such as limitations in their ability to receive up-to-date information, and may depend on others for transportation and other needs. Older adults are more likely to face sensory and physical limitations, including dependence on others for transportation. Institutionalized populations, by their very nature, rely more on others for their safety. Finally, foreign visitors may lack knowledge of their location and resources available to them. Hence, for such individuals, even if they receive the alert, understand the alert, and fully wish to act upon it, there still may be limits to what they can do to protect themselves.

Public Awareness

Conversations with emergency management personnel at the May 2012 WEA Forum in Columbus, OH, highlighted a lack of WEA awareness among potential AOs. Whereas existing data on public awareness of WEA are not available, it is reasonable to assume that public awareness is low as well. Potential AOs at the WEA Forum frequently cited the lack of public awareness of WEA as a concern. Without public awareness, several of the steps in user acceptance of the message will likely break down. Specifically, a lack of awareness could hamper perceived credibility of the message (and the system itself) and increase the perceived need to double-check to confirm that alerts are valid. The NRC highlighted the importance of educating the public, and achieving their buy-in for the system (NRC, 2011). NRC participants cited the successful public awareness efforts deployed in Washington, D.C., for the DC Alerts program, which were funded by FEMA and DHS (NRC, 2011).

While by no means representative of all public reactions, recent anecdotal evidence from early WEA experiences highlight not only the potential for positive reactions, but also potential backlash to what can be seen as surprising, confusing, heavy-handed, and bothersome. For example, a recent flash flood WEA warning (July 20, 2012) sent out to Allegheny County, PA, prompted a variety of reactions. Figure 8.2 presents sample Twitter activity surrounding the alert, as captured just after the alert went out.

Figure 8.2. Sample Twitter Activity Following WEA Flash Flood Message.

I just received a #NWS alert on my mobile phone letting me know about the flashflood warning. Good new service to have!

Why did my phone just nonstop vibrate and tell me there is a Flash Flood warning??

My phone just gave me an emergency message about a flash flood, I don't like that...

Um, my phone just gave me a flash flood warning. ...thanks? But Ice Cream Sammy, I'm not in a flood zone and you're being weird.

Just got a flash flood warning on my phone which says move to a safe place .. I think the 33rd floor is safe enough

Didn't expect my phone to beep like it was about to blow up just to tell me that there was

a flood warning..

My phone just had a freakout session to alert a flood warning. I'm guessing it's serious due to the loud continuous beeping.

If my phone sends me ONE more super-loud-long-buzzing flashflood warning, I'm gonna...... Who knows how to turn this [expletive] off?!

It should be emphasized again that these are merely examples that show a range of potential reactions. Some of these reactions raise concerns about WEA acceptance. However, further and more systematic research is needed to determine the likely prevalence of these (or other) reactions. As this limited evidence shows, WEA message content limitations or inaccurate geo-targeting can lead to confusion. Furthermore, significant time delays in receipt of the message can also lead to confusion and raise concerns about WEA acceptance. More research is needed to understand and improve public response.

Finally, engagement of the community and community organizations may be a critical component in increasing potential user awareness (NRC, 2011). As noted above, individuals naturally turn to those around them to confirm the accuracy and relevance of alerts and warnings. Members of the community, including local officials, may also be more trusted than state or national figures. Finally, local organizations are uniquely positioned to increase communication from AOs to the public, and also to provide feedback from the public to those sending alerts.

9. Conclusions

The data and analysis presented in this report indicate that both the public and private sectors have made considerable progress in the development and implementation of WEA from when it was first conceived in 2008. Given its complexity, its many diverse components, and the diverse interests of its stakeholders, such progress is remarkable. Significant cooperation between the public and private sectors was needed to bring this system to initial operational capability in April 2012.

This chapter summarizes the findings that flow from the data and analyses presented. The findings are followed by a series of recommended steps that can increase WEA penetration and provide the WEA service to a larger percentage of the US population.

Findings

The findings below review the status of the system and WEA penetration at several levels and project what its status and penetration rates will be in the future. Also identified are a number of issues that could limit WEA penetration or adoption.

WEA Penetration Among Alert Originators

Interviews with state EMs indicate that, as of the second quarter of 2012, the majority of states were planning to implement WEA and will use it to issue emergency alerts. Approximately three-quarters of the states categorized themselves as almost certain or possible adopters of WEA. Ten states and the NWS were authorized to disseminate alerts via IPAWS-OPEN as of May 2012.

Some state EMs see no issues with adopting WEA. Other state EMs cited cost, equipment acquisition, and procedural concerns (e.g., maintaining COGs, including time state EMs have to spend to do so) as issues that may prevent or slow WEA adoption among AOs.

The WEA adoption rate is significantly lower at the county level. As of mid-August 2012, 83 of 3,141 U.S. counties (2.6 percent) are connected to or are planning to disseminate alerts via the IPAWS-OPEN aggregator.[50]

Awareness and understanding of WEA is low, especially among local EMs. EMs expressed the need for a better understanding of policy and governance structures, more information on WEA, and an explanation of potential liability.

EMs cited the potential for message fatigue from the system if it is not used carefully. While many AOs believe WEA would be useful, they expressed a desire for improved WEA geo-targeting and testing capabilities.

WEA Penetration Among CMSPs

All of Tier I, the majority of Tier II, and approximately one-quarter of Tier III CMSPs will eventually implement WEA, although the exact date when some CMSPs implement it is uncertain. As of April 2012 at WEA system initial capability, the following Tier I CMSPs declared that they had achieved WEA coverage throughout almost their entire nationwide 3G network coverage area:

- Verizon
- Sprint
- T-Mobile.

AT&T stated that it was providing WEA coverage in the New York City and Washington, D.C., areas by April 2012. In December 2012, AT&T declared that its 3G network is WEA-capable nationwide.

Among Tier II CMSPs, ALTEL, Metro PCS, and U.S. Cellular indicated that they would provide WEA coverage over their entire coverage area by April 2012 or shortly thereafter.

WEA implementation rates are much lower among Tier III CMSPs. Only about one-quarter of Tier III CMSPs plan to implement WEA although this percentage increases to approximately 50 percent if only the largest Tier III CMSPs are considered and pager companies are discounted.

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[50] Note that, as discussed previously, there are differences in how public alerting is managed in different states, and in some states, authority to issue alerts is not apportioned to the county level. As a result, the percentage would be higher of counties with alerting authority, however reliable data to support such a calculation was not collected in this analysis.

CMSP claims of WEA coverage have only been verified in testing in New York City, which hosted the first end-to-end test of WEA in December 2011. The NWS came online as a WEA AO in June 2012. After this date, social media and press reports indicate that the public has received WEA messages in a number of areas.

One significant remaining area of uncertainty in terms of WEA coverage is whether MVNOs will provide WEA coverage to their subscribers. The WEA implementation plans of the MVNOs could not be determined. Because MVNOs do not own or operate their own network infrastructure, this question defaults to whether these companies will demand that their mobile device suppliers provide WEA-capable devices. At present it does not appear that this is a requirement for these companies. This raises the possibility that a significant fraction of the U.S. public, those that are MVNO subscribers, will not be able to receive WEA messages.

WEA Coverage Provided by CMSPs

The estimated percentage of the U.S. population covered by at least one mobile phone network for voice calls is 99.5 percent. “Covered” means that the radio frequency cell base station signals of at least one CMSP network are available to this percentage of the U.S. population. This represents an upper bound for WEA coverage of the U.S. population. The same coverage metric is applied below to estimate the eventual coverage expected to be provided by CMSPs with a declared intention to implement WEA.

An estimated 73.2 percent of the nation’s landmass is covered by at least one CMSP that intends to fully or partially implement WEA. The estimated fraction of the nation’s population that resides in the coverage area of at least one WEA-capable CMSP is 99.4 percent, a number that compares favorably to 99.5 percent with voice coverage. So, in the long term, it is expected that WEA penetration could increase to almost the current mobile device penetration rate if other factors, such as the availability of WEA-capable devices and user acceptance, do not cause WEA penetration to fall over time. Several other factors are important to estimating how WEA penetration may increase in the future. Table 9.1 presents a calculation that takes into account the majority of factors that influence overall WEA penetration for Tier I CMSPs.

The coverage areas of CMSP networks vary widely, with the widest coverage offered by Tier I CMSPs, which provide service to the majority of the nation’s mobile device subscribers, covering 72.7 percent of the nation’s landmass. Fully or partially WEA-compliant Tier I CMSPs cover an estimated 99.2 percent of the U.S. population.

Of course, this assumes that all members of the U.S. public are Tier I carrier subscribers, which is not true. Below this assumption is relaxed and a more precise estimate of the Tier I WEA subscribers is developed.

In addition, due to a growing shortage of wireless frequency spectrum for cellular networks it is likely that small and large CMSPs will increase their use of Wi-Fi and small cells. All indications are that these extensions of CMSP networks will not be WEA-capable. Therefore, it is possible that a significant WEA coverage gap could occur and grow over time if these systems are not made WEA-capable.

WEA Penetration – Mobile Wireless Devices

In the near term, the most significant gap in WEA penetration is the lack of availability of WEA-capable devices. This shortcoming affects all CMSPs currently implementing WEA. As of January 2012, only 3 percent of the mobile device population was WEA-capable.

While the number of WEA-capable devices will eventually increase substantially among CMSPs, a significant number of mobile devices may not be WEA-capable several years from now. Previous analysis of mobile phone purchases and other data shows that two-thirds of the mobile phone population turns over in approximately two years. These turnover rates can be used to project how the number of WEA-capable phones will grow over time. Obtaining high penetration rates for WEA-capable phones depends strongly on the proportion of phones that are WEA-capable at the point of sale. Today this percentage is relatively low. If it were to stay low, for example below 50 percent, then WEA penetration into the mobile device population would probably never climb above this level. Therefore it is important to increase the number of WEA-capable devices for sale as quickly as possible, so they represent a high proportion of all available mobile devices on the market.

Table 9.1. Projected WEA-Capable Mobile Device Quantities and Percentages for Tier I CMSPs

	2011	2014	2016
	Subscriber phones (m)	**Subscriber phones (m)**	**Subscriber phones (m)**
Verizon	4.72	71.93	95.13
AT&T	0.22	66.73	88.26
Sprint	2.27	35.08	46.40
T-Mobile	1.01	22.73	30.06
Total	8.22 (2.8%)	196.46 (67.7%)	259.85 (89.5%)

Table 9.1 provides an estimate of the growth in WEA-capable mobile devices for Tier I CMSPs and serves as a proxy for overall WEA penetration. In 2011 and early 2012, it is estimated that a little more than eight million WEA-capable mobile devices were in use by Tier I CMSP subscribers. By 2014, the WEA-capable mobile device penetration rate increases to 68 percent, or about 196 million devices. By 2016, the WEA-capable mobile device penetration rate increases to about 90 percent, or about 260 million devices. This projection is based on the likely optimistic assumption that Tier I CMSPs will offer 100-percent WEA-capable devices by the end of 2012. Overall, the above projections are conservative because they assume no growth in mobile phone subscriptions from 2011 to 2016. Recent trends indicate that mobile phone subscriptions will continue to increase over the near term, but since this analysis was conducted at the carrier level, the report’s authors were unwilling to make projections or assumptions about changes in market share of CMSPs.

All Tier I CMSPs have committed to ensuring that all of their mobile devices will eventually become WEA-capable, but they are unwilling to commit to firm timelines for reaching these goals. The penetration of WEA-capable mobile devices is expected to increase at a slower rate in Tier II and Tier III carrier networks. The reason for this is that the newest and most capable mobile devices are first available on Tier I CMSP networks (an example of this is Apple’s iPhone). The devices available to smaller CMSPs tend to be ones that were available earlier on large carrier networks. In addition, because small CMSPs are more price sensitive than larger ones, in some cases a significant percentage of the mobile phones they offer are purchased overseas and were originally designed for foreign markets. These low-cost, foreign-sourced devices are very unlikely to be WEA-capable.

The most significant WEA penetration gap over the long term regarding mobile wireless devices is the lack of WEA capability in the tablet computers that are currently offered by Tier I CMSPs. Discussions with Tier I CMSPs indicate that they were unsure as to when WEA capability would be added to the tablet computers that offered cellular network capability. In September 2012, WEA capability was added as part of the software upgrade to iOS 6 for the Apple iPad 2 and iPad (Wimberly, 2012). iPads using OS 5 are not WEA-capable and neither, as best as can be determined, are Android tablets. While the cellular network–enabled tablet population is relatively small now, it is growing rapidly. This could lead to a sizable population of mobile wireless devices that are not WEA-capable in the future.

WEA Penetration of U.S. Population – Demographic Factors

Approximately 73 percent of the U.S. landmass and over 99 percent of the U.S. population are covered by at least one CMSP that elected to participate fully or partially in WEA. So it would seem that WEA penetration would eventually be quite high for the U.S. population. However, for WEA to be useful, individuals must possess a WEA-capable mobile devices and both be aware of and understand WEA messages received by that device.

National surveys show that individuals with lower income, as well as the very old and very young, are less likely to possess mobile devices. Programs such as Lifeline and CMSPs and MVNOs such as Jitterbug or Cricket target these populations, providing potential avenues for increasing WEA penetration in lower-income groups. Those in institutionalized settings may have limited access to mobile devices, underscoring the importance of institution administrators as caretakers of these populations. Foreign visitors to the United States are unlikely to possess WEA-capable devices. These travelers tend to concentrate in coastal regions of the United States, and hence create a potential gap in WEA coverage for those areas.

Other population characteristics may limit awareness and understanding of WEA messages. Hearing disability may increase the likelihood that a WEA message goes unnoticed, and vision disabilities limit the utility of text-based systems. Technological solutions, however, may alleviate these challenges. Cognitive disabilities, on the other hand, may limit the ability of an individual to understand message content, highlighting the importance of testing messages for comprehension with a wide range of recipients with diverse abilities and backgrounds. Similarly, because WEA is currently an English-

only system, difficulty with English will limit comprehension among illiterate and non–English-speaking populations.

Finally, the prevalence of all of these populations varies geographically across the United States, and the primary challenges faced within one region will differ from those in other regions. For example, states such as Texas, Florida, Illinois, New York, and New Jersey face stronger language-related challenges. In contrast, states in the south and southeast face relatively higher disability, illiteracy, institutionalization, and poverty rates. This suggests that a national strategy should be executed at the state and local level so that implementation at the state and local levels can target the main challenges faced in those locations.

WEA Public Awareness and User Acceptance

Public awareness of WEA is very low (as of third-quarter 2012). AOs at the first WEA Forum held earlier in 2012 indicated that the public in their areas have little awareness of WEA. An informal survey of social media responses to recent WEA messages issued in Pennsylvania, New York, New Jersey, and other states indicate that many members of the public are surprised that they are receiving extreme weather alerts on their mobile phones.

CMSPs who are participating in WEA do not provide WEA educational materials at the point of sale in their stores, although they do provide some information concerning WEA on their websites. CMSPs electing to participate in WEA are not required to provide educational materials to the public. However, under 47 CFR 10.280, CMSPs that opt out of WEA are required to provide the subscribers with examples of the types of messages they might *not* receive.

CTIA provides some WEA educational materials on its website, but even though it is the largest wireless mobile telecommunications industry association in the United States, CTIA is not well known to the public at large.

FEMA provides a variety of information on its website regarding WEA. However, much of this information is oriented towards government experts and engineers and concern technical aspects of the system. In other words, the FEMA website is not consumer oriented.

User acceptance of WEA is an important consideration in ensuring the overall effectiveness of the system. This is true because users can opt out of some WEA messages. For users to accept the system, they must find these alerts credible and useful

and they must trust in the system and the source of the alert messages. It is well known to government officials responsible for the development of WEA that the system has a high degree of trust because of the security features built into the IPAWS-OPEN aggregator. These features ensure that only authorized AOs can transmit WEA messages. However, the public is not aware of all of these safeguards and features, because of the low levels of public awareness already mentioned.

If users find the content and structure of WEA messages to be confusing, they may decide to opt out of the system, which would lower the overall WEA penetration rate over time. More research is needed to improve the construction of WEA messages. For example, the design of a message sent out to an entire county may need to be different than one sent to a small area. Furthermore, users may also opt out of the system due to message fatigue if they receive too many WEA messages that are not relevant or useful to them.

Over alerting is a significant risk to WEA as long as geo-targeting capabilities are at the county level. DHS S&T is actively researching improved geo-targeting capabilities of WEA. One short-term solution is to limit the number of WEA messages sent to larger counties until improved geo-targeting capabilities are implemented in WEA. Currently, some CMSPs offer geo-targeting to the county level but not to smaller areas (thus meeting the minimum requirements set by the FCC). Some weather alerts should be sent to smaller areas where the actual extreme or severe weather condition exists, so users not under threat do not receive an alert that is not relevant to them. Improved geo-targeting of WEA messages may be one of the most significant ways to reduce message fatigue. In addition, the public will perceive the system as more relevant and useful if the WEA messages received by the public are timely, appropriate, and issued by their own local alerting authorities.

Another important factor in ensuring that WEA messages are relevant and useful to the public is the overall responsiveness of the WEA system of systems. If alert messages arrive at the user's mobile device with significant time delay, they may be less useful and ineffective in warning the public to seek shelter or to avoid an imminent threat. For this reason, the timeliness of WEA message delivery is an important system performance parameter that should be measured in actual field tests.

Several other factors can potentially limit the utility of WEA messages and thereby reduce user acceptance. WEA messages currently have to be relatively short—only 90 characters in length. This limits the amount of information that can be conveyed in the

alert message. If there were ways of increasing WEA message size this could increase the overall utility of the system and increase user acceptance.

Currently WEA messages can only be sent in English, which limits their utility for segments of U.S. society that do not speak or read English well. If WEA messages could be transmitted in English as well as other languages, then this capability could be tailored to local areas with high immigrant populations, where English is not the first language of many residents.

Recommendations

The above findings identify issues that could reduce WEA penetration and user acceptance both in the short-term and long-term. Below, we offer recommendations that address these issues and that, if implemented together as part of coherent strategy, can increase WEA penetration at all levels where WEA adoption is required. These measures will help to ensure that WEA will be widely available and useful to the U.S. public.

Maximizing WEA Penetration Among Alert Originators

To encourage WEA adoption by AOs, WEA should share CMSP WEA rollout information with emergency management and AO communities. This step will help state and local EMs understand the coverage that WEA can provide in their communities. The results of regional and national WEA tests should be shared with state and local EMs. These test results will illustrate how WEA can be used to alert the public in a variety of crisis and emergency scenarios.

Cost has been raised as a significant issue that may prevent WEA adoption at the state and local level, especially in jurisdictions that have limited funding. Consider providing incentives for state and local emergency management organizations so that they can acquire the equipment and training necessary to disseminate alerts via the IPAWS-OPEN aggregator.

AOs have expressed a need for more information about WEA. To address this, DHS S&T is developing WEA AO best practices guidance, which will be disseminated widely to the AO community. FEMA already offers a mandatory course for AOs, but it could be expanded and published so it can receive wide dissemination at the state and local levels.

Some AOs have expressed the need to transmit WEA messages in other languages to reach non–English-speaking members of the public in their jurisdictions. DHS S&T

should publish guidelines on how to use the current WEA message standard to transmit alert information in other languages. While this is likely to be a stopgap measure and will not lead to an ideal set of alert messages, these steps help to maximize WEA penetration to potentially underserved communities throughout the country.

Maximizing WEA Penetration Among CMSPs

WEA penetration is lowest among the smallest CMSPs and among MVNOs. The latter are of the greatest concern because these virtual network operators provide mobile communications services to a large and growing part of the U.S. population and because they serve lower income groups.

The FCC should require MVNOs to declare whether they will participate in WEA and to inform their subscribers if they choose not to participate. In other words, MVNOs should conform to the same FCC rules as other CMSPs.

The FCC should also ensure CMSPs forward WEA messages to subscriber mobile devices connected to their networks via Wi-Fi or small cells. This will prevent a significant WEA coverage gap from forming in CMSP networks.

Maximizing WEA Penetration – Mobile Wireless Devices

The number of WEA-capable mobile phones offered to the public by wireless CMSPs and device manufacturers must be increased as soon as possible. Discussions with Tier I CMSPs indicate they believe the majority of their mobile device offerings could be WEA-capable within two years of April 2012. However, discussions with mobile device manufacturers indicate they are reluctant to provide a schedule that shows when they will make all of their devices WEA-capable.

To ensure that industry moves rapidly towards 100-percent WEA compatibility, the FCC should establish the following goal for the wireless CMSPs and device manufacturers: By December 2013, 90 percent of the mobile devices offered by Tier I and Tier II CMSPs be WEA-capable.

It is possible that industry and the FCC could reach consensus regarding such a goal. If so, this goal could be disseminated to the public and the news media and would serve a secondary purpose of increasing public awareness of WEA.

A number of mobile devices now in the hands of the public could be upgraded to be WEA-capable by means of a software upgrade. This possibility is especially relevant to smart phones. In September 2012, Apple introduced the iPhone 5 and iOS 6, both of

which provide WEA capability (Wimberly 2012). The Apple iPhone 4s and iPad 2 can be upgraded by their owners to iOS 6, which also makes them WEA-capable. The FCC should encourage the major CMSPs or mobile device manufacturers to push software upgrades to existing devices so they become WEA-capable.

The following are a number of ways in which this could be done:

- The FCC could ask the CMSPs to identify which devices now in the market can be made WEA-capable by software upgrade.
- The FCC could ask the CMSPs or mobile device manufacturers to push these software updates non–WEA-capable devices.
- The FCC could ask the CMSPs or mobile device manufacturers to alert those costumers who have WEA-capable phones that require user interaction to update the device.
- Alternatively, the CMSPs could provide the U.S. government with this subscriber information and have the government email a notification of availability of software update to these users and provide the user with instructions for making the update through their respective CMSPs.

The FCC could consult with industry to determine which alternative should be chosen to undertake the software upgrades.

The FCC should find a means to encourage Tier I CMSPs and major tablet computer manufacturers to add WEA capability to their tablet offerings that have wireless cellular data connectivity.

Maximizing WEA Penetration in Disadvantaged U.S Populations

This analysis has identified a number of disadvantaged populations that may not have ready access to WEA-capable phones or who may not be able to understand WEA messages on the mobile phones available today.

One of these disadvantaged groups is lower-income populations. Mobile device services are currently provided to lower income groups by a number of MVNOs. Some of these MVNOs provide subsidized mobile phone services and are funded in part by the government. These include LifeLink providers. The FCC should require CMSPs participating in the LifeLink program to adopt WEA.

The FCC should also consider establishing guidelines for mobile device manufacturers to improve accessibility for future versions of WEA, for example, to enable those who are visually impaired to more easily read or hear WEA messages.

The next major upgrade to WEA should enable WEA messages to be sent in multiple languages simultaneously. This may be difficult to do using the current cell broadcast standard for 3G networks, but it may be relatively straightforward to do in next-generation 4G LTE networks. Multiple-language transmissions may be possible in 4G LTE networks if additional LTE cell broadcast channels are designated for WEA use in the 4G LTE standard. If the government desires to increase the number of characters or number of languages that can be carried in future versions of WEA, it should actively participate in the development of the LTE cell broadcast standard.

The U.S. government should consider leading international cell broadcast standardization efforts for emergency alert messaging. Greater international standardization and coordination among existing alerting systems could help increase the availability of WEA-capable mobile phones for those visiting the United States, and could aid U.S. residents traveling abroad.

Maximizing WEA Public Awareness and User Acceptance

There appears to be no large-scale coordinated outreach effort to inform U.S. consumers about WEA. Private industry would use advertising and marketing to alert the public of a new product or service. However, U.S. government organizations do not often invest in marketing services to the public. In a time of significant budget constraints, it may be difficult to find resources to support a large-scale marketing campaign. Nevertheless, some steps can be taken to increase WEA public awareness.

A unified, U.S. government–linked web presence should be provided to increase public education and awareness. This web presence should be designed for the consumer and not for policymakers, government officials, or technical staff.

The FCC should direct the wireless CMSPs and other retailers (e.g., Best Buy) to provide WEA educational materials furnished by DHS at the point of sale for mobile devices. If the government provides these educational materials it will help reduce the costs for wireless CMSPs and retailers. At the same time, this approach will provide WEA educational materials to consumers at a specific time when they will be required to make a WEA adoption decision, i.e., whether to purchase a WEA-capable device. Today when consumers purchase a device in a retail store, they are likely not to know which phones are WEA-capable or even what WEA is.

Another measure to counter the lack of public awareness of WEA is to direct the wireless CMSPs to send short WEA “infomercials” to all phones once a quarter or once

every six months to help educate the public. It may be possible to do this using the current WEA cell broadcast message standard by utilizing the monthly test message and by reprogramming WEA-capable phones to display the content of this message.

FEMA, coordinating with DHS and the FCC, should conduct WEA tests with devices from multiple vendors to verify system end-to-end performance and so the timeliness of WEA message delivery can be measured in realistic conditions.

Consumers and their devices should be included in some of these tests. Such inclusion will serve two purposes: (1) It will enable WEA to be tested with a large number of devices in a very cost-effective manner and (2) it will also help increase public awareness of WEA.

Finally, to increase user acceptance and reduce the chance of users opting out of the system, the geo-targeting accuracy of WEA should be improved as soon as possible. This will enable WEA messages to be geo-targeted to areas smaller than the county level. Research indicates that mobile device infrastructure providers and the major CMSPs are ready to proceed and can implement a more precise form of WEA geo-targeting in the near future. This step will reduce the number of potentially irrelevant WEA messages sent to the public and will help to ensure that the alerts transmitted to specific areas warn people of an imminent threat in their specific area. It will also allow AOs to send a targeted message to users in a specific geography and a more general message to users in surrounding areas.

It will take time for all CMSPs and all parts their network to be able to offer high-precision geo-targeted alerts. As a result, AOs may only be able to send WEA messages to the county level for some carrier networks and some parts of the country. As described above, the message content of a WEA message must be carefully crafted to ensure it is easily understood and actionable. Further research needs to be conducted on WEA message design for high- and low-precision geo-targeted messages. More research is also needed to improve the construction of WEA messages. For example, the design of a message sent out to an entire county may need to be different than one sent to a small area. DHS should develop and pilot test templates for WEA messages for different types of emergencies and differently sized geo-targeted areas. It is likely that these templates will differ significantly for a countywide area as opposed to a much smaller area that is defined to closely match the location of an emergency.

A. List of Acronyms

Acronym	Definition
AO	alert originator
AR	American Roamer
ATIS	Alliance for Telecommunications Industry Solutions
BMC	Broadcast Message Center
CAP	Common Alert Protocol
CETC	competitive eligible telecommunication carriers
CDMA	Code-Division Multiple Access
CMAS	Commercial Mobile Alert System
CMSAAC	Commercial Mobile Service Alert Advisory Committee
CMSP	commercial mobile service provider
COG	Collaborative Operating Group
CONELRAD	Control of Electromagnetic Radiation
CR	CoverageRight
CTIA	Cellular Telecommunication Industry Association
DHS	Department of Homeland Security
DMA	designated market area
EAS	Emergency Alert System
EBS	Emergency Broadcast System
EM	emergency manager
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GSM	Global System for Mobile Communications
ILEC	incumbent local exchange carriers
IPAWS	Integrated Public Alert and Warning System
IPAWS-OPEN	Integrated Public Alert and Warning System – Open Platform for Emergency Networks
LTE	Long Term Evolution (Network)
MSA	metropolitan statistical area
MVNO	mobile virtual network operator

NOAA	National Oceanographic and Atmospheric Administration
NRC	National Research Council
NTIA	National Telecommunications and Information Administration
NWS	National Weather Service
OASIS	Organization for the Advancement of Structured Information Standards
RERC	Rehabilitation Engineering Research Center
RF	radio frequency
S&T	Science and Technology
SMS	short message service
START	National Consortium for the Study of Terrorism and Responses to Terrorism
TIA	Telecommunications Industry Association
VPN	virtual private network
WARN	Warning, Alert and Response Network [Act]
WEA	wireless emergency alert
XML	extended markup language

B. WEA History and Motivation

In June 2006, President George W. Bush signed Executive Order 13407 directing the improvement of public alerts and warning systems in the United States. In response, the DHS established the IPAWS-OPEN program. In October 2006, Congress and the president enacted the Warning, Alert, and Response Network (WARN) Act. The WARN Act contains various provisions on WEA, and directed the FCC to establish an advisory committee on WEA and then to adopt relevant technical standards, protocols, and procedures based on the recommendations of the advisory committee. The advisory committee, composed of representatives from industry and government, reached consensus on the design of a new system for sending alerts to the U.S public that—for the first time—would use mobile devices instead of broadcast television or radio (FCC, 2007).

Mobile networks provide an increasingly important pathway for real-time communication with the U.S. public, because of the public’s changing viewing and listening habits and because of possible future changes in television and radio markets. With increasing competition from the Internet and other media, television viewership of local TV channels has dropped over time. Many local TV stations, including those in major markets, are in or near bankruptcy and private equity firms are acquiring local TV broadcasters so they can re-purpose TV spectrum for other markets, including possibly mobile communications (Launder, 2012). These possible market changes could make it increasingly difficult to reach the public by means of local TV to send alerts to people in areas where an imminent threat to public safety exists. Three major broadcast television networks that used local broadcast stations to reach their audience once dominated the television market. Local broadcast television viewership has declined with the introduction of new television networks that span large areas and regions of the United States. The public continues to watch television, but viewership is now spread over a wide number of national cable and satellite channels. These new television distribution channels may not provide an effective communications path for AOs to send messages to viewers in specific local areas under threat, i.e., to send geo-targeted alerts.

Radio stations still provide a means to send geo-targeted messages to specific listening areas. However, according to the FCC, wireless devices are quickly becoming equal to TV and radio in their capacity to reach the U.S. population quickly and

efficiently (FCC, 2007 and Houston et al, 2012). With the growing capability and penetration of mobile devices linked to cellular networks, an increasing number of Americans use such devices instead of radio. Furthermore, they carry these devices with them when outside their homes or workplaces. Consequently, traditional television and radio media provide less attractive communications paths for sending emergency alert messages to the public. In contrast, CMSP networks provide a way to reach a greater percentage of the public and people in geo-targeted areas.

WEA is the component of IPAWS-OPEN that is designed to utilize CMSP networks to provide the public with urgent information in a time of emergency. The larger IPAWS-OPEN system can convey emergency alerts through multiple means, including traditional pathways such as television, commercial AM and FM radio stations, NOAA weather radio stations, and other new pathways, based on newer technologies such as electronic road signs and Internet web services.

IPAWS-OPEN is internet-based, and access to it is free for federal, state, territorial, tribal, and local authorities, provided they have software that meets the requirements for connecting to the system (FEMA, 2012a). A subset of emergency alerts sent through IPAWS-OPEN are routed to mobile devices (i.e., to WEA) based on their designated severity, urgency, and certainty (ATIS/TIA 2009a). [51]

The IPAWS-OPEN program incorporates and builds upon previous public alerting systems, including the EAS. Previous government-sponsored public alerting systems relied on the best available technologies at the time. Although some improvements were made in the 1990s, the commercial networks that could be reached by federal emergency managers through EAS had not been expanded since the 1960s. Summaries of these efforts are presented in Table B.1.

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[51] Messages sent through IPAWS must be formatted using the CAP standard, which has separate elements for these three attributes. Messages that meet the requirements for WEA (*severity* of extreme or severe; *urgency* of immediate or expected; and *certainty* of observed or likely) are routed to mobile devices by the system. Each of the attributes and associated terms is defined in the relevant technical standard (Alliance for Telecommunications Industry Solutions and the Telecommunications Industry Association, 2009a, p. 67).

Table B.1. Timeline of Public Alert and Warning Systems

Year	Program	Dissemination Technologies	Geo-targeting
1951	Control of Eectromagnetic Radiation (CONELRAD)	AM Radio	No
1963	Emergency Broadcast System (EBS)	Radio and television	Initially national only, later an analog geo-targeting capability was added in 1976.
1997	Emergency Alert System (EAS)	Radio and television	Digital upgrade to EBS with finer geo-targeting
2007	Integrated Public Alert and Warning System (IPAWS-OPEN)	Designed for use with radio, television, mobile phones, internet, digital signage, warning sirens, and more.	Varies depending on technology. WEA is currently limited to county-level targeting.

At their inception, the CONELRAD system and EBS did not allow for AOs other than the president. Their initial purpose was to inform the public of approaching nuclear weapons. In 1976, EBS was modified to allow states and localities to originate emergency alerts to the public using television and radio (FEMA, 2012c; and Moore, 2010).

C. Mobile Device Turnover Rate Model

As part of estimating the future prevalence of WEA-capable phones in circulation, researchers used historical data to estimate the rate at which individuals purchase a new mobile phone (i.e., the mobile device turnover rate). Over the next several years, mobile phone manufacturers are expected to increase the number of WEA-capable phone offerings. However, only the most popular phone models receive software updates after they are sold (Hoey, 2012). The majority of existing mobile phones are not updated by CMSPs. Consequently, estimating the mobile device turnover rate is critical to assessing access to a WEA-compatible device.

Two consecutive years (2010–2012) of comScore survey data were used to estimate parameters for a mobile device turnover rate model. Because of the way comScore conducts its surveys (independent annual samples of 30,000 mobile phone owners over the age of 13 drawn from a nationwide sample frame), comparisons between survey years are not straightforward, complicating the estimation of annual mobile device turnover rates.

To overcome this challenge, a conservative approach (i.e., in the sense of underestimating turnover rates) to determining annual mobile device turnover rates was followed. For each mobile phone type in a pair of survey years, the absolute change in the number of people owning the device using the survey population weights was calculated. Next, the number of people with a new mobile device were estimated by summing the absolute changes in the number of people owning each mobile device and dividing the sum by two.

Observe that this is a conservative approach. For instance, suppose that there are two people, A and B, and three mobile devices, 1, 2, and 3. If person A switches from mobile phone 1 to 2 while person B switches from mobile phone 2 to 3, the actual turnover rate is 100, while the estimated turnover rate is 50. Note that the data do not indicate if both persons A and B switched mobile phones, as in this example, or if person A switched from mobile phone 1 to 3 while person B kept mobile phone 2. Hence, this approach will under-predict actual turnover, provided the data are truly representative of the U.S. mobile phone population. Finally, the number of people with a new mobile device is divided by the total population to determine an estimate for the mobile device turnover rate.

Another issue that affects the projection of mobile device turnover rates is the notion of "memory." That is, given that individual A purchases a new mobile phone in the current year while individual B does not, which individual is more likely to purchase a new mobile phone in the following year? One might argue that individual B is more likely since individual A upgraded in the present year and may not want to incur the cost and/or inconvenience of getting a new mobile phone. However, one could also argue that individual A wants the latest technology while individual B is more utilitarian, and hence individual A would be more likely to upgrade in the next year.

To test each hypothesis, one-year turnover rates were calculated for 2010 to 2011 and for 2011 to 2012, as well as the two-year turnover rate between 2010 and 2012. Next, it was determined how well the two-year turnover rate could be predicted using the estimated one-year turnover rates, assuming that individuals A and B would be equally likely to purchase a new mobile phone. As shown in Table C.1, the predicted two-year turnover rates, displayed by income level, were slightly higher than the turnover rates estimated from the data. One would expect the predicted two-year turnover rates to be higher than the actual turnover rates if the same individuals each get a new mobile phone in each year. Hence, it appears that individual A is slightly more likely to purchase a new mobile phone than individual B.

Table C.1. Predicted and Actual Two-Year Mobile Phone Turn Over Rates

Annual Income	Predicted Two-Year Turnover Rate	Actual Two-Year Turnover Rate
<$25,000	66.6	64.4
$25,000–$50,000	64.8	63.1
$50,000–$75,000	66.7	64.2
$75,000–$100,000	70.3	67.8
>$100,000	70.0	67.6
Weighted Average	67.7	65.4

Source: comScore, 2012 and NDRI analysis.

As another check, the average one-year turnover rate that would result in the two-year turnover observed in the data was inferred, again assuming that individuals A and B would be equally likely to purchase a new mobile phone. Table C.2 compares the average predicted one-year turnover rates with the actual one-year turnover rate estimated from the comScore data. The predicted values are slightly lower than the actual turnover rates,

suggesting once again that individuals who purchased mobile phones in the current year are slightly more likely to purchase a new mobile phone in the following year.

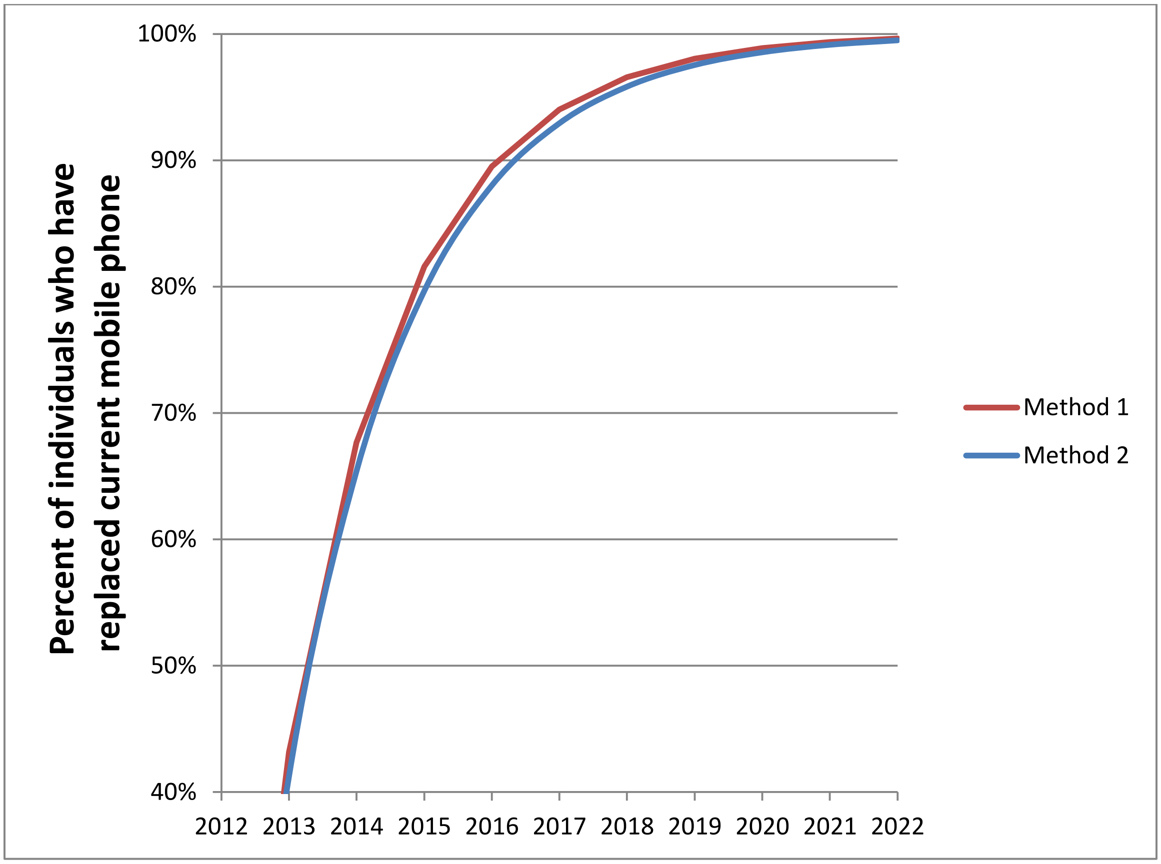
Table C.2. Predicted and Actual One-Year Mobile Device Turnover Rates

Annual Income	Average Predicted One-Year Turnover Rate	Average Actual One-Year Turnover Rate
<$25,000	40.4	42.2
$25,000–$50,000	39.3	40.7
$50,000–$75,000	40.2	42.3
$75,000–$100,000	43.2	45.5
>$100,000	43.1	45.3
Weighted Average	41.2	43.2

Source: comScore, 2012 and NDRI analysis.

The above exposition suggests that there are two methods for projecting the time to replace the current stock of mobile phones. One method, which referred to as "method 1" in Figure C.1, is to calculate the average one-year turnover rate from the data. An alternative method, called "method 2," is to infer the average one-year turnover rate from the two-year turnover rate in the data. For mathematical simplicity, it is assumed that individuals are equally likely to replace their mobile phones in the following year, regardless of whether they replaced their mobile phone in the current year. The two tables above indicate that this assumption is reasonably consistent with the data. As shown in Figure C.1, the two estimation methods yield a very similar prediction regarding the time to replace the current stock of mobile Phones. The closeness of these projections gives a measure of robustness to the approach.

Figure C.1. Modeled Time to Replace the Current Stock of Mobile Phones



Source: comScore, 2012 and NDRI analysis.

D. Additional Detail on American Roamer Data and FCC Election Letter Matching

This appendix provides more detail on the analysis conducted with the American Roamer (AR) CoverageRight (CR) data (Mosaik, 2012).

CR data include all of the Tier I and II CMSPs, but appears to be missing data describing smaller Tier III CMSPs.[52] Another source of data describing CMSPs' intentions (but not their coverage footprints) are the WEA Election Letters (FCC, 2012), a collection of documents submitted to the FCC. These letters describe each CMSP's intention to fully or partially implement WEA, or their election not to implement it. Note that a much larger number of CMSPs (403) submitted letters than are represented in the CR dataset (106).

CMSPs often have reciprocal agreements, which allow devices of customers of one CMSP to roam seamlessly across the coverage of several CMSPs, dubbed a CMSP's "roaming partners." The coverage of a single CMSP is referred to as the CMSP's owned network, and the full coverage including all roaming partners would be the CMSP's roaming coverage. Because each WEA Election Letter only defines the intention of the submitting CMSP and does not address the status of any roaming partners, all of the analyses performed and results portrayed in this document only draw from the advertised owned network coverage of pertinent CMSPs, and not the additional coverage of their roaming partners. CMSPs included in our analyses may roam with one another, however their individual inclusion is based on the consideration of multiple WEA Election Letters.

The CR dataset describes the coverage of 106 CMSPs.[53] The FCC received and filed 403 WEA Election Letters.[54] AR data were reduced to 106 unique CMSPs by

[52] As defined by the FCC, Tier I carriers are CMSPs with nationwide footprints. Tier II carriers are non-nationwide carriers with greater than 500,000 subscribers, leaving the rest of the CMSPs, with no more than 500,000 subscribers, as Tier III carriers (FCC 2008b).

[53] This count does not include one offshore CMSP and collapses six Tier I and five Tier III affiliates.

removing 11 affiliates (duplicates) of CMSPs and one CMSP that operates solely in the Gulf of Mexico. Of these unique AR CMSPs, 92 match one or more FCC Election letters, leaving 14 CMSPs in the CR dataset that do not have a matching FCC election letter. For the purpose of coverage analysis, these CMSPs are considered as not implementing WEA.

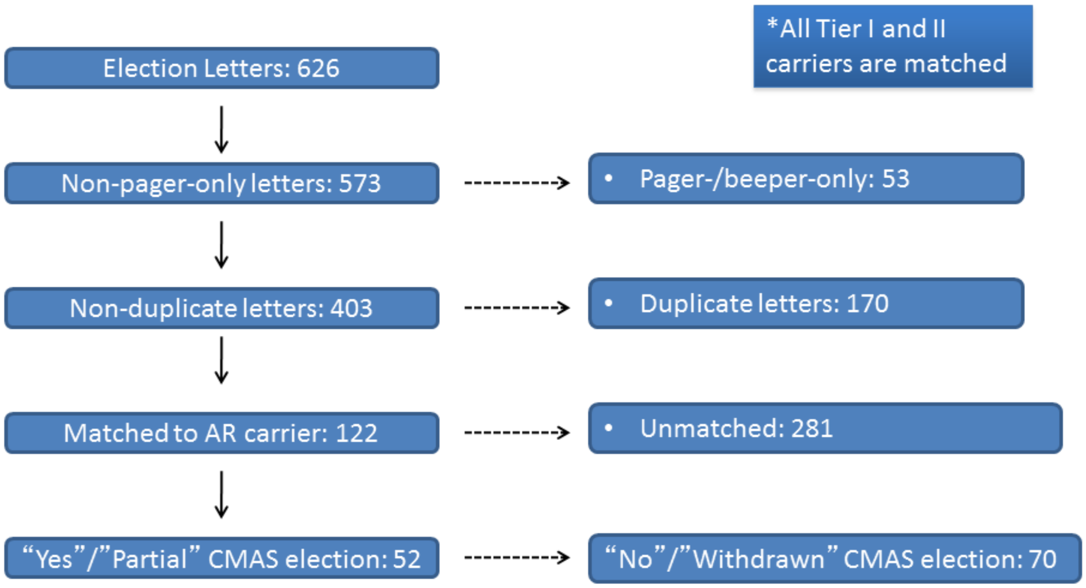
Eighty-eight (88) of the 92 matched AR CMSPs operate in at least one of the 50 states. Roughly half of these (45 of 88) have declared their intention to the FCC to fully or partially implement WEA. The remainder (43 of 88) declared that they will not implement WEA.

The other four CMSPs with matching FCC Election Letters operate exclusively in territories of the United States. Only one of these four (operating solely in Puerto Rico and the United States Virgin Islands) intends to implement WEA fully or partially. The other three operate in Guam only, and all of these CMSPs have elected not to implement WEA.

Figures D.1 and D.2 illustrate the matching processes and results.

[54] This count does not include pager-only companies and duplicate entities.

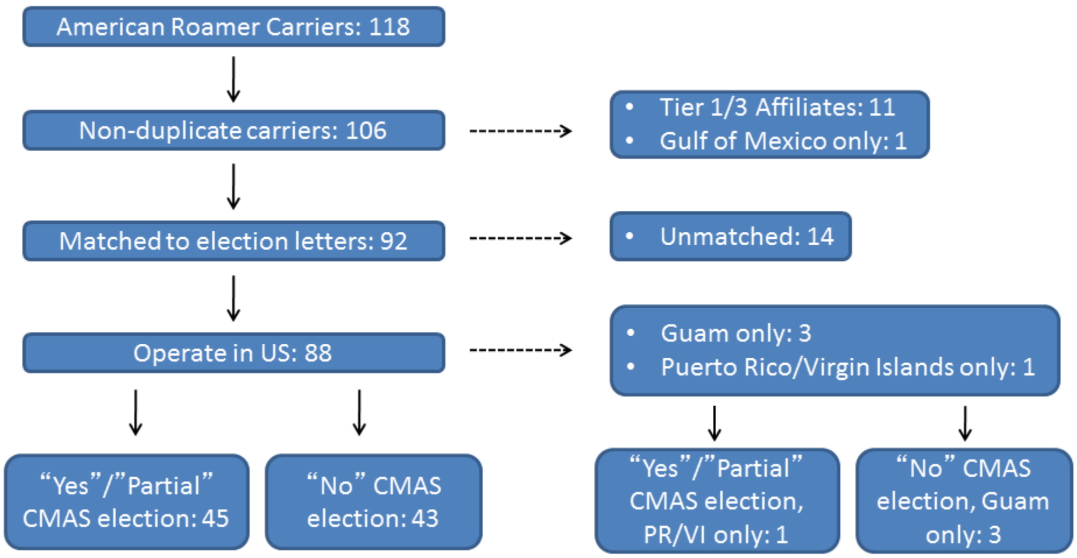
Figure D.1. Matching FCC Election Letters to American Roamer Data



Thirty percent (122 of 403) of the FCC election letters were successfully matched to 87 percent (92 of 106) of the AR CMSPs. This leaves 281 FCC Election Letters that were not matched to any CMSP in the CR dataset, and 14 CMSPs in the CR dataset that were not matched to any FCC Election Letters.

All Tier I and II CMSPs in the CR dataset were each matched to at least one FCC Election Letter. As this listing of Tier I and II CMSPs constitutes the current listing of Tier I and II CMSPs operating in the United States, the CMSPs both in the unmatched FCC Election Letters and in the unmatched CR dataset CMSPs represent Tier III CMSPs. The unmatched CMSPs in AR's data and the FCC Election Letters are all Tier III CMSPs. The overwhelming majority of the 291 unmatched FCC letters (243 of 281 or 86 percent) represent CMSPs that either do not intend to implement WEA or have withdrawn their intention to do so.

Figure D.2. Matching American Roamer Data to FCC Election Letters



AR asserts that its data represent all CMSPs operating in the United States. However, the AR dataset does not appear to be complete, based on the matching process described above. In private communications, many Tier III CMSPs attested to the lack of completeness of the CR dataset, stating that at least their own coverage patterns were not represented therein. Nevertheless, AR appears to be the best available data for estimating CMSP coverage and it is the basis for FCC analyses.

Tier I and II CMSPs alone provide very complete voice coverage for the United States, based upon AR's CR dataset. Because the CR dataset does not appear to include many Tier III CMSPs, the competitive alternatives to Tier I and II CMSPs may be underestimated. However, many of the potential Tier III competitors do not intend to implement WEA so this underestimate is probably not a serious issue. The absence of details about Tier III CMSPs in AR's data may be important in areas where Tier I and II CMSPs do not provide voice or WEA coverage, but these areas are very small by any measure. However, some of them may have business relationships with Tier I and II CMSPs that would expand the coverage, but those relationships are proprietary and thus opaque.

E. Additional Detail on Coverage Analysis

As described in Chapter Three and depicted in Chapter Five, coverage analyses were performed on many subsets of AR's CR dataset. This appendix fully explains the analyses themselves, as well as the specifics of the subsets analyzed, and offers an opportunity to compare the numerical results at a glance (Table E.1).

In each coverage analysis, the advertised coverage patterns[55] of all CMSPs relevant to the particular geographic selection criteria were collected to form one master dataset. The complete set of 2010 U.S. Census tracts was then geographically constrained to the size of advertised coverage. In other words, the advertised coverage of all relevant CMSPs was used as a cookie cutter to reduce the size of the 2010 U.S. Census tracts. Afterward, the new, reduced size of each census tract—the portion of its area that was covered—was compared to its original size; this yielded a direct percentage of land mass coverage. Assuming an evenly distributed population within each census tract, this coverage percentage was multiplied by the tract's 2010 population to yield the number of people covered in that tract.

The data subsets analyzed are as follows:

- Entire United States: This row simply represents the entire United States without any coverage analysis applied, i.e., its area and population as of the 2010 census.
- Not covered by any CMSP: The area for which no CMSP in the CR dataset has advertised coverage.
- Covered by at least one CMSP: The area for which at least one CMSP in the CR dataset has advertised coverage.
- Covered by at least one non–WEA-compliant CMSP network: The area covered by at least one CMSP that is not WEA-compliant and not covered by any other CMSPs that are WEA-compliant.

[55] Wireless voice coverage for any CMSP is, in every case, the same size as or larger than that CMSP's wireless data coverage. Thus, use of the word "coverage" is meant to denote "voice coverage" in every instance.

- Covered by at least one WEA-compliant CMSP network: The area covered by the WEA-compliant network[56] of at least one CMSP.
- Covered by exactly one WEA-compliant CMSP network: The area considered to have WEA-compliant coverage but no competition between multiple WEA-compliant CMSPs.
- Covered by more than one WEA-compliant CMSP network: The area considered to contain possible competition among multiple WEA-compliant CMSPs.
- Covered by at least one WEA-compliant Tier I CMSP network: The area of the United States covered by the WEA-compliant network of at least one Tier I CMSP. Recall that a CMSP is considered Tier I if it has nationwide coverage.
- Covered by at least one WEA-compliant Tier II CMSP network: The area of the United States covered by the WEA-compliant network of at least one Tier II CMSP. Recall that a CMSP is considered Tier II if it has 500,000 or more subscribers but non-nationwide coverage.
- Covered by at least one WEA-compliant Tier I CMSP network: The area of the United States covered by the WEA-compliant network of at least one Tier III CMSP. Recall that a CMSP is considered Tier III if it has less than 500,000 subscribers.

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[56] A single CMSP can have more than one wireless network, each corresponding to a single wireless protocol. Some CMSPs, especially the Tier I carriers, maintain a primary voice network of either CDMA or GSM, along with reduced coverage in a different voice protocol. The WEA elections of the Tier I carriers noted existing or forthcoming WEA compliance in their primary voice networks only, and this standard was used for all CMSPs during the analysis phase: only each CMSP’s primary voice network was included in each consideration. Since a single network of a CMSP is often a subset of that CMSP’s total voice coverage, the word “network” is required here.

Table E.1. CMSP Coverage Analysis Numerical Results

Coverage Extent	Area Covered (%)	Population Covered (%)
Entire United States	100.0%	100.0%
Not covered by any CMSP	22.2%	0.5%
Covered by at least one CMSP	77.8%	99.5%
Covered by at least one non–WEA-compliant CMSP	4.6%	0.1%
Covered by at least one WEA-compliant CMSP network	73.2%	99.4%
Covered by exactly one WEA-compliant CMSP network	14.0%	1.4%
Covered by more than one WEA-compliant CMSP network	59.2%	98.0%
Covered by at least one WEA-compliant Tier I CMSP network	72.7%	99.2%
Covered by at least one WEA-compliant Tier II CMSP network	21.6%	71.7%
Covered by at least one WEA-compliant Tier III CMSP network	17.1%	9.1%

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