November 20, 2020

James Wiley
Public Safety and Homeland Security Bureau
Federal Communications Commission
45 L Street NE
Washington, DC 20554

RE: ATIS White Paper on the Impacts of Cell Selection for WEA Geo-Targeting

Dear James:

Attached is the ATIS WTSC White Paper on the Impacts of Cell Selection for WEA Geo-Targeting (ATIS-0700047). This report, which was developed at the request of the Commission, presents a detailed explanation, accompanied by illustrations, of the broadcast characteristics and other factors that drive the results of the cell/sector selection by Commercial Mobile Service Providers when building the broadcast for a given alert.

WEA 3.0 has the potential to substantially reduce, though not eliminate, the occurrences of alert presentations outside the alert area. While market penetration is increasing, it will be some time before the majority of wireless customers have upgraded to a WEA 3.0 mobile device.

It is important to note that input from the Alert Originators, specifically the alert area definition and the alert text, also plays a critical role in the alerting impact to the public. ATIS continues to work with all stakeholders involved in alert communications to understand the tools available to achieve the best and safest experience for consumers.

ATIS WTSC notes that this report contains sensitive provider-specific information. For this reason, ATIS WTSC is not making this report publicly available.

If you have any questions about this matter, please do not hesitate to contact me.

Regards,

Thomas Goode
ATIS General Counsel

cc: Christina Clearwater, Federal Communications Commission
        Mark Younge, ATIS WTSC Chair
        Don Zelmer, ATIS WTSC Vice Chair
        Peter Musgrove, ATIS WTSC SN Chair
        Terri Brooks, ATIS WTSC SN Vice Chair
        Steve Barclay, ATIS Sr. Director, Global Standards Development
        Katie Bagwill, ATIS Coordinator, Global Standards Development

ATIS-0700047

Impacts of Cell Selection for WEA Geo-Targeting

WHITE PAPER

As a leading technology and solutions development organization, the Alliance for Telecommunications Industry Solutions (ATIS) brings together the top global ICT companies to advance the industry's most pressing business priorities. ATIS' nearly 200 member companies are currently working to address the All-IP transition, 5G, network functions virtualization, big data analytics, cloud services, device solutions, emergency services, M2M, cyber security, network evolution, quality of service, billing support, operations, and much more. These priorities follow a fast-track development lifecycle — from design and innovation through standards, specifications, requirements, business use cases, software toolkits, open source solutions, and interoperability testing.

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ATIS-0700047, *Impacts of Cell Selection for WEA Geo-Targeting*

ATIS Standard on

Impacts of Cell Selection for WEA Geo-Targeting

Alliance for Telecommunications Industry Solutions

Approved November 18, 2020

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Impacts of Cell Selection for WEA Geo-Targeting

1   Executive Summary

Wireless Emergency Alerts (WEAs) carry potentially life-saving information, often of a time-critical nature. Alert Originators (AOs) designate an area for dissemination of the alert, within which they determine the WEA message ("alert") information as being valuable to the extent that it may affect the decisions, actions, and safety of the WEA recipients. The knowledge and experience of the AOs work in conjunction with the Commercial Mobile Service Provider's (CMSP's) WEA and network infrastructure broadcast systems in an effort to have the alert reach as many users as possible who may be impacted by the event(s) or situation which triggered the alert.

CMSP cell site/sector boundaries are designed with the purpose of ensuring cellular coverage that accommodates, among other factors, the local population density, challenging conditions (dense urban) and terrain (mountains, valleys, and other obstacles), and will not allow for the selection of a group of cell sites or cell sectors which will precisely match the boundaries of the designated target area for an alert. This mismatch of boundaries will result in either having the WEA broadcast not reach all parts of the target area ("undershoot"), reach beyond the target area ("overshoot"), or a combination of both. The degree of impact will be related to the extent of the mismatch.

Each CMSP has the sole responsibility for cell selection for WEA on their network, which is dependent on the network topology and other parameters within their network. Two cell selection techniques are currently known to be employed for the dissemination of WEA. This report illustrates these techniques, then describes how these techniques may result in the WEA broadcast falling short of, or reaching beyond, the target area boundaries.

Impacts from cell/sector selection resulting in the broadcast extending beyond the target area boundaries may be mitigated by mobile devices capable of WEA 3.0, as these mobiles will compare their location to the target area prior to presenting an alert. The market penetration of WEA 3.0 capable mobile devices is growing, however, significant market penetration will take some time. In addition, WEA 3.0 will only improve alert delivery targeting when the AO includes polygons and/or circles in the alert message. If only geocodes are included in the alert message, or while pre-WEA 3.0 devices remain in the field, Device-Based Geo-Fencing (DBGF) will not be performed.

Cell/sector selection results will differ by CMSP due to variations in network deployment and cell/sector selection approaches. One section of this report is dedicated to CMSP-specific views and methods, with each subsection containing explanations and illustrations from the CMSP.

The AO as well as the CMSP side of the WEA system should be designed to provide the best possible messaging to the alert recipients. Crafting the alert text in order to communicate the exact nature and location of the imminent threat assists the alert recipient by allowing that person to gauge his or her proximity, and plan accordingly. Having the alert reach the correct recipients is a critical step resulting in the combination of the assessment by the AO of the target area and the delivery by the CMSP to that target area. AOs need to understand the implications in choosing the geo-targeting related parameters for a given alert.

ATIS continues to work with the Alert Originators and FEMA to ensure end-to-end understanding of the tools available to achieve the best results for the users.

2   Introduction

There is an inevitable tension between "false positive" errors, in which an alert is delivered to people outside the intended target area, and "false negative" errors, in which an alert is not delivered to some people in the target area. This is the case with all alerting systems. While having the alert reach all mobile devices within the intended target area is the objective, it is not technically or procedurally feasible to guarantee a broadcast accomplishing 100% coverage of the target area without also broadcasting beyond, due to the complexity and physical characteristics of wireless propagation in the real world. The portion of the broadcast extending beyond the target area will result in false positive errors.

WEA 3.0 technology has the potential to substantially reduce the number of false positive errors for customers using WEA 3.0 devices, but it will be some time before the vast majority of wireless customers have upgraded to a WEA 3.0 device. WEA 3.0 provides the most precise alert delivery targeting of any system devised to date.

Please note that WEA 3.0 will only improve alert delivery targeting when engaged by the AO through the inclusion of polygons and/or circles in the alert message. If only geocodes are included in the alert message, then Device-Based Geo-Fencing will not be performed. AOs need to understand the implications in choosing the geo-targeting parameters for a given alert.

3   Background

Prior to WEA 3.0, there was only one process within the CMSP network to affect the presentation of an alert on a mobile device based on its location. This is the process of Network-Based Geo-Targeting, which is cell selection for the broadcast with the idea of a "best approximation" attempting to match the broadcast as closely as possible to the Alert Area, with the premise that this cannot be exact as the cell sector coverage boundaries do not match the Alert Area boundaries. Any mobile device receiving the alert would then present the alert.[1]

The mismatch between the cell sector broadcast boundaries and the Alert Area boundaries may result in both overshoot and undershoot in the field, meaning that mobile devices inside the Alert Area may not receive the broadcast (undershoot) and mobile devices outside the Alert Area may receive the broadcast (overshoot). When boundaries do not match, there is a choice between only using cell sector selection coverage inside the Alert Area boundaries, or using cell sector selection that crosses those boundaries, broadcasting outside the Alert Area. If the broadcast coverage crosses the boundaries, mobile devices outside the Alert Area will receive and present the alert. If it falls short of the Alert Area boundaries in an effort to avoid crossing them, mobile devices inside the Alert Area, between the edge of the broadcast and the Alert Area boundary, will not present the alert because they will never receive the broadcast.

One approach is to select cell sectors in an attempt to fully cover the Alert Area, which will result in having the broadcast extend beyond some boundaries of the Alert Area, then have an added capability in the mobile device that "trims" the alert presentation back down to those mobile devices within, or very close to, the Alert Area boundaries. This WEA 3.0 process is referred to as DBGF.

When an alert received by a CMSP includes an Alert Area defined by coordinates (e.g., a polygon or circle), the network supports DBGF by conveying the coordinates to the mobile devices as part of the broadcast alert. If a mobile device is WEA 3.0 capable, it will recognize the inclusion of the coordinates as direction from the network to perform DBGF and will have the ability to process those coordinates and use them in the decision-making process of whether to present the alert. If the mobile device is inside the Alert Area, the alert will be presented. If the mobile device is outside of the Alert Area, the alert will not be presented.[2]

When used in conjunction, Network-Based Geo-Targeting may select cell sectors that comprise a total broadcast area with the intent to ensure that the broadcast will reach all mobile devices in the Alert Area with no uncovered gaps, if possible, while at the same time depending on the DBGF in the WEA 3.0 capable mobile devices to only present the alert if the device location is within that Alert Area at the time the alert is broadcast.

WEA 3.0 relies on this coordination between Network-Based Geo-Targeting and DBGF. If a mobile device receiving an alert that includes coordinates is not capable of performing DBGF, the mobile device will simply ignore the coordinates and present the alert. In places where the broadcast area reaches beyond the Alert Area, any mobile devices not capable of performing DBGF will still present the alert.

In addition, there are scenarios in which a WEA 3.0 mobile device may not be able to perform DBGF. For example, the user may have Location Services turned off for any number of reasons, possibly including privacy or the intent to save battery power. If a mobile device has Location Services turned off, or if for any other reason is unable to

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[1] Note that statements concerning presentation of the alert in this document make the assumption that the user has configured the mobile device to allow presentation of the alert.

[2] Note that the FCC Requirements allow presentation up to 0.1 miles outside the boundary of an Alert Area defined by coordinates.

obtain a current location to be used for performing DBGF when an alert is received, the mobile device will default to presenting the alert.

WEA 3.0 mobile device market penetration is growing daily. As a result of this, the incidents of overshoot in the field are continuously shrinking.

4 Cell/Sector Selection: Building the Alert Broadcast

Two terms are used to describe the broadcast coverage used for alert dissemination. These terms are Best Approximation and 100% Coverage.

When an alert is received, the CMSP uses the associated defined Alert Area to perform Cell/Sector Selection. This is the process of selecting the specific cell sites/sectors that will comprise the total area over which the alert will be broadcast.

The results of the selection algorithm may vary due to something referred to as provisioning of the cell/sector information. This means placing cell/sector equipment location information and the associated broadcast radius of that equipment in a database accessible by the selection algorithm. This combination of location and radius information provides what is referred to as the coverage (i.e., physical area covered by the broadcast) for that cell/sector.

The algorithm for Cell/Sector Selection checks for any overlap between the coverage of each cell/sector and the defined Alert Area. The results may then be driven by the method of provisioning of the radius information. For example, provisioning the estimated radius of the cell/sector equipment should result in having the algorithm select every cell/sector with any degree of overlap of the Alert Area; whereas provisioning a very small radius, such as one meter, would result in a Cell/Sector Selection of only the equipment inside the Alert Area. Another option would be to scale the radius to something in between these two examples. Scaling the radius down may result in a decrease of overshoot, however, this would risk creating effective undershoot due to uncertainty as to whether the mobile device is receiving the broadcast from a cell/sector excluded from the broadcast.

As seen in the remainder of this section, the Cell/Sector Selection, driven by operator policy and steered through provisioning, will result in overshoot, undershoot, or both.

Another critical factor that influences the degree of overshoot is the cell/sector size. A comparison is illustrated by the two figures below using the same blue Alert Area polygon with an overlay of small cells (Figure 1) and an overlay of larger cells (Figure 2). The same scale is assumed in both figures. In Figure 1 with the small cell overlay, cell/sectors 2B and 5C may be selected as part of the broadcast area for the alert and will cause overshoot, but these cells/sectors will not produce the depth or breadth of overshoot that may occur in larger cells/sectors. In comparison, using Figure 2, sectors 1A and 2C may be selected as part of the broadcast area for the alert. Each will produce a large total overshoot area, as well as a greater degree (depth) of overshoot, as compared to the smaller cells/sectors Figure 1.

Depending on operator policy and provisioning, the Cell/Sector Selection for Best Approximation may equal the Cell/Sector Selection for 100% Coverage.
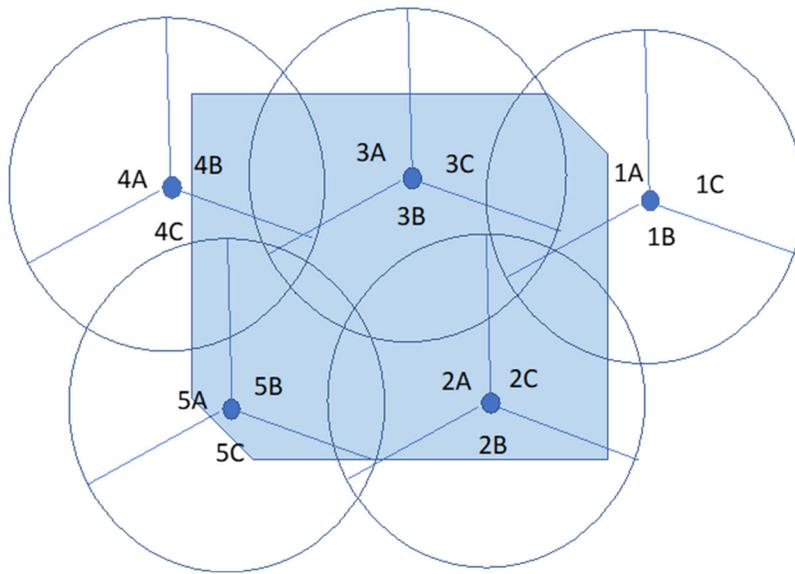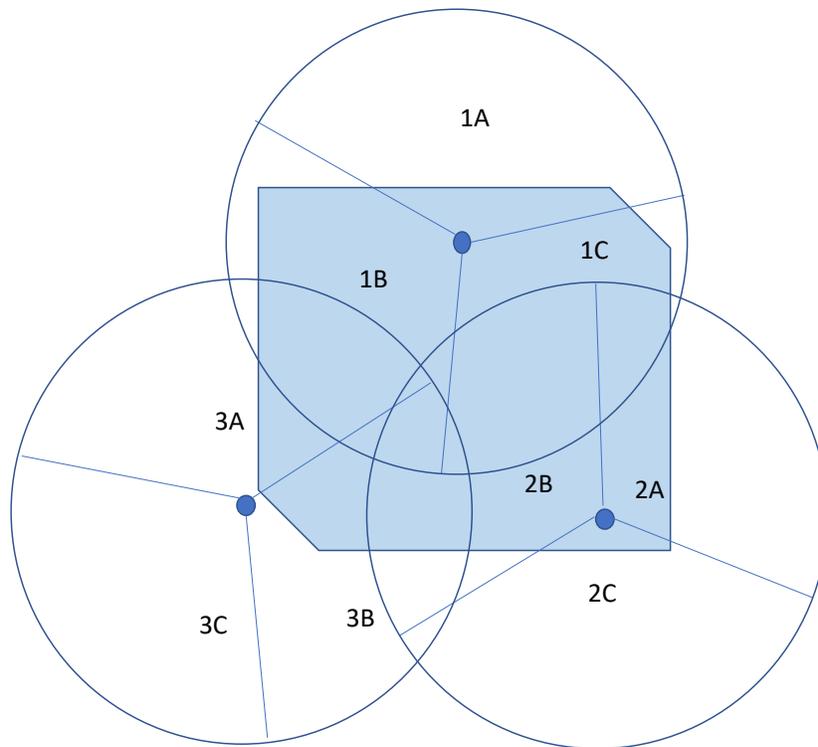
Figure 1 - Small Cell Overlay

Figure 2 – Large Cell Overlay

Figure 2 is used in the sections below to illustrate the Cell/Sector Selection techniques. This figure includes an Alert Area designated by the blue polygon.

4.1 Cell/Sector Selection: Best Approximation

4.1.1 Description

The purpose of this selection technique is to select the cells or sectors that will build a broadcast area that approximates the Alert Area. The use of additional decision-making factors may apply. The provisioning of the cell/sector information will steer the results.

A CMSP may choose to perform Best Approximation selection that attempts to minimize overshoot by selecting only cell site equipment inside the Alert Area. In this case, the selection in Figure 2 would include cell sectors 1A, 1B, 1C, 2A, 2B, and 2C in the broadcast. For each of these choices, the cell site equipment falls inside the polygon. The provisioning that steers toward this result may involve using a very small radius number, just large enough to produce a positive overlap result during the comparison process.

Another option is to perform cell selection covering the full Alert Area, attempting to eliminate undershoot. In this case, the selection in Figure 2 would include 1A, 1B, 1C, 2A, 2B, 2C, 3A, and 3B. This represents a variation of Best Approximation equivalent to 100% Coverage. The provisioning that steers toward this result would involve using the estimated radius of the cell/sector equipment.

The Best Approximation technique does not impose specific restrictions. This is a list of example variations, and not meant to be exhaustive in representing all options.

4.1.2 Impact

This selection technique allows for the possibilities of overshoot and undershoot.

Where undershoot occurs, mobile devices inside the Alert Area may not receive the broadcast.

Overshoot will result in presentation of the alert by mobile devices outside the Alert Area. Due to the number of mobile devices currently in the field which are not capable of DBGF, a significant percentage of mobiles receiving the WEA from the overshoot portion of the broadcast may present the alert. WEA 3.0 mobile devices would have the capability to perform DBGF, not presenting the alert if outside the Alert Area.

4.2 Cell/Sector Selection: 100% Coverage

4.2.1 Description

The purpose of this cell selection technique is to select the cells or sectors in such a way that, to the extent technically possible, no portion of the Alert Area will be left uncovered by the broadcast. Due to challenging terrain and other factors, this will not always be possible.

As the cell or cell sector boundaries do not exactly match the Alert Area boundaries, this selection technique will result in having the broadcast overshoot some or all boundaries of the Alert Area.

This technique works best when used in conjunction with the DBGF capability in the mobile device to mitigate the overshoot.

Using the 100% Coverage method, cell/sectors 1A, 1B, 1C, 2A, 2B, 2C, 3A, and 3B in Figure 2 would be included in the broadcast. The selection of cell sector 1A may produce extreme overshoot of the broadcast, but not selecting this cell sector may result in mobile devices inside the Alert Area not receiving the alert.

4.2.2 Impact

Overshoot will result in presentation of the alert by mobile devices outside the Alert Area due to the number of mobile devices in the field which are not capable of DBGF. WEA 3.0 mobile devices would have the capability to perform DBGF, not presenting the alert if outside the Alert Area.

5 Wireless Operator Cell/Sector Selection

This section provides individual wireless operator views of cell/sector selection techniques. These are neither common nor consensus operator views; rather, the content in Sections 5.1, 5.2, and 5.3 below conveys opinions, views, and cell/sector selection procedures provided by the respective individual operator.

5.1 T-Mobile USA Approach

The Geo-Targeting Final Rule of FCC R&O 18-4A1 (§ 10.450 Geo-targeting) that resulted in the ATIS WEA work to specify the capability for WEA 3.0 DBGF sets forth the requirements from the FCC, with acknowledgment of possible field and implementation conditions noted as allowed exceptions to meeting those requirements.

> **§ 10.450 Geo-targeting**
> (a) This section establishes minimum requirements for the geographic targeting of Alert Messages. A Participating CMS Provider will determine which of its network facilities, elements, and locations will be used to geographically target Alert Messages. A Participating CMS Provider must deliver any Alert Message that is specified by a circle or polygon to an area that matches the specified circle or polygon. A Participating CMS Provider is considered to have matched the target area when they deliver an Alert Message to 100 percent of the target area with no more than 0.1 of a mile overshoot. If some or all of a Participating CMS Provider's network infrastructure is technically incapable of matching the specified target area, then that Participating CMS Provider must deliver the Alert Message to an area that best approximates the specified target area on and only on those aspects of its network infrastructure that are incapable of matching the target area. A Participating CMS Provider's network infrastructure may be considered technically incapable of matching the target area in limited circumstances, including when the target area is outside of the Participating CMS Provider's network coverage area, when mobile devices have location services disabled, and when legacy networks or devices cannot be updated to support this functionality.

The FCC's wording indicates the goal set for the industry of presenting the alert on mobile devices in 100% of the Alert Area with no further than 0.1 miles of overshoot. The wording also clearly indicates the FCC's understanding that support in both the network and the mobile device is required to achieve this goal. The network carries the capability of ensuring 100% coverage of the Alert Area. The mobile device carries the capability to adhere to the limitation of 0.1 miles of overshoot.

The FCC provides allowances for not meeting this goal:

> With regard to network support, allowances are made for mobile devices in a portion of the Alert Area that the CMSP is not technically capable of reaching with their broadcast coverage area at the time of the alert broadcast. This is understood to be the case for mobile devices beyond the boundaries of the CMSP's coverage area, as well as mobile devices within their coverage area but in terrain not reachable with current radio technology characteristics. The other network-based exception applies when the network cannot be updated to support the new functionality.

> With regard to mobile device support, the FCC has provided an exception for mobile devices with location turned off, as the mobile cannot then perform the location comparison. As an extension of this exception, it is understood that should the mobile device for any reason be unable to obtain location at the time the alert is received, the mobile device will default to presentation of the alert. The ATIS specifications call for defaulting to presentation of the alert under these circumstances. The FCC has provided a second exception for mobile devices that "cannot be updated to support this functionality." Mobile devices that cannot be updated to support this functionality include many legacy mobile devices, as well as those devices which do not carry the level of capability needed to support this functionality.

T-Mobile USA performs cell/sector selection to achieve, barring the network allowances set forth by the FCC, 100% coverage of the Alert Area. Please see the cell/sector selection technique illustrations in this report detailed descriptions and examples of this technique. The figure below gives one example with regard to the provisioning used by T-Mobile.

Cell/sector radius can vary widely in deployments, from only a few meters to tens of kilometers, depending on the technology, capacity needs, terrain and other decision points. This figure is used for illustrative purposes only and includes only three provisioned sizes. The Alert Area is represented by the two orange polygons. The cells/sectors that would be selected for this broadcast are filled with magenta, in contrast to the cells/sectors that would not be selected, shown as clear. Darker magenta areas reflect overlapping broadcasts in the cell/sector selection. This ensures no effective undershoot, as the mobile devices in these areas could be listening to either broadcast. The impacts of the radius size are demonstrated not only by the amount and degree of overshoot of the selected cells/sectors, but also by the cells/sectors not selected due to lack of overlap with the Alert Area.
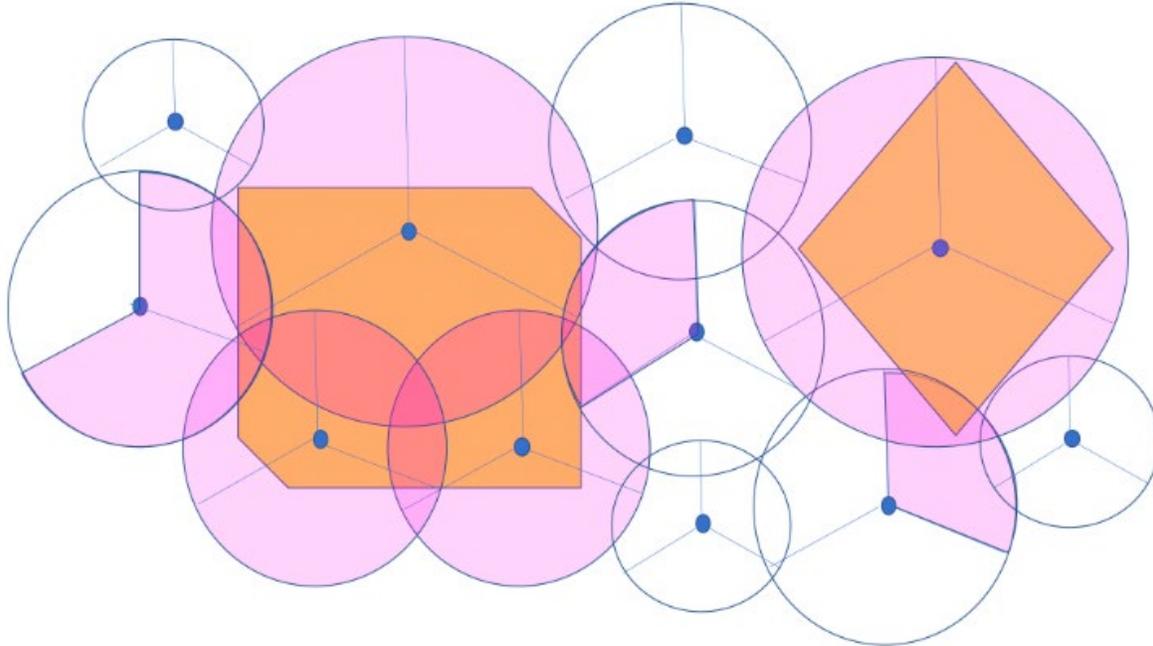

Figure 3 - T-Mobile Cell/Sector Selection

5.2 AT&T Approach

Introduction:

AT&T recognizes extent of overshoot and/or undershoot is a difficult trade-off and requires both technical as well as policy considerations. AT&T has heard from some AOs that it may be better to overshoot to ensure potential life-saving alerts are received by as many impacted as possible, at the risk of alert fatigue from those receiving alerts well outside the impacted area. In addition, through actual field experience, AT&T has seen reports on the impact to life and property for not receiving a WEA alert in difficult terrain, such as in mountainous regions and valleys, that are subject to flash flooding and wildfire events. It is for these reasons that AT&T's cell site selection procedure emphasizes *coverage* of the target area to the maximum extent possible, even in these difficult terrain locations. That is why, for example, AT&T's cell selection process chooses cell sites outside the polygon that provide coverage back into "difficult to cover" terrain within the alert area.

AT&T believes that undershoot is not acceptable. The problem is that any attempts to quell the overshoot may result in some level of undershoot in the alert area/polygon. A real-life example was a WEA alert in the Los Angeles area, where it was required to get the WEA broadcast into difficult terrain north of Los Angeles. This required the selection of cell sites up to ~30 miles away to ensure coverage, at the expense of overshoot.
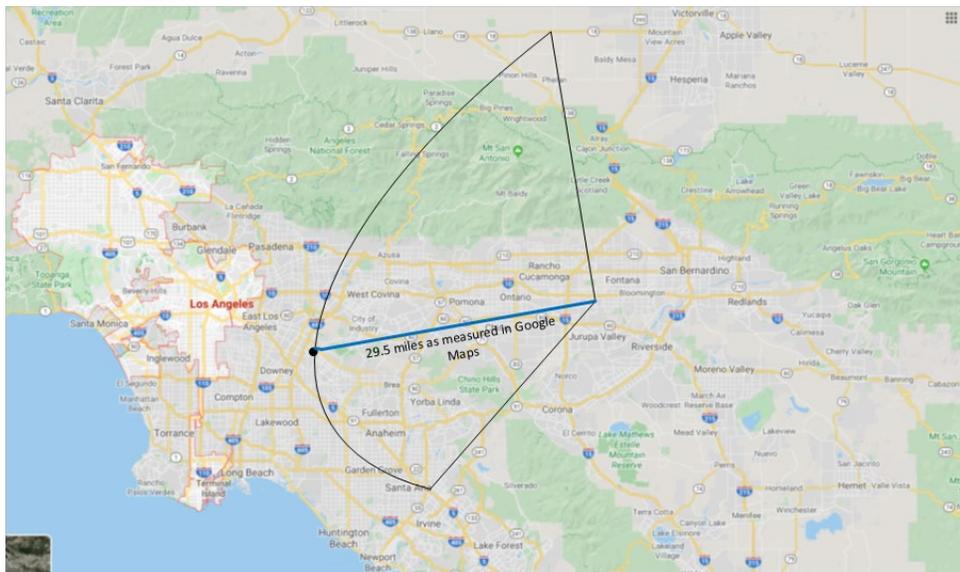
Figure 4 - Example alert in difficult terrain Northeast of Los Angeles, CA

Since WEA 3.0 was implemented in the wireless networks in December 2019, the National Weather Service has had an increase in reports of WEA "overshoot" on several weather-related WEA messages that were sent out. The incidents of overshoot are reported by citizens who receive the alert while located outside the warning polygon. These reports come into the local weather forecast office and/or via social media reports. In several instances, citizens reported receiving the WEA when they were tens of miles outside the polygon. The concern from the AO, the National Weather Service, is alert fatigue – that is, citizens complaining about receiving WEA messages that do not impact them, and in fact are for events many miles away. This could result in citizens turning off WEA on their mobile devices.

To understand why these complaints increased since December 2019, it is necessary to look at the deployment of "WEA 3.0", where several things took place:

- Participating carriers began broadcasting the polygon coordinates so that WEA 3.0 capable handsets would be able to receive the applicable alert area.
- Participating carriers ___may have___ changed the cell site selection algorithms to ensure 100% coverage of the polygon, to meet the new FCC requirement. *Note that this is not consistent across all carriers.*
- WEA 3.0 capable devices started entering the marketplace, enabling DBGF. *Note that this capability is not initially included across all handsets and many non-DBGF-supporting WEA 1.0 and WEA 2.0 handsets are still deployed.*

The FCC's wording from the Final Rules indicates the goal set for "A Participating CMS Provider is considered to have matched the target area when they **deliver an Alert Message to 100 percent of the target area with no more than 0.1 of a mile overshoot**" (47 CFR §10.450(a)). The wording also clearly indicates the FCC's understanding that achieving this goal requires support from both the network and the mobile devices. The network must have the capability of ensuring 100% coverage of the Alert Area ("deliver an Alert Message"). In addition, the mobile device carries the capability to adhere to the limitation of 0.1 miles of overshoot, via DBGF.

Unfortunately, however, these rules do pose a conflict in the implementation in a pre-100% WEA 3.0 environment.

From AT&T's perspective, the FCC requirement for the WEA broadcast to cover 100% of the polygon ultimately is the cause of the significant overshoots. Prior to WEA 3.0, the FCC requirement was for CMS providers to "best approximate" the polygon given the challenges of RF coverage. With WEA 3.0. however, the FCC combined potentially competing mandates to ensure 100% coverage of the polygon (to the extent the carrier has the capability to provide 100% coverage) and the objective to minimize overshoot (to 1/10th of a mile for WEA 3.0). In other words, it is maximizing the probability of getting the WEA message to everyone in the polygon versus the risk of complaints for people outside the polygon receiving the WEA.

In a perfect WEA 3.0 world, there is no conflict with maximizing the polygon coverage and limiting the overshoot to 1/10th of a mile. DBGF would handle any overshoot. However, as long as there is a mix of WEA 3.0 capable and

non-WEA 3.0 capable devices, and a carrier is required to provide 100% coverage of the polygon, then there will always be the possibility of devices well outside the polygon that potentially could receive the WEA.

In summary, without 100% WEA 3.0 devices, the implementation conflict driven by the FCC rules can be described as follows:

- Is the priority to ensure 100% RF coverage of the polygon, increasing the likelihood of a WEA broadcast from cell sites a significant distance outside the polygon, and thus increases the chance for overshoot for non-WEA 3.0 devices?
- Is the priority to minimize the overshoot to avoid complaints, with the risk of not covering the polygon 100% and the possibility of citizens missing the possible life-saving WEA message?

Understanding Cell Site Selection

When an AO draws a warning polygon, they are identifying the area that is at risk for the event. It is based on the analysis and data for the event and considers the probability of the event occurring within the polygon. It is to be assumed that the risk level is the same everywhere throughout the polygon.

When the polygon is delivered to the participating carrier's network, a determination must be made on which cell sites provide RF coverage to meet the carrier's goals for coverage of that polygon. The polygon is delivered to the participating carrier's CMSP Gateway via FEMA IPAWS. However, the CMSP Gateway does not do cell site selection. Each carrier has its own process for determining their network's cell sites that provide coverage of the polygon, and this is provided to the CMSP Gateway/Cell Broadcast Center. It is also important to note that since each carrier's network is configured differently (cell site locations, RF parameters of the cell site, etc.), each participating carrier in the warning area likely will have different coverage of the polygon.

Methods for the identification of cell sites that provides coverage of the polygon vary among participating carriers and may include:

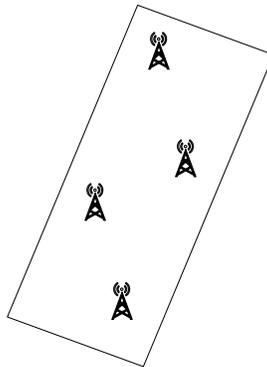- Choose cell sites that are contained within the polygon

Figure 5 – Cell Sites Chosen within a Polygon

- Choose cell sites that are within the polygon and also sites located just outside the polygon but provide RF signal into the polygon
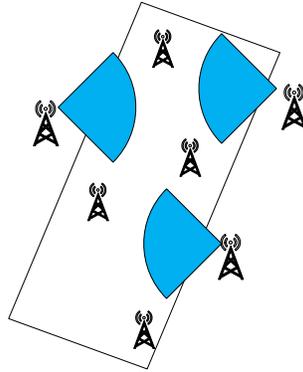
Figure 6 – Cell Sites Chosen with RF coverage within a Polygon

- Choose cell sites using an RF "best server plot" that identifies cell sites that provides signal in the polygon
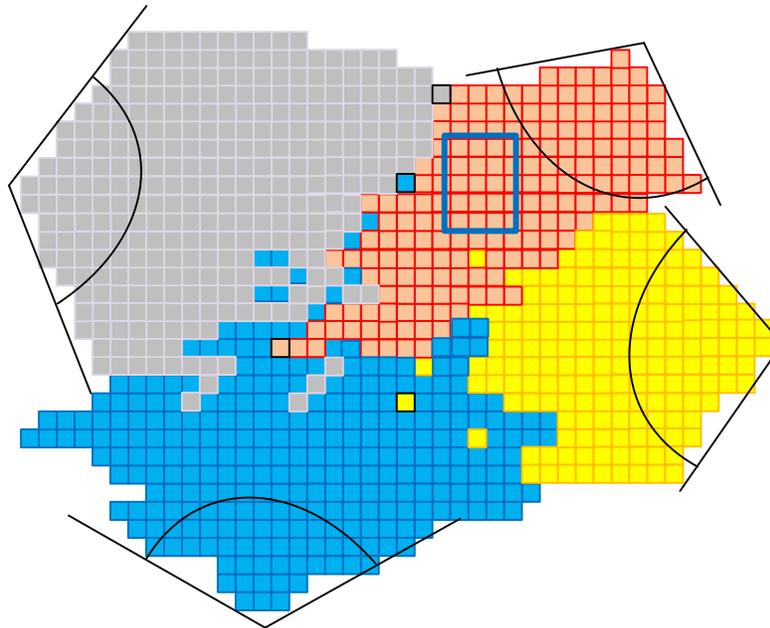

Figure 7 – RF Best Server Plot

Each of these methods runs risk for undershoot and/or overshoot. For this discussion, the "best server plot" method will be used to explain the overshoot when the goal is 100% polygon coverage.

Best Server Plot Method of Cell Site Selection

There are various RF engineering tools that carriers use to plan wireless coverage. These tools take into account many parameters that influence RF signal propagation, including broadcast signal strength, antenna height, angle of antennas, terrain of surrounding area, etc. However, one also needs to understand that RF is sometimes more "magic" than science, and these tools still only provide an estimate of actual coverage.

While these tools typically are used for cell site planning, they also can be used to assist in the cell site selection for WEA. This is especially true when the goal is to obtain 100% coverage of the cell site using the coverage models that are provided.

Since WEA is broadcast as part of the SIB, the signal levels to receive a SIB broadcast are lower than the signal levels required for a voice call or data session. Assume a handset is configured to attach to control channel at signal levels as low as $(S_{WEA})_{min}$ dBm.

The "best server method" segments the warning area into bins (each "bin" being b m²), and the RF modeling tool plots the best server for each bin. Best server is the site/sector that provides greatest percent of coverage to the bin based on the signal level ($S_{WEA})_{min}$ dBm.
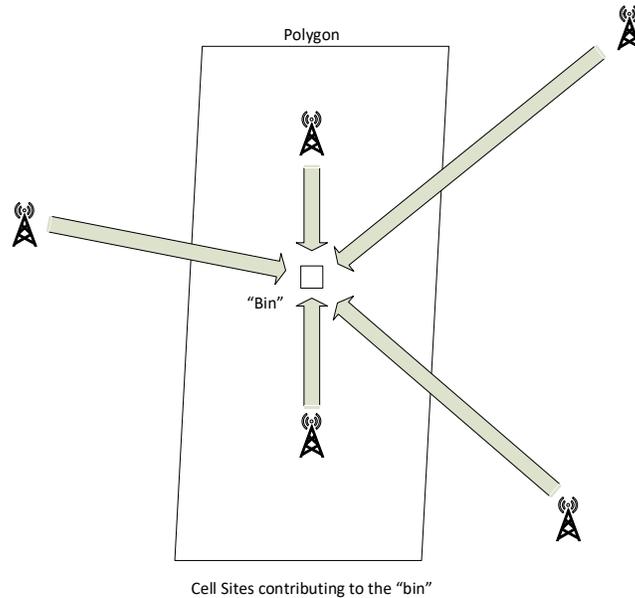

Figure 8 – Cell Sites Contributing to the "Bin"

While the above shows the contributions to a single bin within the polygon, a complete model needs to look at all possible best servers for each bin within the polygon. The goal is to identify best servers for every bin in the polygon such that there is 100% coverage of the polygon. Each of these best servers are then the cell site/sectors for which the WEA is to be broadcast for the specified alert polygon.

Additional parameters that need to be considered, in addition to bin size b and ($S_{WEA})_{min}$ are:

- Antenna angle in degrees
- Maximum cell radius, R_{max} km

Using anonymized data for a real National Weather Service WEA alert, the output from a simplified best server plot may appear as follows:
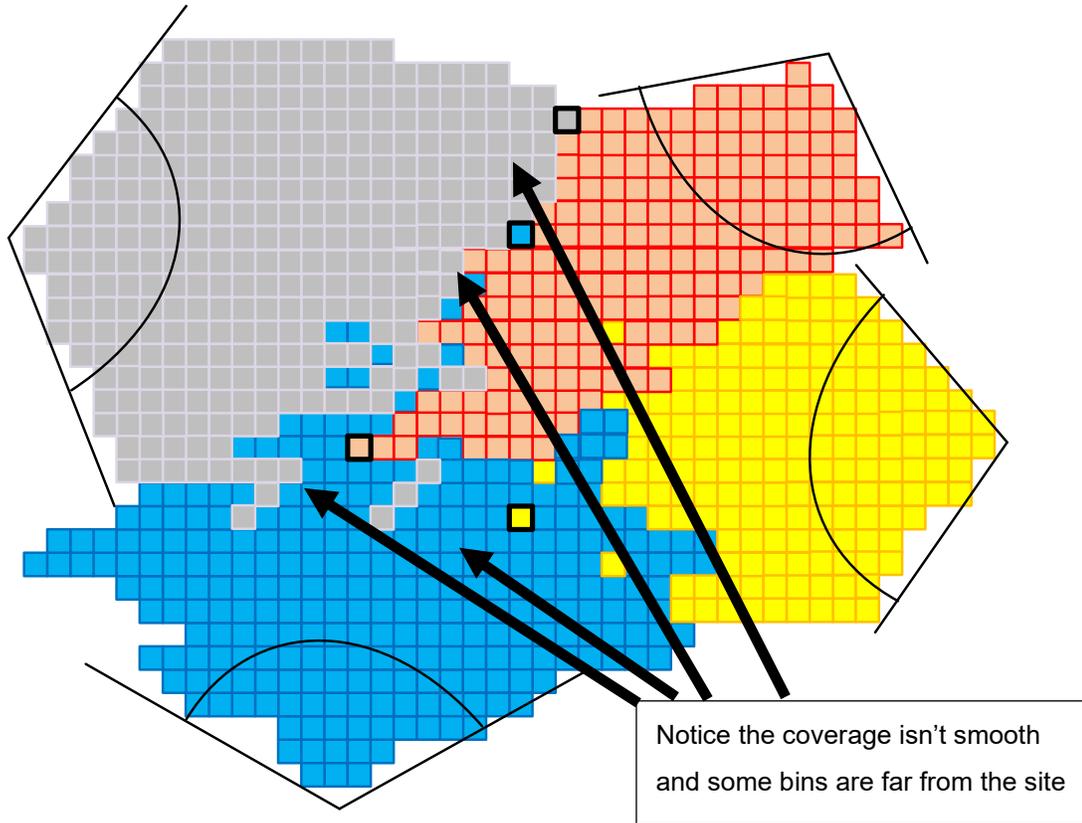
Notice the coverage isn't smooth and some bins are far from the site

Figure 9 – Sample Output from Simplified RF Best Server Plot

Each color represents the signal from the 4 respective cell sectors, with the antenna angles limiting the signal as depicted.

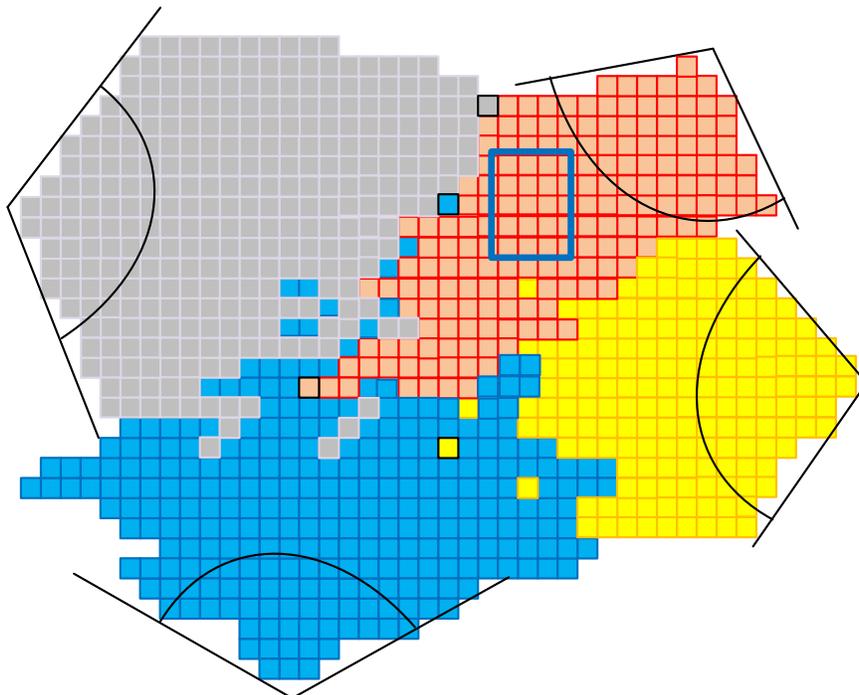The next step is the overlaying of the WEA polygon with the best server plot:

Figure 10 – Overlaying Polygon with RF Best Server Plot

This is then provided to the CMSP Gateway, which takes the maximum coverage area from the RF coverage tool and creates a smooth coverage plot for the entire arc of the cell site. The result is where there is potential overshoot. As shown in this example, all 4 sectors overlap the alert polygon while the RF coverage tool shows only one overlap.
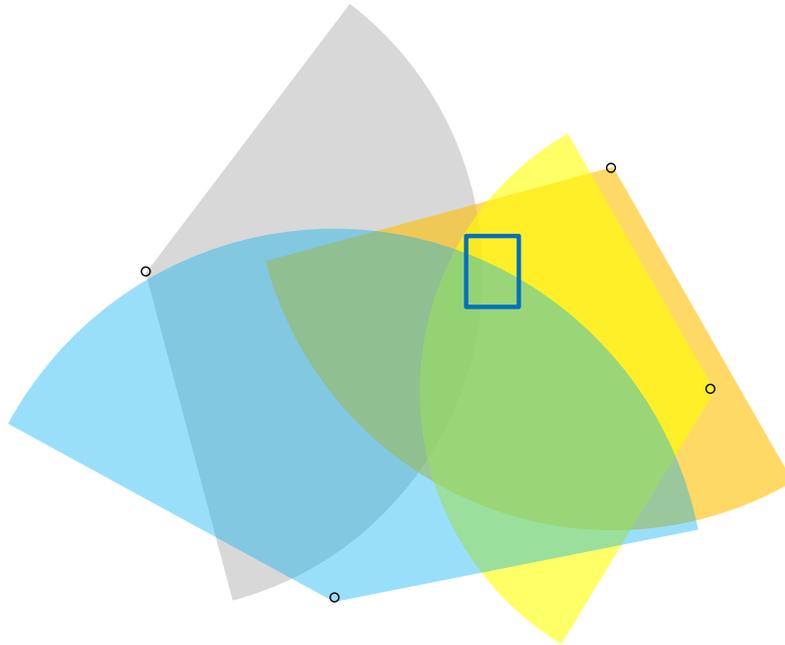

Figure 11 - CMSP Gateway Smoothing of RF Coverage

As a result, the CMSP Gateway will select all 4 sectors to broadcast the WEA. From the figure, it is clear that non-WEA 3.0 devices will potentially receive the alert even if they are well outside the polygon.
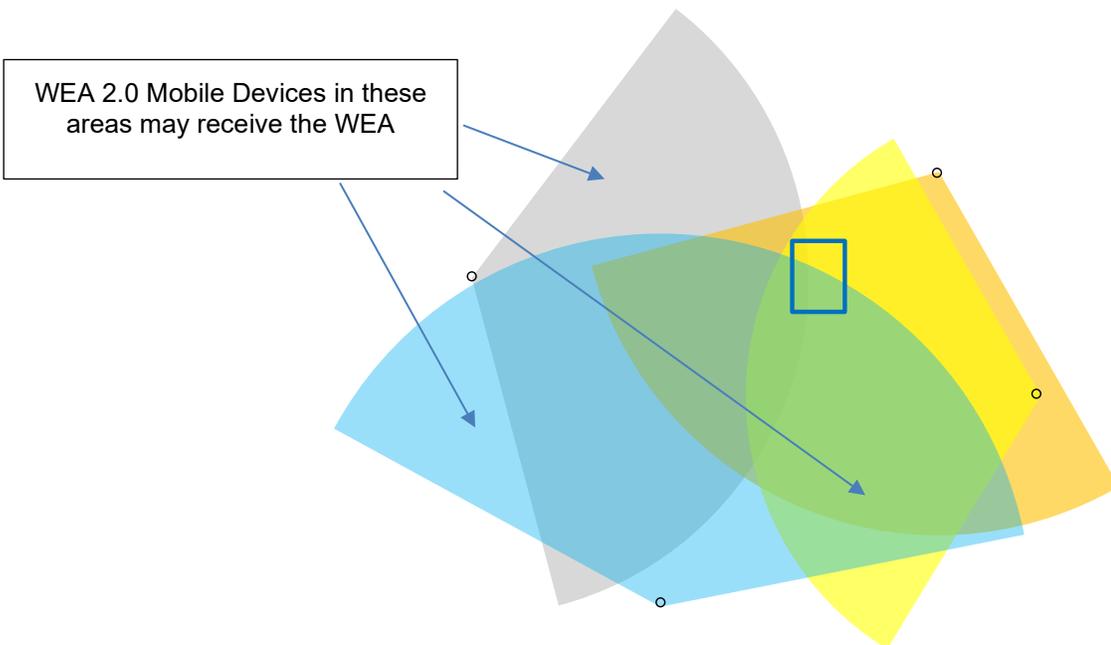

WEA 2.0 Mobile Devices in these areas may receive the WEA

Figure 12 – Overshoot Areas in Which Legacy WEA Devices May Receive WEA Alert

The result is significant overshoot that has been observed when attempting to provide 100% coverage of the polygon.

Possible Mitigations to Limit Overshoot

In an attempt to limit the overshoot, several possible mitigations have been investigated. The parameters that can be changed in the RF modeling are:

- $(S_{WEA})_{min}$
- Bin size **b**
- Cell radius **R**
- Antenna angle

Changing $(S_{WEA})_{min}$ and the bin size **b** was found to have minimal effect on overshoot.

One factor that has an impact appears to be the cell radius **R**. When the cell radius is artificially limited, this will effectively exclude bins that may appear as a "best server". For example, in the following figure, if we artificially limit the cell radius to 50km (from 75km), the blue bin would be excluded. Thus, this may exclude the cell sector from the best server list and will possibly limit the overshoot from that sector. The possible issue is that the eliminated bin may be the only bin that best serves the given area, thus there is an undershoot potential. This is especially true in difficult terrain.
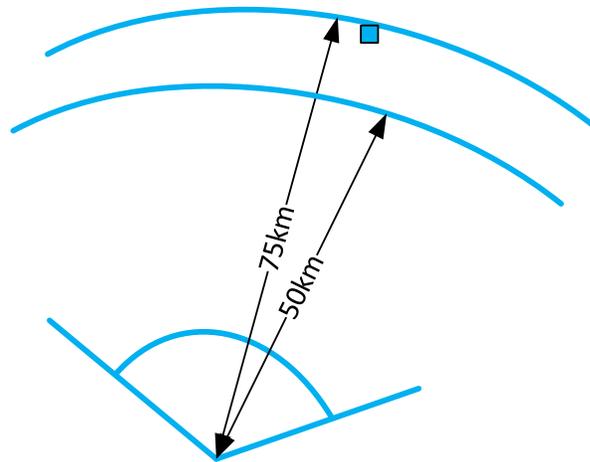

Figure 13 – Limitation of Cell Radius

When used in the previous example, a 50km cell size will effectively lower – but not eliminate – the overshoot:
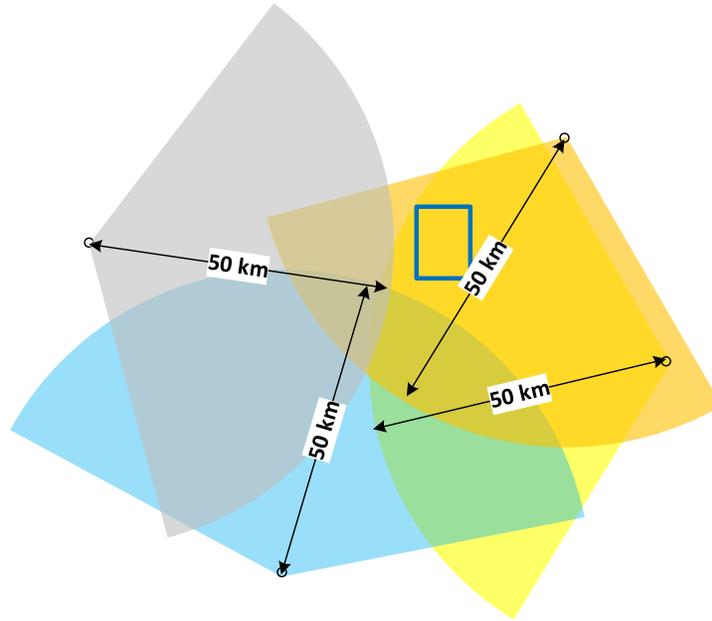
Figure 14 – Impact of Limiting Cell Radius

Unfortunately, when the edge of sector (limited to 50km in a 120° sector) intersects the alert polygon, simple geometry shows resulting broadcast area is still nearly 87km across. Most sites are 120° or less.
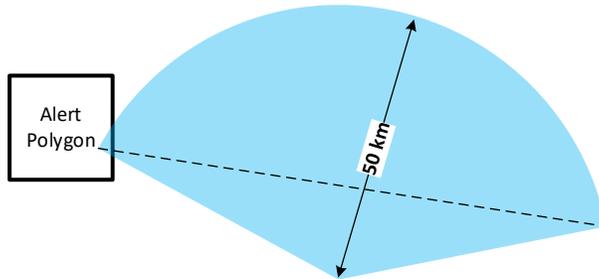

Figure 15 – 120 degree Sector Coverage Minimally Overlapping Polygon

$$\sin A = opposite/ hypotenuse$$
$$\sin 60° = O/ 50km$$
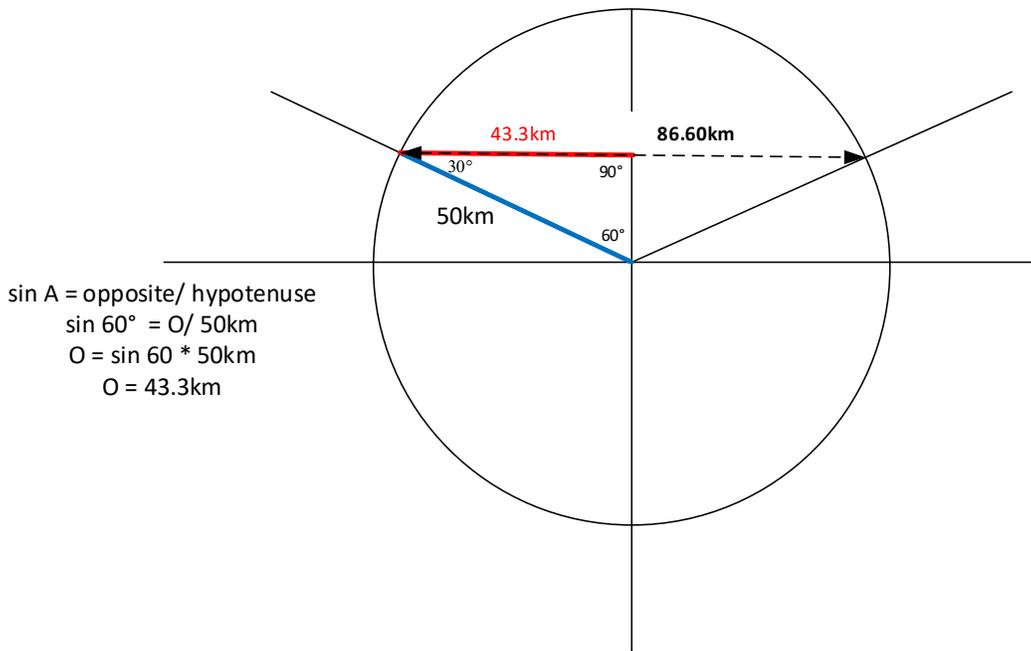$$O = \sin 60 * 50km$$
$$O = 43.3km$$

Figure 16 – Coverage Dimensions with 50km Cell Radius

Summary from AT&T's Perspective

The purpose of this study is to understand the WEA overshoot reported by the National Weather Service, and to determine whether RF modeling parameters can be adjusted while still maintaining the 100% coverage of the target area until WEA 3.0 handsets are more broadly available.

The overshoot issue becomes apparent when an RF modeling tool is used to identify the cell sites/sectors that contribute to the "best server" for a WEA broadcast in order to achieve the FCC's rule of delivering to 100% coverage of the target area ("polygon"). This is further exacerbated when the CMSP Gateway does a "smoothing" operation on the RF coverage.

The parameter in the RF modeling software that appears to have the greatest immediate impact is the cell radius **R**. Decreasing the cell radius will decrease the overshoot radius, but the consequence is the potential for leaving coverage gaps in the target area, or "undershoot". This does not completely eliminate overshoot, however, which will still exist even with decreasing the cell radius.

This study highlights the implementation conflict brought upon by the WEA 3.0 FCC rules – without all devices being WEA 3.0 capable, a carrier's attempt to "match the target area when they deliver an Alert Message to 100 percent of the target area" conflicts with "no more than 0.1 of a mile overshoot" as demonstrated through an RF "best server" coverage of the target area. As long as there are non-DBGF-supporting WEA 1.0 and WEA 2.0 handsets outside the target area, those devices will continue to receive the WEA when there is an attempt to cover 100% of the target area.

5.3 Verizon Wireless Approach

Regulatory Requirements for WEA Geo-targeting

FCC rules require that CMS Providers (1) match the alert area by providing 100% coverage within the alert area "polygon" with no more than 0.1 mile overshoot for new devices, and (2) continue to use the "best approximation" geotargeting method when serving legacy devices and devices with location service disabled. The FCC has not adopted specific parameters for what constitutes "best approximation." CMS Providers instead are expected to take reasonable efforts to leverage existing technology to its fullest extent. The FCC notably recognized that "best approximation" would result in some overshoot particularly in rural areas due to cell site propagation.

ATIS Standards WEA 3.0

ATIS WEA 3.0 Standards provided the capabilities to meet the FCC WEA geo-targeting accuracy requirement of no more than 0.1 mile overshoot by adding the alert area "polygon" to network broadcast and device based geo-fencing capabilities. However, the standards do not address the specifics of 100% coverage and best approximation. The details instead are left for carrier network implementation.

Verizon Implementation on Best Approximation Prior to WEA 3.0:

In initial WEA deployment in 2012, Verizon's first cell selection approach was to include any cells with potential RF coverage, to the targeted alert area. This approach aimed to eliminate the undershooting problem but generated significant overshooting. With the cell radius ranging from several meters to 100 kilometers (~ 60 miles), the overshoot could be up to 2X cell RF radius or up to 120 miles in a worst case scenario resulting in an overshooting area that would be several times larger than the intended alert area polygon.

In fact, in several instances, the National Weather Service brought it to our attention that Flash Flood Warning alerts were received by people more than 100 miles away from the targeted alert area. They expressed concerns that the severe overshooting problems would cause people to lose trust to the WEA systems and may lead them to opt out the WEA service altogether.

To address the concerns from National Weather Service, Verizon changed to a conservative cell selection approach, which was to include cells within the targeted alert area plus cells outside but near the boundary of the targeted alert area. This conservative cell selection approach attempted to balance concerns for overshooting and undershooting. In the worst case, overshooting was cut down to 1X cell RF radius. However, it has its drawback of a potential undershoot problem, especially in rural areas. In some instances, it resulted in no network alert broadcast at all when the alert area polygon was drawn so small that it did not include any cells.

Verizon WEA 3.0 Implementation

The FCC requires delivery of alerts to 100% coverage within the polygon (plus not more than 0.1 mile overshoot) to new devices, and that best approximation continue to apply for legacy devices and devices with location service disabled. Because our existing "best approximation" approach foreshadowed the 100% coverage approach by including some cell sites located outside (but close to) a polygon, we maintained that approach. In our implementation of WEA 3.0 over LTE networks, however, the same networks must provide WEA broadcast for both WEA 3.0 devices and legacy devices. It is not technically feasible to provide 100% coverage for new devices at less than 0.1 mile overshoot while at the same time limiting geo-targeting of alerts to legacy devices to the best approximation.

Between the two extremes of (1) capturing all sites with any potential coverage in a polygon, and (2) capturing only sites within a polygon, choices, we continue to pursue an approach that would benefit the most of our customers by beginning to address the 100% standard while also meaningfully addressing customers' and alert originators' concerns for overshoot. During the initial deployment of WEA 3.0 and sometime afterwards, there are fewer new devices with geo-fencing capability than the legacy devices. In the interest of not degrading the WEA experience for the majority of our customers with legacy devices, and based in part on continued concerns from the National Weather Service, we have maintained our current geo-targeting approach in the interim, while continuing to make some adjustment to include more cells outside the alert area to address potential undershooting issues based on feedback from and discussions with some alert originators.

We think the optimal time to use all the cell sites with coverage to the alert area is when the WEA 3.0 device market penetration reaches the majority of Verizon subscribers. However, it would remain a concern that customers with legacy devices and devices with location services disabled would experience more significant overshooting.

6 Conclusion

There are many factors stemming from both technological and human sources, in addition to physics of radio propagation, which impact the definition of the broadcast area and the user's perception for an alert. The target area specified by the Alert Originator based on the current knowledge of the alert event, together with possible extrapolation (e.g., expansion for expected immediate weather path), may itself sometimes be imperfect from the perspective of individual recipients. From this target area, the broadcast area is built. Due to factors mentioned above, the broadcast area cannot be directly matched to the target area.

The selection techniques for cell sites/sectors used by the CMSPs to broadcast WEAs as described in this paper have pros and cons, resulting in overshoot and/or undershoot. If measures are taken to reduce either undershoot or overshoot, the result will almost always be an increase in the other.

A CMSP's cell site/sector selection technique, as well as the parameters that are used in choosing cell site/sectors for broadcasting WEAs, are evaluated based on specific CMSP network configurations and attempt to account for both the technical and policy considerations. As market penetration of WEA 3.0 capable devices increases, the cell site/sector selection technique may shift as DBGF may also be factored into the cell site/sector selection technique, however, significant market penetration will take some time. In addition, WEA 3.0 will only improve alert delivery targeting when the Alert Originator includes polygons and/or circles in the alert message. If only geocodes are included in the alert message, DBGF will not be performed. If only a geocode is included in the alert message, but the intention is to target a much smaller area within that geocode, this creates perceived overshoot because the alert would be delivered to the entire area covered by the geocode. AOs need to understand the implications in choosing the geo-targeting related parameters for a given alert.

Although not directly related to geo-targeting, the alert text plays a critical role in the alerting impact to the public. For example, an AO should assist the alert recipient by including an explicit description of the alert area. The use of the "in this area" formulation should be replaced by, for example, "Southern Chicago".

ATIS continues to work with the AOs and FEMA to strive toward ensuring end-to-end understanding of the tools available in order to achieve the best safety and experience for the users and is in the process of documenting the guidelines being developed through this collaboration.