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Communications Security, Reliability and Interoperability Council

September 2016 WORKING GROUP 2

Emergency Alerting Platforms

Wireless Emergency Alerts – Recommendations to Improve Geo-Targeting and Offer Many-to-One Capabilities

Final Report & Recommendations

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# Results in Brief

## Executive Summary

The Warning, Alert, and Response Network (WARN) Act of 2006 provided for the creation of the Commercial Mobile Alert System (CMAS), now known as Wireless Emergency Alerts, or WEA.

WEA is a collaborative partnership that includes the cellular industry, Federal Communications Commission (FCC), Federal Emergency Management Agency (FEMA), and U.S. Department of Homeland Security Science and Technology Directorate (DHS, S&T). The WEA capability provides a valuable service: disseminating emergency alerts to users of capable mobile devices if they are located in or travel to an affected geographic area.

This report has two distinct goals. First, is intended to advocate WEA usage by addressing the most frequent complaint of alert originators (AO), perceived geo-targeting capability at the sub-county level. An examination of the historical use of WEA and a digest of best practices from a diverse set of users indicates that confidence in WEA, as presently constituted, could be improved by increasing the targeting precision. Due to cell tower locations and topography, message delivery best approximates the alert area, which by the nature of RF nearly always varies from the alert originator (AO) specified polygon leading to a significant risk of either over-alerting or under-alerting.

Recognizing that Congress specified WEA to be a voluntary service with obligations placed on the participating Commercial Mobile Service Providers (CMSPs), there is considerable difference of opinion between the AOs and the wireless industry concerning the appropriate future direction for WEA as well as the feasibility of various enhancements under contemplation. The success of WEA to date is primarily based on balancing these obligations on the participating CMSPs with the goals of the WEA service (defined by the WARN Act) and the desires for enhancements from the AOs. While there is broad agreement that, given time, many (if not all) enhancements favored by the alerting community are feasible and make sense to add to the participating CMSP voluntary obligations possible, ultimately a balance must be struck between the original intent of Congress in passing the WARN Act, the capabilities of the technology both in the CMSP infrastructure and devices, the impacts and added obligations to the CMSPs that voluntarily participate, the desires of the AOs, and the public need. Second, this report seeks to shed light on the potential benefit of expanding WEA messages to enable a new, non-WEA service that could allow message recipients to communicate with AOs through other communication methods. In just the past decade, communications technology such as crowdsourcing has evolved to allow emergency managers and other public officials to efficiently receive information from the public. This “many to one” communication is vital in the creation of a common operating picture for responders. This report will discuss these systems in the context of how they can inform and influence emergency alerting strategies and enhance life-safety. This “many-to-one” communication should not be considered under WEA obligations nor place any additional obligations on participating CMSPs.

While most but not all of the public has adopted the smartphone as their primary communications device, there are still a significant number of users who choose not to use smartphones or who cannot afford smartphones. Any consideration of future enhancements to WEA must allow for support of the basic feature phones as well as the advanced smartphones. In addition, WEA is part of a global family of global Public Warning System of standards, allowing for inbound roamers to the U.S. to receive WEA alerts on capable devices, as well as U.S. citizens traveling to receive WEA alerts in participating countries. WEA is also widely deployed on most devices in the U.S. Consideration of future WEA changes must not break the global roaming WEA capability, and must be backwards compatible to existing deployed handsets.

With this report, the FCC will have the opportunity to consider the future capabilities and direction of WEA as well the appropriate steps necessary to proceed. The findings and recommendations in this report are intended to present a vision of what the system can become and how that transformation can save lives.

# Introduction

This report is from Communications Security, Reliability & Interoperability Council (CSRIC) Working Group 2: Alerting Subgroup which is investigating topics related to Wireless Emergency Alerts and Many-to-One Communications.

This final report documents the efforts of those two working groups.

## CSRIC Structure

|  |  |  |  |
| --- | --- | --- | --- |
| **Communications Security, Reliability, and Interoperability Council (CSRIC) V** | | | |
| **CSRIC Steering Committee** | | | |
| **Working Group 1**  **Evolving 911 Services**  **Co-Chairs:** Susan Sherwood & Jeff Cohen  **FCC Liaisons:** Tim May & John Healy | **Working Group 2**  **Wireless Emergency Alert**  **Co-Chairs:** Francisco Sánchez & Farrokh Khatibi  **FCC Liaisons:** Chris Anderson, James Wiley & Gregory Cooke | **Working Group 3**  **Emergency Alert System**  **Co-Chairs:** Steven Johnson & Kelly Williams  **FCC Liaison:** Gregory Cooke | **Working Group 4**  **Communications Infrastructure Resiliency**  **Co-Chairs:** Kent Bressie & Catherine Creese  **FCC Liaison:** Emil Cherian |
| **Working Group 5**  **Cybersecurity Information Sharing**  **Co-Chairs:** Rod Rasmussen, Christopher Boyer, Brian Allen  **FCC Liaisons:** Greg Intoccia & Vern Mosely | **Working Group 6**  **Secure Hardware & Software**  **Co-Chairs:** Brian Scarpelli & Joel Molinoff  **FCC Liaisons:** Steven McKinnon & Emily Talaga | **Working Group 7**  **Cybersecurity Workforce**  **Co-Chairs:** Bill Boni & Drew Morin  **FCC Liaison:** Erika Olsen | **Working Group 8**  **Priority Services**  **Co-Chairs:** William Reidway & Thomas Anderson  **FCC Liaisons:** Tim Perrier & Ken Burnley |
| **Working Group 9**  **Wi-Fi Security**  **Chair: Brian Daly, AT&T**  **FCC Liaisons:** Peter Shroyer & Kurian Jacob | **Working Group 10**  **Legacy Systems & Risk Reduction**  **Co-Chairs:** John Kimmins & Danny McPherson  **FCC Liaison: Steven McKinnon** |

Table 1 - Working Group Structure

## Working Group 2 - Alerting Team Members

Working Group 2 - Alerting consists of the members listed below.

|  |  |
| --- | --- |
| **Name** | **Affiliation** |
| Francisco Sanchez - Co-Chair | Harris Co. (TX) Emergency Management |
| Dr. Farrokh Khatibi - Co-Chair | Qualcomm |
| Alexander Gerdenitsch | EchoStar |
| Alfred Kenyon | Federal Emergency Management Agency/IPAWS |
| Amanda Faulkner | Twitter |
| Benjamin J. Krakauer | New York City Office of Emergency Management |
| Bob Sherry | Intrado |
| Brad Gaunt | Sprint |
| Brian Daly | AT&T |
| Brian Murray | Harris Co. (TX) Emergency Management |
| Caitlin Shockey | Centers for Disease Control |
| Carol Woody | Software Engineering Institute |
| Charity Dominguez | Harris Co. (TX) Emergency Management |
| Chris Anderson | Federal Communications Commission |
| Chris Tarantino | Epicenter Media & Training |
| Dana Golub | Public Broadcasting Service |
| David Layer | National Association of Broadcasters |
| Denis A. Gusty | Department of Homeland Security, S&T/FRG |
| Dharma Dailey | University of Washington |
| Dr. Gina M. Eosco | Eastern Research Group |
| Greg Cooke | Federal Communications Commission |
| Dr. Keith Bhatia | TeleCommunication Systems, Inc. |
| Elizabeth T. Dexter | Watch Officer/EOC Team Member |
| Hutch McClendon | Advanced Computer and Communications, |
| James Tyson | Centers for Disease Control |
| James Wiley | Federal Communications Commission |
| Dr. Jeannette Sutton | University of Kentucky |
| Jennifer Manner | Echostar |
| John Davis | Sprint |
| Jonathan W. Gaddy | Calhoun Co. (AL) Emergency Management Agency |
| Jose Rivera | Department of Homeland Security |
| Dr. Kate Starbird | University of Washington |
| Larry Rybar | Verizon |
| Larry Walke | National Association of Broadcasters |
| Mark D. Annas | Riverside (CA) Fire Dept. |
| Mark Lucero | Federal Emergency Management Agency/IPAWS |
| Matthew Straeb | GSS Net |
| Mike Gerber | National Weather Service |
| Paul Lupe | Fairfax County VA Office of Emergency Management |
| Peter Musgrove | AT&T (ATIS) |
| Rick Wimberly | Galain Solutions |
| Robbie Turner | NextDoor |
| Robert Bunge | National Oceanic and Atmospheric Administration |
| Scott Enright | Emmis Communications |
| Shelley Blakeney | T-Mobile |
| Steve Mace | National Cable & Telecommunications Association |
| Tim Dunn | T-Mobile |
| Tony Surma | Humanitarian Toolbox |

Table 2 - List of Working Group Members

Working Group 2 chairs would like to acknowledge the contributions of Brian Murray (Geo-Targeting) of the Harris County Office of Homeland Security & Emergency Management and Benjamin Krakauer (Many-to-One Communications) of the New York City Office of Emergency Management. Charity Dominguez, a graduate intern at the Harris County Office of Homeland Security & Emergency Management, also contributed to the creation of the final report. Their leadership and scholarship is appreciated.

# Objective, Scope, and Methodology

## Objective

WEA is a multi-stakeholder service with obligations for transmitting the WEA alerts placed on the participating CMSPs. The Subgroup is tasked to provide recommendations on how best to encourage the use of wireless emergency alerts by state and local officials at a local/geo-targeted level, balancing with the obligations for enhancements by the participation CMSPs, and encouraging additional CMSPs to participate. Surveys of AOs, including those in Working Group 2, indicate the single greatest impediment to widespread WEA acceptance and use is rooted in a mistrust of the geo-targeting capability. This report examines the trust issues and seeks outline a potential path toward building system trust among AOs and, ultimately, the public.

## Scope

This Working Group was directed to provide recommendations on how best to encourage the use of WEA by state and local officials at a local/geo-targeted level, including leveraging different alerting platforms and the coordination of information flow from both “one-to-many” and “many-to-one”. The Working Group would also discuss and provide recommendations on technical issues such as the use of “many-to-one” methods for public safety officials to rapidly receive and accumulate feedback from the public concerning developing incidents.

The initial scope provided by the FCC included study of complementary alerting platforms and social media. Because these subjects are not generally under the direct jurisdiction of FCC and the deliverables from those working groups would constitute best practices rather that items of policy, permission was sought and received to address them in a separate report.

## Methodology

In general, this report is not based on new quantitative research. Instead, subject matter experts have been asked to review and discuss existing technologies and their uses as applicable to the development of Wireless Emergency Alerting. Over the course of 2016, subject matter experts from academia, Commercial Mobile Service Providers (CMSP), device manufacturers, and the AO community were invited to make presentations to the work group on various topics relevant to the group’s mandate. This report was compiled based on information from those presentations, studies cited within those reports, and feedback from the work group members.

# GEO-TARGETING: Background, Findings and Recommendations

## Background

The FCC has charged Working Group 2 to promulgate recommendations that, if adopted, will enhance WEA, leading to a greater use of the technology by AOs and improvements in public safety outcomes. Feedback from public safety officials strongly indicates that more alerting authorities would use WEA if they were confident WEA messages could be granularly geo-targeted.

As acknowledged by CSRIC IV, “the effectiveness of WEA alert messages may remain suppressed until they can be distributed to finer geospatial areas, so that messages only reach the people who are at risk” (80 FR 77301). Studies conducted by Carnegie Mellon University (Opportunities, Options and Enhancements for the Wireless Emergency Alerting Service – December 2015) and the Johns Hopkins University Applied Physics Laboratory (New Emergency Alert Technology Could Fine-Tune Warnings for Smartphones – October, 2015) concluded that device augmented geo-targeting positioning provides a higher degree of granularity. The subject matter experts in the wireless industry have also examined device based geo-targeting, and as noted in this report, device augmented geo-targeting does pose challenges: how to transmit the coordinates of the polygon while maintaining backwards compatibility and not breaking roaming; support for low end devices such as feature phones, network loading due to A-GPS location determination, etc.

WEA was established pursuant to the Warning, Alert and Response Network (WARN) Act of 2006. WEA is a voluntary public safety system that allows customers who own certain WEA-capable wireless phones and other enabled mobile devices to receive geographically-targeted, text-like messages alerting them of imminent threats to safety in their area. Receipt of these WEA messages is through obligations on the transmission of WEA alerts by participating CMSPs. To meet these obligations without significantly impairing the ability of the network to provide service, the wireless industry has developed standards for the transmission of WEA using the standards-based cell broadcast capability in the CMSP infrastructure and mobile devices; these standards are compliant with the global Public Warning System defined in 3GPP, thus supporting a global solution. Cell broadcast technology has unlimited communication capacity within the broadcast area, is a one-way broadcast that does not extract information from devices, thus minimizing the load on the network while protecting privacy. Moreover it uses capabilities of the control channels that ensures emergency alerts will not get stuck in highly congested areas, which can happen with standard mobile voice and texting services.

Cell-broadcast based WEA provides geo-targeting capability that is dependent on cell site topology and RF characteristics. Thus, WEA enables government officials to target emergency alerts to specific geographic areas – lower Manhattan, for example – through cell towers that broadcast the emergency alerts for reception by WEA-enabled mobile devices.

While cell broadcast based WEA does offer geo-targeting capabilities down to the cell site/sector, Geo-targeting precision has been cited by the AO community as a significant concern in the NPRM 15-91 comment and reply process as well as research studies. The Carnegie Mellon University - Silicon Valley Alert Originator Requirements Study (AORS) specifically noted that many AOs “felt that the current WEA service did not meet their needs, primarily for lack of sufficiently fine-grained geo-targeting.”

## Defining Geo-Targeting Precision

Geo-targeting precision is expressed in terms of decimal places in each latitude/longitude coordinate pair – the more decimal places included, the more precise the area being described and the greater the ability to pinpoint the area being alerted. The precision of geographic granularity correlates to the number of decimal places in latitude/longitude pairs as follows.

* The **first decimal place** is worth up to 11.1 km: it can distinguish the position of one large city from a neighboring large city.
* The **second decimal place** is worth up to 1.1 km: it can separate one village from the next.
* The **third decimal place** is worth up to 110 m: it can identify a large agricultural field or institutional campus.
* The **fourth decimal place** is worth up to 11 m: it can identify a parcel of land. It is comparable to the typical accuracy of an uncorrected GPS unit with no interference.
* The **fifth decimal place** is worth up to 1.1 m: it distinguish trees from each other. Accuracy to this level with commercial GPS units can only be achieved with differential correction.[[1]](#footnote-1)

## Enhancement vs. Technology

The argument has been made that this working group is tasked with recommending enhancements to WEA. FCC expectations are that we “will provide recommendations on how best to encourage the use of emergency alerts by state and local officials at a local/geo-targeted level” and promulgate “standards that could result in improvements to public safety outcomes.” Even the most basic analysis of this objective means that, WEA, proposed enhancements must strike a balance between the obligations on participating CMSPs and impacts to standards, CMSP infrastructure and devices, while working toward meeting the needs and expectations of the public, including the desires of the AOs. Moreover, encouraging further use of the system by AOs is wholly dependent on it being seen as an authoritative source of emergency public information. Accuracy of alert delivery area is at least as important as message content as those receiving messages that do not pertain to them (or not receiving messages that do pertain to them) may develop a distrust of WEA messages that will be difficult to reestablish later.

In addition, based on the recent flooding disaster in Louisiana where six or more WEA Flash Flood alerts were issued by NWS using the WEA system, this flood event was unprecedented, inundating areas that had never experienced flooding in the past. As a result, the multiple WEA alerts, “Flash Flood Warning this area until XX:XX. Avoid flood areas. Check local media.-NWS”, went un-heeded by tens of thousands who were rescued from the flooded areas, many of whom assumed the alert was not for them since their home had never flooded before. The alerts were ignored by far too many. Over 30,000 people were rescued. Though negative public safety outcomes in this example are not attributable to WEA, finer granularity would have allowed AOs to tailor warning messages to those in immediate danger. Dennis Mileti with START research stated it this way “Warnings must overcome people’s natural belief to think that they are safe, and then guide them to take protective actions that are inconsistent with their perceptions of safety.”[[2]](#footnote-2) Alerts need greater granularity and precision of alert delivery along with displaying a map of the alert area (polygon) and the devices location (blue dot) within the targeted area to significantly improve the personalization of the emergency alert and enhance the desired response of targeted population. By including the display of the targeted area (a neighborhood) along with the device location, the recipient will be able to visually confirm the message is intended for them. The finer the granularity of the alert polygon, the more personalized the message becomes, the more likely the population will respond as desired by public safety.

Discussions of over or under alerting are purely academic, if not irrelevant, if this basic requirement of the technology cannot be met. It is understood that cellular broadcast technology, like all radio communications methods, has limits. But, it must also be assumed that it will be improved over time if only because the competitive nature of the enterprise demands it.

Based on the research conducted, several issues must be resolved in order to achieve the objectives of the working group:

1. “Best approximate” must be defined in a way that meets public safety objectives but respects the technical capability and limitations of cell broadcast to geotarget.
2. The role of device-based geo-location applications in significantly improving alert delivery precision
3. Leveraging device based applications to enhance WEA display and public confidence in information received, so that the threat is personal and people take life-saving action.

## Defining “Best Approximate”

**Best Approximate Geo-targeting for Cellular Broadcast Based on Current Technology**

During this group’s tenure, multiple presentations provided insight into the actual capabilities of the WEA system. Based on subject matter expert presentations to the working group, it is clear that it is difficult, if not impossible, to provide a concrete definition of “best approximate.” Geo-targeting of cell broadcast is dependent on several factors, as specified in the ATIS-0700027, *Feasibility Study for WEA Cell Broadcast Geo-Targeting*. The percent of the alert area covered as well as the overshoot/undershoot (“variance”) is directly dependent on the cell tower topology, as well as the RF characteristics, spectrum band, and propagation of each of the cell towers chosen to broadcast the WEA alert. For any given polygon, the percent coverage is dependent on the relationship of the cell towers to the alert polygon; the location of the cell towers as well as the RF characteristics/spectrum band of the signals broadcast by those cell towers affect the variance of that coverage. Cell tower topology is dependent on cellular traffic distributions, vary by geography as well as by operator, and RF characteristics impacted by parameters both within and outside of the control of the operator (e.g., RF propagation may be impacted by terrain, reflections, foliage, man-made objects, spectrum bands, etc.).

Cell coverage also varies due to the density of distribution of the towers are in a given area. For example, in dense urban areas, there is densification of the cell sites, allowing for a greater percentage of the alert area coverage and potentially less variance, while in rural areas the cell sites are typically less dense resulting in potentially greater variance in the alert area coverage. This non-uniformity is a result of the cell site topology, which varies not only by geography but will also vary by operator. Thus, the variance can be considered as roughly the size of the propagation area of the cell sites at the borders of the alert polygon; these cell sizes will vary depending on cell topology, urban vs. rural, etc.

In densely populated cities, the alert is broadcast to nearly all of the actual alert area due to the high density of cell towers which broadcast the alert.  Anecdotal information suggest the alert broadcast may reach locations about up to about 2 miles outside the actual alert area.

In suburban areas, there may be small pockets where pockets with limited/no cell tower coverage so WEA will not reach those areas.  Anecdotal information suggests the alert broadcast may reach locations up to about 5 miles outside the actual alert area.

In rural areas, there are the greatest number of areas with limited/no cell tower coverage where WEA does not reach those areas.  The alert broadcast from “boomer” towers reach locations 30,000 meters (approximately 20 miles) or more outside the actual threat area.

# Commentary and Recommendations from Wireless Industry

WEA is a secondary voluntary service offered by participating CMSPs, and has been effective and successful in its intended mission. Since participating CMSPs bear the burden of any changes to the WEA service, any enhancements to WEA must first and foremost give careful consideration on the impacts to the CMSP infrastructure and mobile devices. WEA is designed to support the WARN Act as a bell ringer service, using cell broadcast technology which does not significantly impact the CMSP networks or operations, and uses the cell broadcast capabilities in the mobile device hardware and OS. Changes to the existing deployed service will impact the significant base of deployed devices, and any changes not standardized globally have the potential to impact roamers into the U.S. from receiving alerts.

There is an assumption among some AOs that the best effort matching of the alert polygon geo-targeting offered by CMSPs and cell broadcast technology is hindering some alert originators from using WEA. This is an area for potential study by ATIS along with CMSPs and alert originators to fully understand if and why alert originators are under the assumption that current geo-targeting schemes deployed by CMSPs is insufficient for the WEA mission as intended in the WARN Act, and if this is a significant reason for alert originators to not use WEA.

While there have been some geo-targeting issues noted in the early deployments of WEA when county-level geo-targeting was the norm, there is only anecdotal evidence that the current best effort to match the polygon employed by CMSPs is insufficient for the geo-targeting needs of WEA alerts. The current CMSP infrastructure based calculation of the WEA alert broadcast area using polygons continues to be the best solution for WEA geo-targeting. As such, AOs should always expect some amount of overshoot or undershoot of the WEA alert broadcast area as compared to the provided WEA alert polygon. This is due to a number of factors, including:

* The location, shapes and sizes of the cell sites and cell sectors will vary upon factors such as radio configurations (e.g., power levels, antenna inclinations), radio wave propagation characteristics, and the geographic topology of the coverage area
* It is impossible to determine, in advance, the Broadcast Area vs. the Alert Area
* Cell site topology varies across CMSPs so expect different broadcast areas

There is evidence that to achieve the geo-targeting necessary for more public safety officials to use WEA, the intelligence of the mobile device must be leveraged in rendering emergency alerts. However, CMSPs and SMEs in the wireless industry have expressed concern over these mechanisms, and have requested further study to determine the impacts to CMSP networks and mobile devices; an ATIS feasibility study has described challenges with supporting these capabilities. They warn that any changes to support such capabilities will not be backward compatible with the existing based of deployed WEA capable devices, and will require changes to both U.S. and global standards (to support roamers). The timeline for such work can be better determined once the standards timelines are evaluated, but indications from the CMSPs are that it would be 5-7 years before such devices could even start to be deployed.

It is likely that the WEA message length for LTE will be increased to 360 characters, once standards are complete, which will allow alert originators to provide more specificity in the alert messaging, including alert area descriptions. Focus should be on using these additional characters to enhance the messaging rather than adding complexity to the WEA ecosystem.

Overall, alert originators should be able to determine the granularity of alert areas using vertices with two to four decimal places depending on the nature of the hazard. The second decimal place provides resolution up to 1.1 km which can separate one town from the next. The third decimal place provides up to 110 m resolution which can identify a large agricultural field or institutional campus. Four decimal places provides resolution up to 11 m which can identify a parcel of land and is comparable to the typical accuracy of an uncorrected GPS unit with no interference.

It should be noted that providing this level of polygon granularity from the alert originator does not imply or guarantee that the broadcast of the WEA alert on the CMSP network will meet the granularity specified by the number of decimal places in the supplied polygon. Granularity of the broadcast of the WEA alerts is dependent on the cell broadcast technology, which in turn is dependent upon the cell site topology, RF characteristics, etc. as described in the Alliance for Telecommunications Industry (ATIS) feasibility study. This capability, if adopted, should not impose any further obligations on the CMSP to broadcast the WEA alert more granular than the best approximation of the supplied polygon using the capabilities of the cell broadcast technology on the CMSP network.

On the question of device-based geo-location assistance, further study by ATIS, and specifically participating CMSPs, is clearly necessary. The presumption by AOs and other proponents of device based solutions is that, using this data, if the device determines itself to be inside the alert area, then the alert is rendered on the device. ATIS and other stakeholders in the cellular industry should be tasked to develop a report on the feasibility of and impacts to CMSP networks to broadcast the coordinates of the alert area to the wireless device. Further, ATIS should investigate the feasibility of the mobile device hardware and respective operating system to receive and use the coordinates of the alert area at an application layer so that the device can determine if it is inside the alert area. This report should also study the assumptions that device based location is always/readily available to process the alert area information, the impacts to CMSP networks for potentially all devices in the alert area having to simultaneously determine its location, and potential delays in mobile devices displaying alerts using this method. They should also develop a timeline for the development of standards, both for the U.S. and globally, to support such capabilities if determined to be feasible, as well as estimates of development and deployment timelines once standards are complete.

One technique to improve WEA geo-targeting that was discussed in the ATIS-0700027 feasibility study is the inclusion of nested polygons in an alert area sent from an alert originator. Changes would be needed to OASIS CAP, 3GPP, and ATIS standards to support changes on the interface between the alert originators and the IPAWS system, as well as between IPAWS and the cellular operator networks. The report noted that this change will require 18-24 months of standardization, and another 18-24 months for development and implementation in both the government systems and the cellular operator networks. The clock would not start on standardization until the firm requirements from the FCC are known. Note that this timeline was for a nested polygon capability that was determine to be feasible in ATIS-0700027. This item is also awaiting action from the FCC.

The timeline for mobile-assisted geo-targeting would be similar to the timeline in the above paragraph but would require additional time, as mobile-assisted geo-targeting was not determined to be feasible in ATIS-0700027. Further, mobile device requirements, development, and manufacture would need be taken into account, likely adding additional time to fully develop the technology.

ATIS provided the following timeline for pursuing WEA Enhanced Geo-targeting, assuming it is a feasible solution:

1. Study and evaluation of a voluntary framework for enhanced WEA requirements (6-12 months)
2. Standardization of the enhancements – expedited at 12-18 months (previously 18-24 months)
3. Embedding the enhancements in the device OS (iOS, Android, Windows, etc.) and developing mobile chipsets with the capabilities (18-24 months)
4. Developing handsets with software to support the new capability (6-12 months)

ATIS estimates that, even if these measures could begin immediately, it will take another 42-66 months to have devices with that capability in the market. ATIS recommends that, in an effort to speed up the timeline for enhanced WEA geo-targeting and for other WEA enhancements, a CSRIC recommendation to the FCC should be to recommend a joint public-private partnership, led by ATIS and including a variety of WEA stakeholders (including public safety alert originators, DHS/FEMA, academics, and cellular operators/vendors) to study and evaluate a voluntary framework for enhanced WEA (call it WEA 2.0) requirements and standards development. The work of the partnership could begin as soon as the FCC evaluates the CSRIC V output and would be a cooperative effort to determine how the simplest WEA enhancements could be worked first, with the more difficult capabilities to be examined later. Cost/benefit analyses of the various enhanced WEA proposals from the perspectives of both government and industry could be performed to assist with the determination of the feasibility of proceeding with certain capabilities.

There is a significant risk, according to AT&T, that including such capabilities in WEA, which is a voluntary service under the WARN Act, may result in some participating CMSPs to consider withdrawing from WEA due to the added complexity of these capabilities.

# Commentary and Recommendations from Alert Originators

Numerous local, state, regional, and federal alert originators and stakeholders from geographically and demographically diverse backgrounds have publicly commented to the FCC that geo-targeting is an important public safety matter. In comments before the FCC, the Boulder Regional Emergency Telephone Service Authority disclosed “WEA [has] limited utility to local public safety agencies because messages cannot be targeted to affected area. More narrowed geo-targeting of WEA messages would make the service more useful and avoid causing people to opt out of WEA and ENS.”[[3]](#footnote-3)

According to a study performed by Carnegie Mellon University (CMU) Silicon Valley, the more finely tuned the geo-targeting of WEA, the more likely public safety officials are to use WEA. Of 67 respondents, 81% were very likely or likely to use WEA if minimum geo-targeting resolution were less than 10 city blocks. 63% were likely or very likely to use WEA if the minimum geo-targeting resolution were as large as 10 square miles. The desire to geo-target alerts with finer resolution was strongest among city-level respondents. The CMU Alert Originator Requirements Study (AORS) revealed the following:

Key observations from all three parts of the AORS pertain to the low WEA adoption rate among AOs, a resounding need for better education, a strong desire by AOs for the ability to test and evaluate system effectiveness, the WEA service’s wide reach as a major advantage, the advantages of geo-targeting specificity, and strategies for increasing both the capacity of an alert to prompt action and likelihood of an alert to be relevant to the recipient via longer messages, maps and rich media.

It was surprising to learn how few AOs had actually used WEA, just 48 as of January 2016 according to FEMA IPAWS. While a small number were approved to issue messages or were in the process of approval, many had not yet had the need or did not have the ability to issue WEA messages. Some felt that the current WEA service did not meet their needs, primarily for lack of sufficiently fine-grained geo-targeting.[[4]](#footnote-4)

This working group asked several public safety officials for cities ranging from small to large population density to describe the geo-targeting resolution necessary in order for them to use WEA.

* Matt May (Emergency Management Director for Wyandotte County, KS) said that before pushing a WEA, he needs to know how much unintentional overreach there is going to be, so he’ll know the extent of his problem and what mitigating actions to take. May would like some idea, a metric, so that if he draws a circle or polygon, he will have a good idea as to who is going to receive the alert. He said approximate resolution of ½ mile is good. May could live with 1 mile resolution, but probably not anything more than 1.5 mile. He also needs to know if his alert in going to overlap his partners next door in Missouri.

Given the way WEA is currently done with cellular broadcast, he wants a tool showing the cell towers and approximate coverage, so he'll know who is going to get the warning. He said he understands there are differences between cell towers and carriers. He wants to adjust the circle or polygon based on tower locations or the approximate broadcast footprint from towers. If there is a boomer tower, he wants to see it. May also said if a metric isn’t established and approximate resolution is not granular enough, then he needs WEA to display a map showing the recipient with respect to the actual alert area.

* Jonathan Gaddy (Emergency Management Director for Calhoun County, AL) said over-alerting in a high population density area would likely have greater consequences than in a rural area where population density is lower. He suggested ½ mile resolution as a good starting point. Gaddy said if he alerts a small area, such as 5 square miles, there is no doubt plenty of people outside that area will also be actively following the incident and may also take actions on their own, such as evacuating, despite not being at risk.
* Mark Annas (Emergency Operations Coordinator for Riverside, CA) said resolution over 1/4 mile can be more of a burden than a help depending on what we are warning about. Sometimes over-alerting isn't an issue but it can be if you are issuing an evacuation or call to shelter-in-place. Calls for service or further information will increase once an alert goes out.
* Ben Krakauer (Director of Watch Command for the New York City Emergency Management Department) said he needs block by block resolution, because there are tens of thousands of people in a city block due to the many high rise buildings in New York City. However, he said he could live with a resolution of several blocks.

Krakauer added that he’d like to draw polygons along highways for highway related emergencies. He also added that improvements in geo-targeting could also likely open the system up to additional categories of alert originators (e.g., universities, corporate office campuses, residential apartment complexes) since those institutions would be able to craft and send messages to their discrete populations without alerting the broader populous. Krakauer said the key to this effort is device assisted geo-targeting and felt the accuracy of commercial based geo-targeting in mobile applications would be good enough (e.g., Uber, Lyft, etc.).

* Francisco Sánchez (Public Information Officer for the Office of Homeland Security & Emergency Management in Harris County, TX) expressed concern that alerting of non-threatened persons would, over time, reduce public confidence in WEA, eroding its impact as a communications tool.

Sánchez recognizes that some, minimal, overshoot can be highly beneficial. For example, a motorist entering an alert area might use information received in a WEA message to change course away from potential danger. At the same time, he is concerned that inability to achieve a high degree of granularity in densely populated areas would ultimately degrade the value of WEA to emergency managers. Sánchez also notes that much of the controversy surrounding granularity stems from FCC’s decision to allow alerting below the county level, or sub-FIPS Code. As such, FCC must take some responsibility for ensuring that the technical capabilities of the system match the burdens they have placed upon it.

Given the technology available today and experience from the industry including field studies conducted by Department of Homeland Security Science & Technology (DHS S&T), it has been determined that immediate improvement in granularity can be achieved through ensuring that cell sector level geo-targeting algorithm be implemented by the CMSPs. As specified by the Federal Communications Commission “First Report and Order” number FCC 08-99, the current geo-targeting mandatory requirement is limited to county level accuracy only. Sub-county level accuracy implementation is optional and is left to the discretion of the CMSPs. However, the largest four carriers AT&T, Sprint, T-Mobile and Verizon all support polygon level geo-targeting voluntarily. Consequently, no sub-county level geo-targeting granularity capability is guaranteed across participating WEA service providers. In order to meet the geo-targeting precision needed by the AOs voiced to date, a change in the rule making should be made to require that all participating service providers implement cell sector level accuracy using a standard and acceptable engineering method to be determined by the industry experts.

In summary, the majority of public safety officials have stated they want geo-targeting granularity ranging from 1 block to 1/10 mile while some could live with granularity from ¼ mile to 1 1/2 miles depending on the type of alert (e.g. an active shooter alert or evacuation will require more granularity than for a tornado or hurricane). The desire to geotarget alerts with the finest granularity is in cities with high density population. However, the clear consensus of AOs is that the definition should be 100% of the polygon selected with less than .10 mile overshoot.

Furthermore, recent deadly events in Baton Rouge, Dallas, and Orlando emphasize the need for the most precise geo-targeting of life-saving alert information possible. In any of these cases, alerting precision would be of paramount importance. Failure to alert to the entire AO-designated polygon could easily have contributed to a higher death toll as intended warning recipients might have had no indication that they should take protective action or flee.

Consider the diagrams below. For discussion purposes, assume that each “block” contains a high rise building containing 2,000 individuals. In Figure 1.1, with an alert area of one block, a resolution of 161 meters could alert as many as 50,000 people – 25 times the number at risk. Shrink that resolution to 80 meters, as shown in Figure 1.2, and the over alerting shrinks to just 18,000 people being alerted.

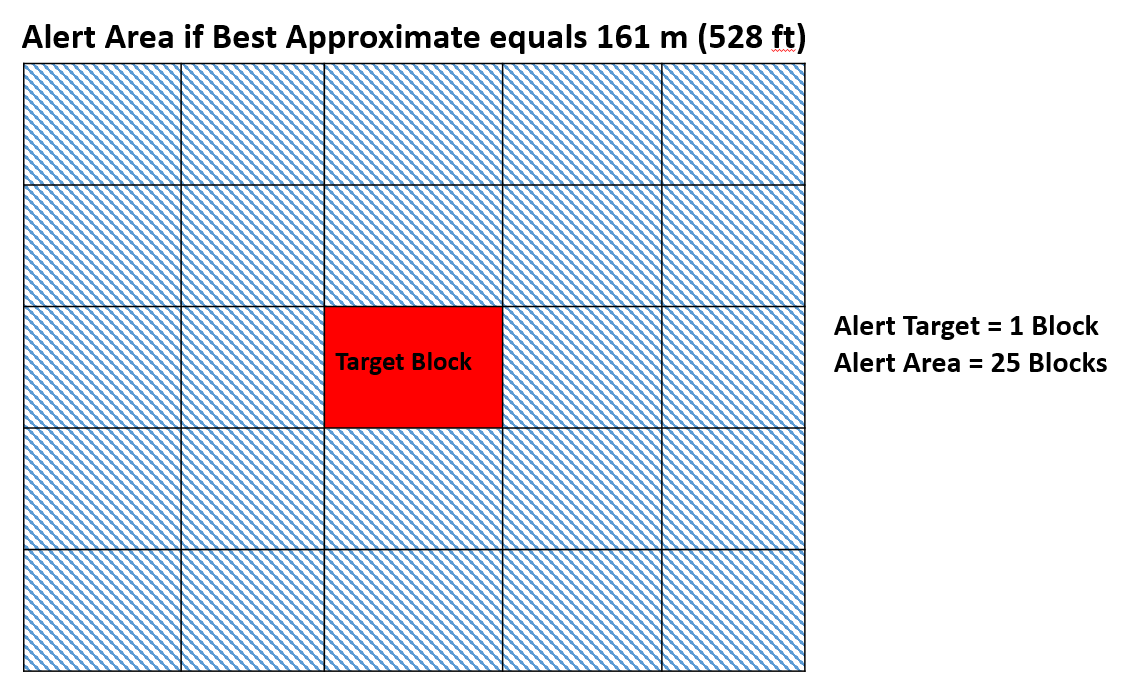


Figure 1.1

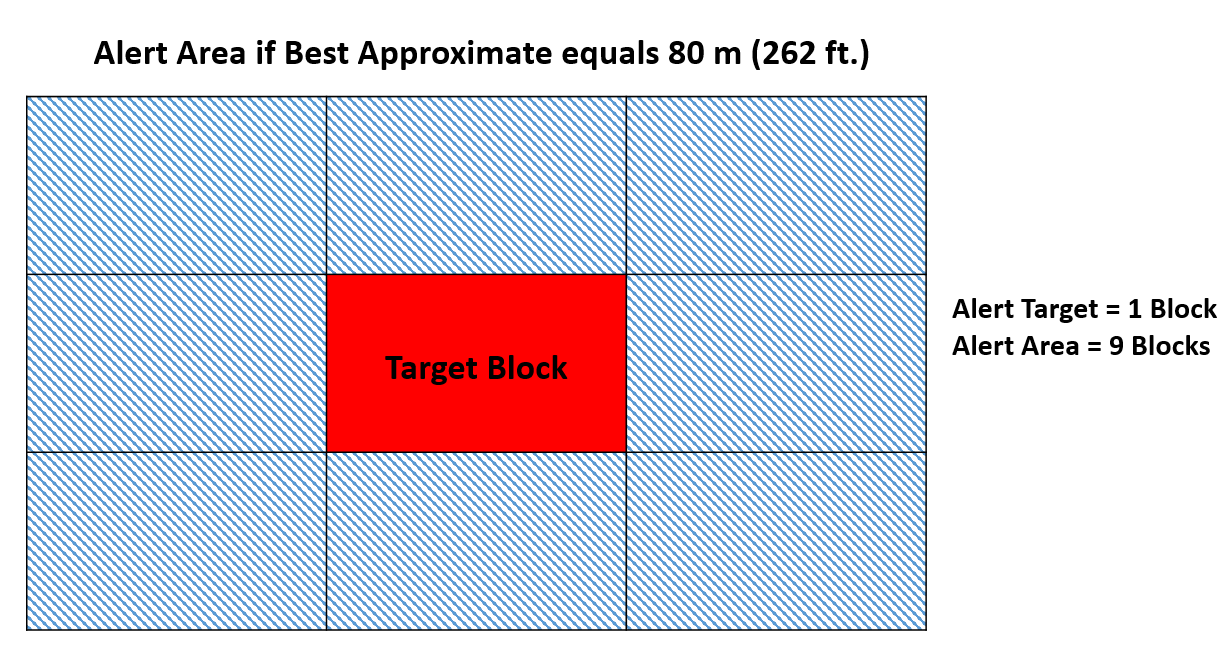


Figure 1.2

It is clear that confidence in WEA among AOs is dampened by perceived unpredictability of WEA geo-targeting. The last NPRM on WEA was issued on December 15, 2007, just six months after the release of the very first iPhone. FCC issued the first WEA Report & Order on April 9, 2008. Smartphones were a mere shadow of what they are today - with capabilities almost beyond the imagination of that first iPhone user. Today, the vast majority of the public has adopted the smartphone as their primary communications and newsgathering tool, making WEA the optimal choice for emergency public information. The future development of WEA should be geared to meet public expectations as well as AO needs.

Building confidence for AO use will require a means by which they can know that the polygon provided is what is actually delivered at the towers for distribution. Carol Woody of CMU-SEI feels this will mean sharing of information from CMSPs beyond what has been done in the past. In some regions this sharing is occurring informally which could provide a leverage starting point. She also notes that, currently, there is no consistency among CMSPs as to their use of tower mapping to affected area – the adoption of a standard approach so that expectations can be consistently established is also needed

Previous recommendations from CSRIC IV are pending in the rule-making process, leaving several questions open to additional debate. As there is agreement among nearly all parties that proposals to expand WEA message length, allow local tests of WEA, and add an Emergency Government Information category, it now falls to the Commission to determine whether they should be adopted. Given the breadth of agreement on this topic, the AO community strongly urges that ATIS and the CMSPs begin work to create standards on cell sector based algorithm and the 360 character message length as a voluntary, self-initiated improvement. Increasing message size, in particular, will inform nearly all future system enhancements. As these enhancements have not been standardized, tested, or implemented, the timeline for any recommended enhancements is dependent on completion of that work. Therefore, the AO community also strongly urges the Commission to make determinations on those recommendations as soon as practicable.

# Many-to-One Communications Systems

## Background

This work group was tasked to consider the use of “many-to-one” methods for public safety officials to rapidly receive and accumulate feedback from the public concerning developing incidents.

By definition, WEA was originally designed to be a one-way, authority to citizen broadcast service. The definition of the Commercial Mobile Alert System, now known as WEA, was specified by Congress in the WARN Act defining WEA as participating CMSPs which “voluntary elect to transmit emergency alerts”. Given this one-way broadcast nature of WEA, the Commercial Mobile Alert Service Advisory Committee (CMSAAC) developed recommendations to the FCC around a broadcast-based service, with ATIS/TIA and 3GPP developing global WEA standards using the underlying cell broadcast capabilities. FCC §10.330, Provider infrastructure requirements, specifies the infrastructure functions are dependent upon the capabilities of the delivery technologies implemented by a Participating CMSP for the distribution of Alert Messages to mobile devices. Deployments of WEA by participating CMSPs use cell broadcast based technology. Cell broadcast is an unconfirmed broadcast and is not intended to nor does it provide a mechanism for “replies” to the broadcast message. This design is intentional to allow for the broadcast of messages to a large number of users while minimizing congestion on the network.

WEA as a broadcast service was designed to minimize the risk of network congestion. Point to point messaging, either through text messaging or data services through “apps”, can pose a significant risk of causing congestion on the wireless network. “Many to one” replies to WEA messages, where the replies would be point to point messages or data connections, will also raise the risk of congesting the networks. Per the recommendation of the CMSAAC, “in order to minimize the possibility of network congestion and false alerts, mobile devices should not support any user interface capabilities to forward received CMAS alerts, to reply to received CMAS alerts, or to copy and paste CMAS alert contents”. The wireless industry says that this recommendation holds true today as the underlying resource, limited, contention based design of cellular networks, have not changed. While there has been an explosion of data services on CMSP networks, network engineers have the task of trying to keeping up with the demand by engineering the network to the “busy hour” traffic loads which are expected and planned for; emergencies and disasters can easy exceed this “busy hour” load, and a “many to one” situation adds additional unplanned traffic to the network which can result in congestion. “Many to one” solutions must look at all possible methods for sending the messages back to the AOs, especially solutions that offload the CMSP networks. Modern information & communication technology (ICT) can be used to improve crisis communication between alert managers and residents. Citizens can profit from context-aware communication and become more resilient. Crisis managers can use the citizens as human sensors to improve their situation awareness or use their workforce.[[5]](#footnote-5) This “many-to-one” communication is vital in the creation of a common operating image for responders.

During terrorist attacks, many-to-one communication is essential for deploying first responders and proper evaluation of the situation. The multi-site terrorist attack in Paris taught emergency managers and medical personnel some very important lessons. The main issues for further exploration are management of uncertainties, victims and teams. All of these rely on communication, where responsiveness is a key element to ensure that appropriate resources are mobilized for response, and all actors have to be able to communicate quickly.[[6]](#footnote-6) Utilizing a many-to-one communication system would clarify for emergency managers when and where to deploy resources, ensuring the care of all victims and being able to properly follow-up with all responders.

Beyond deployment of traditional “emergency resources” (e.g., ambulances, fire suppression apparatus, law enforcement officers, etc.), “many-to-one” communication could assist emergency managers with identifying the highest impact areas following a natural disaster, like a tornado, hurricane, or other severe weather event. Such information, gathered from human sensors, would lead to a more efficient response and facilitate community recovery more rapidly.

The recent Orlando shooting illustrated that many individuals in the Pulse nightclub engaged friends, family, and responders using text messaging and social media texting applications. Victims in the nightclub texted family and friends to call 911 for help, so not to draw attention to themselves. Eddie Justice, whose death was later confirmed, frantically sent out this last text, “Call them mommy. Now. He’s coming.” While WEA was not used for this incident, standards have been developed for text to 911 and, while some agencies across the nation have deployed this technology, it is not available in Orlando. Emergency managers in Orlando may or may not have been monitoring social media platforms for the sudden confluence of messages related to the nightclub shooting.

Essential information was sent into digital space, providing an opportunity for emergency managers with procedures in place prior to the incident, to monitor social media platforms, and recognize an emergency situation. Therefore, providing an appropriate dispatching of police and medical resources to the scene. The possibility of having the capability of being able to link the vast number of messages containing substantial knowledge from the center of the crisis to an assigned emergency responder could prevent more fatalities.

As of August 3, 2016, the Centers for Disease Control and Prevention (CDC) was tracking 1,825 cases of the Zika virus within the United States and another 5,525 cases in U.S. territories.[[7]](#footnote-7) CDC identified one Miami, FL neighborhood, Wynwood, where they were able to verify Zika spread due to mosquitoes. Consider the potential for many-to-one communications in this scenario. Rather than deploying, and endangering, expensive and scarce manpower to canvass Wynwood door-to-door, a precisely geo-targeted cell broadcast message with an embedded URL that allows message recipients to provide information back to the CDC (outside the cell broadcast system) would be a safer and more efficient alternative. Responses from the public would be received in real-time provided the method for responding is a real time service (e.g., not a store and forward service like SMS). The public would be able to provide specific information on issues such as standing water locations that would be of direct benefit to public health officials working to halt the spread of the virus.

Map courtesy CDC: http://www.cdc.gov/zika/intheus/florida-update.html

## Example Use Cases

**Use Case 1 (Incident Data Gathering, Active Response):**

*Potential Message:* “Freedom City is responding to several tornados and thunderstorms that have moved through the area. In order to help the city respond efficiently, please report any damage by replying to this message with the number (letter) that corresponds to the damage that you see.”

(1)    I see down trees/branches

(2)    I see damaged houses/buildings

(3)    I see hanging power lines

(4)    I see damaged cars

*Data Sought:* A simple spreadsheet (collected by the FEMA IPAWS-OPEN aggregator) that includes the x/y coordinates of where the customer was at the time of the report (column A) and the contents of the report (column B). This information would subsequently be mapped to facilitate efficient resource deployment. For privacy purposes, the emergency management community is **not interested in** and **does not want** the customer’s phone number, name, or any other personally identifiable information shared.

Technology Discussion: As currently designed, cell broadcast based WEA is neither designed to handle nor capable of supporting an interactive 2-way service as defined in this use case. On the mobile device, receipt of the WEA message triggers a display of the text –based WEA message. There is no mechanism in WEA or the underlying cell broadcast technology to allow a menu to be displayed, or for the user to select from a menu of options for a response. Additionally, the address of where to send such a response is not known to the mobile device. None of these capabilities currently exist within global cell broadcast or public warning system standards, and the feasibility of developing a “response” service needs to be evaluated.

**Use Case 2 (Evacuation Compliance, Passive Response):**

*Potential WEA Message: “*In preparation for Hurricane Francisco, the Mayor of Freedom City has order a mandatory evacuation of Zone 1. Everyone living, visiting, or working in Zone 1 must evacuate by April 24, 2016 at 5:00PM.”

*Data Sought:* How many handsets received the message and their locations (not necessarily x/y)? This would allow emergency managers to evaluate evacuation compliance and target additional outreach ahead of the storm.

Technology Discussion: Cell broadcast, as currently designed, is an unacknowledged broadcast service and as such there is no mechanism for determining how many or which mobile devices received the cell broadcast message. In addition, such replies, including the location determination, poses significant risk of network congestion. Determination of the penetration of WEA messages, or identifying the number of subscribers in an alert area after a WEA message was issued, goes well beyond the original intent and design of the WEA service and requires further study to understand the implications on CMSPs and CMSP infrastructure.

**Use Case 3 (Active Shooter, Active Response)**

*Potential WEA Message:* “An emergency has been reported at 1234 Main Street, Building A. If you are inside the building and receiving this message, press 1. If you are injured and inside the building, press 2.”

*Data Sought:* Emergency managers could obtain a rough estimate of how many people, still alive in the building, as well as any who may be injured.

*Technology Discussion:* Currently, WEA messages can only be sent out, without any information or response to be transmitted back to emergency managers. Technological improvements to WEA messages, to receive responses, would exponentially benefit emergency managers to deploy appropriate response teams.

## Discussion

Although crowd sourcing applications exist, public adoption/penetration rates in most communities are not sufficient to assist local government emergency managers and leaders rapidly collect sufficient information to make resource deployment decisions as contemplated in *Use Case 1*. Additionally, these commercial applications do not support the ability to monitor evacuation compliance as contemplated in *Use Case 2. Use Case 3* would establish direct contact to those in the building, while keeping them safe with silent communication. Both emergency management and wireless industry representatives on this subgroup concur that further exploration is needed on the ability to collect this information and leveraging a piece of technology that most people have (a cellular phone) is a natural mechanism by which to collect data. The challenge is how to accomplish the goal while balancing network constraints, handset software changes, and individual privacy. In addition, not all users have smartphones or subscribe to data service. With the understanding that the Wireless Emergency Alert (WEA) system as presently designed and deployed is unable to provide handset delivery information nor a return path for consumers to respond back to messages, it is the consensus of this group that either a new or significantly modified non-WEA system would need to be developed in order to achieve “many to one” communication.

FEMA’s mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain and improve our capability to prepare for, protect against, respond to, recover from and mitigate all hazards. As a major stakeholder in WEA and public alert and warning, FEMA is in an ideal position to perform the information aggregation tasks. FEMA’s “Strategic Plan 2014-2018” outlines the objectives and strategies of the agency which align with the goals of many-to-one communications:

*FEMA Strategic Priority 1: Be Survivor Centric in Mission and Program Delivery*

*Objective 1.3: Increase disaster awareness and action by improving communication*

*Strategy 1.3.1: Encourage constructive use of communications mechanisms and messaging (e.g., social media) in the immediate aftermath of disasters.*

<https://www.fema.gov/media-library-data/1405716454795-3abe60aec989ecce518c4cdba67722b8/July18FEMAStratPlanDigital508HiResFINALh.pdf>

As FEMA is a compartment within the DHS, the need to facilitate communications is emphasized in the “DHS Strategic Plan 2014-2018”:

*DHS Strategic Mission 5: Strengthen National Preparedness and Resilience*

*GOAL 5.3: Ensure Effective Emergency Response*

*Goal 5.3 strategy 1 – Provide timely and accurate information to individuals and communities to support public safety and inform appropriate actions by the public before, during, and after emergencies.*

*Goal 5.3 strategy 4 - Ensure effective emergency communications through the provision of technical communications capabilities enabling security, situational awareness, and operational decision making to manage emergencies under all circumstances.*

<https://www.dhs.gov/sites/default/files/publications/FY14-18%20Strategic%20Plan.PDF>

# Findings

1. The definition of “best approximate,” based on the current capabilities of cell broadcast technology is as follows:
   1. In densely populated cities, the alert is broadcast to nearly all of the actual alert area due to the high density of cell towers which broadcast the alert. Anecdotal information suggest the alert broadcast may reach locations about up to about 2 miles outside the actual alert area.
   2. In suburban areas, there are typically small pockets where pockets with limited/no cell tower coverage where WEA does not reach those areas. Anecdotal information suggests the alert broadcast may reach locations up to about 5 miles outside the actual alert area.
   3. In rural areas, there are the greatest number of areas with limited/no cell tower coverage where WEA does not reach those areas. The alert broadcast from “boomer” towers reach locations 30,000 meters (approximately 20 miles) or more outside the actual threat area.
2. The FCC should adopt expanded message capacity as recommended by CSRIC IV in order to accommodate nearly all future WEA enhancements. ATIS/TIA confirmed this is technologically possible in *Feasibility Study for LTE WEA Message Length* in October 2015 and recommends a maximum permissible message length 360 characters.[[8]](#footnote-8)
3. Message granularity must be improved in order to help build system trust among both AOs and the public. A balance must be established between the capability and impacts to technology within the CMSP network, mobile devices, device OSs, and the desires of the AOs. First, the testimony of AOs corroborates the view that confidence in WEA is dampened by the unreliability current granularity, variability, and overreach of WEA geo-targeting. Second, the most but not all of the public has adopted the smartphone as their primary communications and newsgathering tool but there is still a portion of the public who cannot or do not want to use smartphones. Based on that, WEA is the optimal choice for broadcast of emergency public information. The future development of WEA should be geared to address the balance between the obligations on the CMSPs, the impact to CMSP infrastructure, the impact to mobile devices and device OSs, the global support for Public Warning Systems including inbound and outbound roaming, and meeting public expectations as well as AO needs. Current cellular broadcast technology is has limitations to achieve the necessary geo-targeting fencing precision desired by the AOs. However, mobile devices including smartphones utilize Assisted GPS (A-GPS) and not stand-alone device based GPS capabilities. The use of A-GPS requires network resources from the cellular network operator, as described in this report. Industry and CMSPs are clear that extensive changes in WEA are subject to multiple factors including development and deployment of software and standards, both domestic and international.

# Recommendations

The Working Group recognizes that many of the proposed enhancements, from both CSRIC IV and CSRIC V, will necessarily be interrelated and raise questions regarding the timing for coordinated development and implementation.  We emphasize that the timelines provided in the Report and Recommendations represent estimated targets but actual timelines should be flexible and informed by the deliberations of the groups referenced in these Recommendations.

**Recommendation 1:** It is recommended by Working Group 2 that the FCC modify existing county-level down to cell level, with “best approximate” then being defined as covering as much of the AO specified polygon as possible with minimal overshoot or undershoot, given the technical challenges posed by cell site topology and RF propagation. There are opportunities beyond cell broadcast such as device assisted alerting that may lead to improvement in WEA precision as technology develops and changes. We further recommend that this definition be revisited regularly to account for changes in technology. This definition is written as an aspirational goal and implies no penalty or sanction on any party if the goals cannot be met.

ATIS should develop a “best practices” document to help AOs understand the reasonable expectations of existing geo-targeting technology. In addition they should work to develop technical consistency among carriers.

The public safety community strongly believes that the aspirational definition of “best approximate” should be defined as 100% of the targeted area with no more than .10 miles overshoot. WEA stakeholders, including ATIS, carriers and the public safety community have committed to working to close the gap between current capabilities and aspirational goals.

**Recommendation 2:** It is recommended by Working Group 2 that alert originators determine the granularity of alert areas using vertices with two to five decimal places depending on the nature of the hazard. The second decimal place provides resolution up to 1.1 km which can separate one town from the next. The third decimal place provides up to 110 m resolution which can identify a large agricultural field or institutional campus. Four decimal places provides resolution up to 11 m which can identify a parcel of land and is comparable to the typical accuracy of an uncorrected GPS unit with no interference. This issue should be revisited from time to time as technology improvements may allow greater precision. AO specification of the alert area to this granularity should not place any obligation on the CMSPs for transmission of the WEA alert. Rather, FEMA and CAP software developers should make appropriate adjustments to the IPAWS aggregator and alerting systems to enable precision at this level.

**Recommendation 3:** It is recommended that by Working Group 2 that the FCC collaborate with ATIS, CMSPs, AOs, geo-targeting experts, device manufacturers, and other subject matter experts to conduct research, develop standards and implement systems that support enhanced geo-targeting and allow device operating systems and device based applications to do the following:

* Identify methods to transmit the polygon coordinates to the mobile device using cell broadcast
  + While supporting the legacy WEA system for existing deployed devices as well as newer, “enhanced” WEA service for new devices
  + Methods need to be standardized internationally to support roaming
* Identifying changes needed to cell broadcast to allow a received cell broadcast message containing the coordinates to be passed to an OS or device based WEA application
  + Changes needs to be made on an international basis to support roaming
* Understanding the full impacts on the network by the device determining its location using A-GPS or other location technologies.
* Use the polygon of the alert area embedded in the WEA message to help the device determine if it is inside the alert area. If the device is determined to be inside the alert area, the alert is rendered on the device depending on the configuration of the user location and alert preferences on the mobile device.
* In the event the device is unable to obtain location information as described above, within a predetermined amount of time, the alert is displayed on the device in plain text form depending on the configuration of the user location and alert preferences on the mobile device.
* Render the alert on compatible devices in a manner that provides a map clearly illustrating the alert area, the location of the device (if known), and any additional relevant life-safety information depending on the configuration of the user location and alert preferences on the mobile device.
* Provide an archive of the alert so that WEA recipients may reference the relevant previous message content.

Implementation of the above items should be done in consideration of device compatibility, potential privacy issues, network congestion and consumer impacts due to increased data plan usage. This should be completed within up to 18 months of an FCC Report and Order on this document with a full outline of issues developed and presented to the key stakeholders, including the FCC, within 6 months of commencement of work. Once the standards work is complete, full system deployment including new handsets should be deployed within no more than 24 months.

**Recommendation 4:** Working Group 2 strongly recommends that the FCC expedite modifying 47CFR§10.430 Character limit as follows:

“A WEA Alert Message processed by a Participating CMS Provider must not exceed 90 characters of alphanumeric text for 2G and 3G, and 360 characters of alphanumeric text for 4G LTE and later technologies.”

It is also recommended that ATIS develop the appropriate standards, both regionally and globally, needed to increase the WEA message length to 360 characters for LTE and later technologies, which will allow alert originators to provide more specificity in the alert messaging, within 12 months of the FCC Report and Order based on this document.

**Recommendation 5**: It is recommended by Working Group 2 that FCC collaborate with ATIS lead a development group comprising of CMSPs, AOs, FEMA, device manufacturers, OS providers, and other subject matter experts to create a set of minimum specifications for an enhanced, secured and trusted, standards-based, CMSP-controlled WEA mobile device based application which can be developed, tested, and deployed under strict guidelines adopted by CMSPs and their device manufacturers and OS providers and not modifiable by the consumer, while maintaining CMSP control of the customer experience in order to ensure high level support.  This standard workgroup should:

* Define the set of minimum specifications for features the application should support, e.g. determining a device’s location relative to a warning polygon specified by the AO, rendering the alert to the user based on specific location criteria, display of a user’s location relative to the alert polygon on a map, etc., including mechanisms which allow restricted access by the CMSP defined WEA application to WEA cell broadcast data
* Define the requirements taken into consideration of impacts on the AOs, FEMA, and CMSP networks for data that is needed to be broadcast over WEA to the application to support the enhanced mobile device capabilities defined in the set of minimum specifications
* Define the mobile device behavior under various user opt-out capabilities and corner cases, including security measures to prevent hacking, user opt-out of imminent threat and Amber Alerts, user opt-out of location/ location not available, no data network connectivity, etc.
* Identify backwards compatibility and support for legacy devices, low end feature phones, roaming devices
* Identify standards impacts, both regionally (ATIS) and globally (3GPP)
* Define the back end of the application; that is, identify any data in FEMA or other trusted servers that the application may access to perform its desired functions, including security and authentication of the data and impacts to CMSP networks for access to the back end, and application design guidelines to minimize chattiness and signaling surges on the CMSP network.  Identify correlation methods for the received WEA broadcast message with any back end data.
* Develop a timeline for completing the above tasks, including a timeline for deployment across new capable handsets on Participating CMSP networks once network infrastructure and new capable handsets are available.
* Note: To control the impacts to CMSP networks and to maintain CMSP control of the customer experience, a general OS/SDK WEA “API” allowing any third party app developer access to WEA data for development of applications is not recommended.

This set of specifications should be completed in accordance with the requirements and timeline as stated under recommendation 3.

**Recommendation 6:** It is recommended by Working Group 2 that FCC collaborate with ATIS to convene, within 6 months of the adoption of this report, a public-private partnership comprised of the wireless industry, device manufacturers, academics, and AOs to further the concept of Many to One outside the WEA regulatory framework. Many to one falls outside the current obligations to CMSPs to transmit emergency alerts under the WARN Act. However, all stakeholders agree that further investigation into many-to-one solutions is beneficial. A public-private partnership of key stakeholders should be established to advance the many to one concept under a voluntary framework, using the ATIS studies as a basis for the technical feasibility of solutions. It is further recommended that as part of this study, FEMA should investigate modifying IPAWS to support “Many to One” communication and data collection as contemplated in the use case examples evaluated by this subgroup. ATIS should also study the feasibility of mechanisms for the delivery of “many to one” data to FEMA IPAWS.

**Recommendation 7:** It is recommended by Working Group 2 that, within 18 months of the adoption of this report by CSRIC V, the FCC collaborate with ATIS and CTIA study and evaluate potential “back-end” mechanisms to passively collect and share geo-fenced usage data with emergency management stakeholders. They should identify the feasibility of the capabilities described in *Use Case 2* without requiring each handset to respond to a WEA message or to transmit its specific location. It should be understood that neither CMSPs nor cell broadcast networks have the capacity to perform voluminous data processing tasks such as may result from this activity.

**Recommendation 8:** It is recommended by Working Group 2 that FCC request that ATIS develop standards enabling the inclusion of Uniform Resource Locators (URLs) into WEA messages, if determined to be feasible by studies currently underway. These URLs would open in device-based Internet browsers, allowing AOs to provide message recipients with an avenue, outside of the WEA system, to share situational awareness and other information with AOs during emergencies. If inclusion of URLs is determined to be feasible by ATIS, it is recommended that this should be completed within 18 months of the Report and Order from the FCC based on this document.

# Items for Further Discussion

Based on the findings and recommendations of this report, the following items deserve additional discussion before the FCC:

1. Throughout this process, the issue of CMSPs or other entities withdrawing from the WEA program has arisen. The FCC should consider whether it is necessary to outline a mechanism to affect withdrawal with minimal disruption to the system and public safety outcomes.
2. The FCC should consider convening a panel of subject matter experts from the alert origination committee, wireless providers, academia, researchers, and device manufacturers to consider the next generation of Wireless Emergency Alerts (WEA 2.0). This panel should begin work within 18 months of adoption of this report by CSRIC V.
3. CSRIC VI should consider how new technologies can be coupled with WEA to serve the Access & Functional Needs community.

# Conclusion

The potential of modern technology to help save lives in emergencies is staggering. WEA was conceived and developed in the mid-2000s as a “bell ringer” – providing for the rapid deployment of emergency public information. While the value of that function has not changed, newer technology could offer the ability to provide more information to a better defined audience than could have been imagined a decade ago.

Technological hurdles to upgrading the system are not inconsiderable. However, the participants of this working group concur that there is value in exploring new capabilities for WEA in order to improve public safety outcomes.

# Informative Appendices

## Appendix A - Recommendations Not Adopted

Recommendation: As the majority of the issues discussed in this report and debated throughout this process were initially raised in the Commission's Notice of Proposed Rulemaking, we strongly encourage the Bureau and the Commissioners to include these recommendations as part of the upcoming order. By implementing these extremely important WEA upgrades as soon as possible, the Commission will take positive action to save lives and provide public safety officials, alert originators and the communities they serve with a powerful, contemporary alerting tool.

## Appendix B – Discussion of Hybrid Geo-Targeting

**Note:** *The information in this appendix discusses the question of device assisted geo-targeting, largely from the perspective of the alert originator community. Working Group 2 members were unable to reach agreement on the text and the decision was made to relocate it from Section 4.5 to the Appendix. A contrasting view from AT&T follows.*

The inability of cell broadcast technology to provide the degree of granularity requested by AOs, and expected by citizens, strongly suggests that device based technology may provide the solution. As industry has expressed legitimate concerns about potential network stress resulting from additional taskings within WEA, it seems logical to tap the substantial computing power extant in contemporary devices. As one example, smartphones, carried by 68% of all Americans[[9]](#footnote-9), have sophisticated, Assisted Global Positioning System-based (A-GPS) applications embedded in them that show some potential for lessening this strain – in effect, transferring much of the computing burden to the device to affect greater precision in geo-targeting.

One possible solution is using the location services available on a user’s device to assist in determining whether or not the user is inside a message target area. This can be accomplished by including the AO defined alert area, represented by a polygon, with the alert message and delivering this to the device. Using this information, the device can determine if it is inside the AO defined alert area by comparing its location with the polygon and if the device is inside the polygon, then it renders the alert. As most cellular phones, mobile enabled tablets, and other similar technology have highly evolved geo-location capabilities, it seems logical to leverage the computing power in these devices to provide greater WEA accuracy. In addition, since the alert area coordinates would be contained in the data file with the alert message, the ability to geo-target is maintained using any delivery medium and evolves with the carriers chosen technology, including rapid deployed networks in the aftermath of natural and man-made disasters. Furthermore, the alert area coordinates could be used for visual presentation of the alert area along and recipient’s location on the device.

A study and trials conducted by Carnegie Mellon University for the Department of Homeland Security found that:

Fine-grained, precise geo-targeting based on filtering on the phone is the most significant finding of the trials. In particular, it improved the alert messages’ relevance to the recipients markedly. This feature is straightforward to implement using modern smart phones’ location services, as was demonstrated in the Android WEA+ app. No user interface changes are required on the phone’s built-in app that intercepts the WEA messages: the feature is completely transparent to the users. However, it requires the representation of the alert region, the geo-target specified by a polygon with geographical coordinates as vertices, to be attached to the alert message for processing by the recipient’s phone. This would be the only change required on the alert origination end by minor modifications to the gateway functionality, but the change would be transparent to the AOs themselves. Using computationally cheap and efficient compression and decompression techniques, we can significantly reduce the size of both the polygon and the alert text, allowing even the current 90-character limit to be sufficient to carry both the main payload and the geo-target in most situations. A moderately increased message length limit would make this enhancement extremely feasible in future WEA implementations.[[10]](#footnote-10)

The ATIS-0700027 feasibility study raised concerns regarding the inclusion of handset capabilities into WEA service. It is important to remember that the WARN Act does not specify the technological means by which emergency alerts are transmitted. There are strong indicators suggesting that many of the issues involving granularity can be addressed through a concerted effort from carriers, handset manufacturers, and public safety representatives. In this case, capabilities already in use by countless commercial offerings can be incorporated into future iterations of the WEA service. The question becomes a matter of adopting and integrating extant technologies and not of developing new capabilities. A broader discussion of the ATIS report is located in the Appendix.

Comtech TCS said that, given the challenges and limitations imposed by both network and device based geo-targeting methods, it may be necessary to employ both methods simultaneously to obtain the best possible solution. The network based method that uses Radio Frequency (RF) propagation model or sectorization, allows a small area (a few square miles) to be targeted and can identify exactly the list of cell sectors affected by this area. This is the first step in geo-targeting to limit the cell broadcast to the targeted area.

Cell sectors, however, can be quite large and can extend for several miles in rural areas meaning, over-alerting can therefore extend for miles. To avoid this problem, a second step is needed and this is where the device assisted geo-targeting can complement the solution. A location-aware mobile device knows its own location. Thus, if the target area latitude/longitude or circle can be conveyed to the mobile device over the cell broadcast message, the mobile device would be able to determine if it is located inside the target area and subsequently notify the user. Otherwise no alert will be triggered on the device. Such combined technology would provide the best possible result and is recommended as a subject of future experiment.

Just as significantly, many mobile device applications are dependent upon accurate location services for both commercial and convenience uses. Service providers such as Uber, Lyft, Google Maps, and Apple (Find My Friends, Find My iPhone) allow users to visualize their relative geographic location with remarkable accuracy.

Emergency managers indicate support for geo-targeting and device-based solutions for the FCC's Notice of Proposes Rule Making (NPRM). The California Office of Emergency Management advised that “targeting is even essential given a number of other proposals under consideration by the Commission and (we) do not believe compliance with these rules should be voluntary; it should be required. For WEA to be effective, it is imperative that WEA messages be able to be geo-targeted.” The U.S. Geological Survey also supports the enhancement of geo-targeting, “More precise geo-targeting will reduce ‘over-alerting’ which undermines public confidence in the system. We also support pursuing geo-targeting using network-based, device-based, and third-party-assisted solutions. ‘Smart’ devices are now ubiquitous and it is irresponsible not to harness their capabilities to refine and customize alerts.”

**Perspectives and edits offered by AT&T:**

Given the capabilities and limitations of cell broadcast technology to provide the degree of granularity requested by AOs, the working group strongly suggests that additional methods to provide further granularity, such as device based technology, may provide the solution. As industry has expressed legitimate concerns about potential network stress resulting from additional taskings within WEA, from an outside view it seems logical to tap the substantial computing power in smartphone devices. However, the Commission must also recognize there is non-insignificant number of feature phone devices in use which may not have the computing power or capabilities of smartphones; citizens using these devices must not be disenfranchised. As one example, smartphones, carried by 64% of all Americans, have sophisticated, Assisted Global Positioning System-based applications embedded in them. While making use of GPS capabilities in smartphones may appear to provide a solution for geo-targeting, Assisted GPS in smartphones works differently than a standalone GPS, and pose additional considerations for the CMSP networks. In addition, users have control over whether they want their location enabled for applications, and there have been new reports on the concerns over privacy (http://www.today.com/money/your-smartphone-may-be-tracking-your-every-move-t17056).

One possible solution is using the location services available on a user’s device to assist in determining whether or not the user is inside a message target area. This possible solution requires modifications to WEA to broadcast the AO defined alert area (represented by a polygon) along with the alert message, to the device. Using this information, the device can determine if it is inside the AO defined alert area by comparing its location with the polygon and if the device is inside the polygon, then it renders the alert. As most cellular phones, mobile enabled tablets, and other similar technology have A-GPS capabilities, it seems logical to leverage the A-GPS in these devices to provide greater WEA accuracy. Furthermore, the alert area coordinates could be used for visual presentation of the alert area along and recipient’s location on the device.

However, any consideration of broadcasting the AO defined alert area must account for legacy mobile devices, as well as mobile devices that are roaming into the U.S. from other countries supporting the global Public Warning System standard. Without consideration of these devices, as well as standardizing the method for broadcasting the polygon information, the user may be presented with a screen full of lat-long coordinates, losing the valuable WEA alert message.

Also, the impact of large number of devices obtaining their location at the time of a WEA receipt needs consideration as there are implications to the CMSP network. The difference between Standalone GPS and Assisted GPS must be understood.

A user may also have location disabled for privacy reasons, thus any on-board solution will not work.

Standalone GPS devices depend solely on information from satellites. Standalone GPS provides first fix in approximately 30–40 seconds. Standalone GPS needs orbital information of the satellites to calculate the current position. The data rate of the satellite signal is 50 bit/s, so downloading orbital information like ephemerides and the almanac directly from satellites typically takes a long time, and if the satellite signals are lost during the acquisition of this information, it is discarded and the standalone system has to start from scratch.

An Assisted GPS (A-GPS) system addresses the problems of obtaining that data by using external data obtained from the cellular network (thus the term “assisted”). In Assisted GPS, the CMSP deploys an A-GPS server. These A-GPS servers download the orbital information from the satellite and store it in the database. An A-GPS capable device connects to these servers and downloads the orbital and ephemerides information using the CMSP network. A-GPS also uses this data to enhance quality and precision when in poor satellite signal conditions, or when the GPS antenna is inefficient. In exceptionally poor signal conditions, for example in urban areas, satellite signals may exhibit multipath propagation where signals skip off structures, or are weakened by meteorological conditions or tree canopy. Some standalone GPS navigators used in poor conditions can't fix a position because of satellite signal fracture, and must wait for better satellite reception. A GPS unit may need as long as 12.5 minutes (the time needed to download the GPS almanac and ephemerides) to resolve the problem and be able to provide a correct location.

“Assistance” falls into two categories:

1. Mobile Station Based (MSB): In MSB mode A-GPS operation, the A-GPS device receives ephemeris, reference location, reference time and other optional assistance data from the A-GPS server on the CMSP network. With the help of this data, the A-GPS device receives signals from the visible satellites and calculates the position.

2. Mobile Station Assisted (MSA): In MSA mode A-GPS operation, the A-GPS capable device receives acquisition assistance, reference time and other optional assistance data from a CMSP. The CMSP continuously logs GPS information (mainly the almanac) from the GPS satellites using an A-GPS server in its system. With the help of this data (the data received from the mobile device and the data already present in A-GPS server) the A-GPS server calculates the position and sends it back to the A-GPS device. In mobile station assisted implementations, the amount of processing and software required for a GPS receiver can be reduced by offloading most of the work onto the assistance server.

An A-GPS-enabled receiver requires a network connection to obtain the assistance data. Thus, the use of A-GPS to assist in geo-targeting will place addition load on the CMSP network, both the data network and the A-GPS Servers. Depending on the scale of the WEA alert and the number of devices attempting to do a location fix, this could result in significant congestion on both the data networks as well as the A-GPS Servers, impacting service. The congestion at the A-GPS Servers will also impact other services requiring location, including E9-1-1.

If the mobile device also has functioning autonomous GPS, then potentially it may use standalone GPS, which is sometimes slower on time to first fix as described above, but does not depend on the network.] Some A-GPS devices do not have the option of falling back to standalone or autonomous GPS; thus, there is no guarantee that all smartphones have this capability.

A-GPS protocols are part of Positioning Protocol defined by two different standardization bodies, 3GPP and Open Mobile Alliance (OMA).

The Control Plane Protocol is defined by 3GPP and include the RRC position protocol – 3GPP defined this protocol as part of the RRC standard for UMTS network and the LPP – 3GPP LTE positioning protocol for LTE Networks.

User Plane Protocol (Secure User Plane Location) is defined by OMA to support positioning. Two generations of User plane Protocol have evolved, SUPL V1.0 & SUPL V2.0.

Some mobile devices also just have a L1 front-end radio receiver and no GPS acquisition, tracking, and positioning engine, and thus only works when it has a connection to the CMSP network, where the position fix is calculated in the A-GPS server. For these devices, A-GPS doesn't work in areas with no coverage.

A study and trials conducted by Carnegie Mellon University for the Department of Homeland Security found that:

*Fine-grained, precise geo-targeting based on filtering on the phone is the most significant finding of the trials. In particular, it improved the alert messages’ relevance to the recipients markedly. This feature is straightforward to implement using modern smart phones’ location services, as was demonstrated in the Android WEA+ app. No user interface changes are required on the phone’s built-in app that intercepts the WEA messages: the feature is completely transparent to the users. However, it requires the representation of the alert region, the geo-target specified by a polygon with geographical coordinates as vertices, to be attached to the alert message for processing by the recipient’s phone. This would be the only change required on the alert origination end by minor modifications to the gateway functionality, but the change would be transparent to the AOs themselves. Using computationally cheap and efficient compression and decompression techniques, we can significantly reduce the size of both the polygon and the alert text, allowing even the current 90-character limit to be sufficient to carry both the main payload and the geo-target in most situations. A moderately increased message length limit would make this enhancement extremely feasible in future WEA implementations.*

However, the wireless industry notes that the study did not consider all implications on CMSP infrastructure and devices, and that such a capability is not as straightforward to implement when considered on a large scale using deployed WEA technology, and does require device user interface changes to the operating system cell broadcast and WEA handling.

The ATIS-0700027 feasibility study ~~raised concerns~~ cited the implications regarding the inclusion of handset capabilities into WEA service. It is important to remember that the WARN Act or FCC rules do~~es~~ not specify the technological means by which emergency alerts are transmitted. The technology choices for CMSPs to meet their obligations to transmit WEA alerts under the FCC WEA rules are left to the CMSPs, who rely on industry standards to support interoperability and global roaming. Many of the issues involving granularity must ~~can~~ be addressed through a concerted effort from carriers, infrastructure & handset manufacturers, and AO representatives. A broader discussion of the ATIS report is located in the Appendix.

Comtech TCS’s presented their view that, given the challenges and limitations imposed by both network and device based geo-targeting methods, it may be necessary to employ both methods simultaneously to obtain the best possible solution. The network based method that uses Radio Frequency (RF) propagation model or sectorization, allows a small area (a few square miles) to be targeted and can identify exactly the list of cell sectors affected by this area. This is the first step in geo-targeting to limit the cell broadcast to the targeted area and is already the method of geo-targeting deployed by the major carriers today.

While there is an industry trend to densify the network (by deployment of small cells), cell sectors, however, can be quite large and can extend for several miles in rural areas meaning, over-alerting can therefore extend ~~for~~ up to miles in the rural case. To avoid over-alerting, a possible second step is needed and this is where the device assisted geo-targeting can complement the solution. An A-GPS capable mobile device can determine its own location, which may take time and require network resources. Thus, if the alert area (latitude/longitude or circle/radius) can be conveyed to the mobile device over the cell broadcast ~~message~~, the mobile device would be able to use this information to determine if it is located inside the target area and subsequently ~~notify~~ render the associated WEA alert to the user. Otherwise no WEA alert will be rendered on the device. Such combined technology ~~would~~ could provide the best possible result and is recommended as a subject of future experiment. However, such a solution is not without issues for consideration. These include standardizing the method to broadcast the polygon to the mobile device in a backways compatible manner without impacting roaming; how feature phones are supported; impacts to the network and the load on the CMSP infrastructure and A-GPS servers, determining how to over-broadcast both the polygon and WEA alert to maximize the number of recipient mobile devices while not over-alerting to legacy devices, and mobile device changes on how it receives and processes cell broadcast.

Many mobile device applications are dependent upon relatively accurate location services for both commercial and convenience uses. ~~Service providers~~ Apps such as Uber, Lyft, Google Maps, and Apple (Find My Friends, Find My iPhone) allow users to visualize their relative geographic location with good accuracy. However, it should be noted that these applications use the location capabilities of the underlying operating system and mobile device.

For example, Apple states the following (https://support.apple.com/en-us/HT203033):

* “Depending on your device and available services, Location Services uses a combination of cellular, Wi-Fi, Bluetooth, and GPS to determine your location. If you're not within a clear line of sight to GPS satellites, your device can determine your location using crowd-sourced Wi-Fi and cell tower locations or iBeacons.”
* “Maps, directions, and location-based apps depend on data services. These data services are subject to change and might not be available in all geographic areas, resulting in maps, directions, or location-based information that might be unavailable, inaccurate, or incomplete”.
* Capabilities supported in the device OS when you turn on Location Services, include other location-based system services such as:
* Location Based Alerts: Your iOS device will use your location to provide you with geographically relevant alerts, such as a reminder to call someone when you get to a specific place or when to leave for your next appointment based on where you currently are.
* Share My Location: You can choose to share your current location with others, on a temporary or ongoing basis, from within certain apps, such as Messages and Find my Friends.

Note that these location services all requires both a valid subscription with the OS provider, a valid data subscription with the CMSP, and a data connection to be established to transfer information from the mobile device to the OS provider’s servers. Users and devices not having these will not be able to do location.

This location determination is part of the OS, is outside the scope of the CMSP, and thus no obligations on the CMSP regarding the device location should be made.

Emergency managers indicate support for geo-targeting and device-based solutions for the FCC's Notice of Proposes Rule Making (NPRM). The California Office of Emergency Management advised that “targeting is even essential given a number of other proposals under consideration by the Commission and (we) do not believe compliance with these rules should be voluntary; it should be required. For WEA to be effective, it is imperative that WEA messages be able to be geo-targeted.” The U.S. Geological Survey also supports the enhancement of geo-targeting, “More precise geo-targeting will reduce ‘over-alerting’ which undermines public confidence in the system. We also support pursuing geo-targeting using network-based, device-based, and third-party-assisted solutions. ‘Smart’ devices are now ubiquitous and it is irresponsible not to harness their capabilities to refine and customize alerts.” This working group recognizes that smart devices make up 64% of devices, and there is still a significant number of feature phones in use.

1. http://wikilena.blogspot.com/2015/01/decimal-places-precision-and-accuracy.html [↑](#footnote-ref-1)
2. Dennis S. Mileti, Ph.D. April 7, 2016 Ex Parte for FCC meeting regarding NPRM 15-91 [↑](#footnote-ref-2)
3. Benkert, Joseph. Comments of the Boulder Regional Emergency Telephone Service Authority. January 2016 [↑](#footnote-ref-3)
4. Erdogmus, H., et al. (2015). Pg. 14. [↑](#footnote-ref-4)
5. Havlik, Denis, and Adam Widera. 2016. "Interaction with Citizens Experiments: From Context-aware Alerting to Crowdtasking." *ISCRAM 2016 Conference.* Rio de Janerio. [↑](#footnote-ref-5)
6. Philippe et al. 2016. “French Ministry of Health's Response to Paris Attacks.” *Critical Care*. [↑](#footnote-ref-6)
7. http://www.cdc.gov/zika/geo/united-states.html [↑](#footnote-ref-7)
8. ATIS. (2015). *Feasibility Study for LTE WEA Message Length.* pg. 19. https://access.atis.org/apps/group\_public/download.php/25045/ATIS-0700023.pdf [↑](#footnote-ref-8)
9. http://www.pewinternet.org/2015/04/01/chapter-one-a-portrait-of-smartphone-ownership/ [↑](#footnote-ref-9)
10. Erdogmus, H., Griss, M., & Iannucci, B. (2015) *Opportunities, options, and enhancements for the wireless emergency alerting service*. P. 64. Moffett Field, CA: U.S. Government Printing. [↑](#footnote-ref-10)