FEASIBILITY STUDY

**ATIS-0700027**

# FEASIBILITY STUDY FOR WEA CELL BROADCAST GEO-TARGETING

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**ATIS-0700027**

ATIS Standard on

# Feasibility Study for WEA Cell Broadcast Geo-Targeting

**Alliance for Telecommunications Industry Solutions**

Approved December 2, 2015

**Abstract**

This feasibility study performs a technical analysis of the geo-targeting of Wireless Emergency Alert (WEA) Messages. This feasibility study is in response to Recommendations 3.6 and 3.7 of the December 2014 Federal Communications Commission (FCC) Communications Security, Reliability & Interoperability Council (CSRIC) Working Group 2 Wireless Emergency Alerts final report of December 3, 2014.

## Foreword

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between carriers, customers, and manufacturers. The Wireless Technologies and Systems Committee (WTSC) develops and recommends standards and technical reports related to wireless and/or mobile services and systems, including service descriptions and wireless technologies. WTSC develops and recommends positions on related subjects under consideration in other North American, regional, and international standards bodies.

The mandatory requirements are designated by the word *shall* and recommendations by the word *should*. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages. The word *may* denotes an optional capability that could augment the standard. The standard is fully functional without the incorporation of this optional capability.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, WTSC, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time of consensus on this document, WTSC, which was responsible for its development, had the following leadership:

M. Younge, WTSC Chair (T-Mobile)

D. Zelmer, WTSC Vice-Chair (AT&T)

P. Musgrove, WTSC SN Chair (AT&T)

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D. Sennett, Technical Editor (AT&T)

The Systems and Networks (SN) Subcommittee was responsible for the development of this document.

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# Feasibility Study for WEA Cell Broadcast Geo-Targeting

## 1 Scope, Purpose, & Application

### *1.1 Scope*

The scope of this document is a feasibility study of the geo-targeting of Wireless Emergency Alert (WEA) Messages to address recommendations from the Federal Communications Commission (FCC) Communications Security, Reliability & Interoperability Council (CSRIC).

### *1.2 Purpose*

At the December 3, 2014 meeting, the FCC CSRIC approved the final report from the CSRIC Working Group 2, Wireless Emergency Alerts [Ref 1].

The FCC has received the recommendations from the CSRIC working group and, at the time of the completion of this feasibility study, the FCC has issued a Notice of Proposed Rulemaking (NPRM). The CSRIC working group report does contain recommendations that require action by the Alliance for Telecommunications Industry Solutions (ATIS). Specifically, Recommendation 3.6 [Ref 1] (as quoted below) tasks industry to study cell broadcast geo-targeting for WEA alerts:

> *"**Recommendation 3.6:** It is recommended that industry, FEMA, and Alert Originators collaborate on an ATIS/TIA feasibility study of WEA Cell Broadcast Geo-targeting. The feasibility study will investigate technology enhancements, including mobile-assisted geo-targeting, for enhancing the delivery of alert messages to a given geocode, circle, or polygon. The WEA Cell Broadcast Geo-targeting feasibility study should leverage the results of research, including the DHS Studies on Geo-targeting which are currently underway. The results of the ATIS/TIA feasibility study will be reported at the regular WEA partner meetings hosted by the FCC-CTIA-DHS-FEMA-NWS-CMSPs.*
>
> > *Note: This WEA Cell Broadcast Geo-targeting feasibility study should include the evaluation of simple versus complex polygons, number of maximum points in polygon, polygons with crossing lines within the polygon, responsibility for validation of polygons, multiple polygons, multiple circles, and combinations of polygons and circles."*

Recommendation 3.7 of the CSRIC working group report [Ref 1] (as quoted below) requires the study be completed one year after acceptance of the recommendation by the CSRIC (that were accepted on December 3, 2014).

> "***Recommendation 3.7:** It is recommended that the WEA Cell Broadcast Geo-targeting feasibility study in Recommendation 3.6 be completed within one year after this recommendation is adopted by the full CSRIC in order to be available for input into the FCC rule making process."*

### *1.3 Application*

This feasibility study is applicable to commercial mobile service providers (CMSPs), to the FCC, to the FCC CSRIC, and to the WEA stakeholders that include the FCC, the Cellular Telecommunications Industry Association (CTIA), the Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), the National Weather Service (NWS), and CMSPs.

# 2 Normative References

The following standards and papers contain provisions which, through reference in this text, constitute provisions of this study. At the time of publication, the editions indicated were valid. All references are subject to revision, and parties to agreements based on this study are encouraged to investigate the possibility of applying the most recent editions of the references indicated below.

[Ref 1] FCC CSRIC IV Working Group 2, *Geographic Targeting, Message Content and Character Limitation Subgroup Report*, October 2014.[1]

[Ref 2] J-STD-101, *Joint ATIS/TIA CMAS Alert Gateway to CMSP Gateway Interface Specification*; October, 2009 including J-STD-101.a, *Supplement A to J-STD-101, Joint ATIS/TIA CMAS Alert Gateway to CMSP Gateway Interface Specification*, August 2011 and including J-STD-101.b, *Supplement B to J-STD-101, Joint ATIS/TIA CMAS Alert Gateway to CMSP Gateway Interface Specification*, December 2012.[2]

[Ref 3] *Common Alerting Protocol, v. 1.1; OASIS Standard CAP-V1.1*; October 2005.[3]

[Ref 4] ISO 6709:2008, *Standard Representation of Geographic Point Location by Coordinates*; 2008.[4]

[Ref 5] ATIS-0700023, *Feasibility Study for LTE WEA Message Length*; October 2015.[5]

[Ref 6] ATIS-0700026, *Feasibility Study for WEA Supplemental Text*; December 2015[6]

[Ref 7] Abhinav Jauhri, Martin Griss & Hakan Erdogmus, Carnegie Mellon University, *Small Polygon Compression for Integer Coordinates*; presented June 12 2015 at American Meteorological Society 43rd Conference on Broadcast Meteorology / 3rd Conference on Weather Warnings and Communication.[7]

[Ref 8] Michele Wood, Hamilton Bean, Brooke Liu & Marcus Boyd, DHS START, Comprehensive Testing of Imminent Threat Public Messages for Mobile Devices: Updated Findings; August 2015.[8]

# 3 Definitions, Acronyms, & Abbreviations

For a list of common communications terms and definitions, please visit the *ATIS Telecom Glossary*, which is located at < http://www.atis.org/glossary >.

## *3.1 Definitions*

**Centroid**: The geographic center (centroid) of the cell site/cell site sector transmission area.

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[1] Available from the FCC at:

< http://transition.fcc.gov/pshs/advisory/csric4/CSRIC_CMAS_Geo-Target_Msg_Content_Msg_Len_Rpt_Final.pdf >.

[2] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS) at: < https://www.atis.org/docstore/product.aspx?id=24919 >.

[3] This document is available from the Organization for the Advancement of Structured Information Standards (OASIS). < http://www.oasis-open.org/specs/index.php >.

[4] This document is available from the International Organization for Standardization (ISO) < http://www.iso.org/ >

[5] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS) at: < https://www.atis.org/docstore/product.aspx?id=28243 >.

[6] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS) at: < https://www.atis.org/docstore/product.aspx?id=28248 >.

[7] Available at: < https://ams.confex.com/ams/43BC3WxWarn/webprogram/Paper273645.html >. (Last visited October 21st 2015).

[8] Report available from Department of Homeland Security (DHS) at:
< http://www.firstresponder.gov/TechnologyDocuments/WEA%20-%20Comprehensive%20Testing%20of%20Imminent%20Threat%20Public%20Messages%20for%20Mobile%20Devices%20Updated%20Findings.pdf >. (Last visited October 21st 2015).

## 3.2 Acronyms & Abbreviations

| | |
|---|---|
| ATIS | Alliance for Telecommunications Industry Solutions |
| CAP | Common Alert Protocol |
| CBS | Cell Broadcast Service |
| CMAS | Commercial Mobile Alert System |
| CMSP | Commercial Mobile Service Provider |
| CSRIC | Communications Security, Reliability & Interoperability Council |
| CTIA | Cellular Telecommunications Industry Association |
| DHS | Department of Homeland Security |
| eNB | Evolved NodeB |
| FCC | Federal Communications Commission |
| FEMA | Federal Emergency Management Agency |
| FIPS | Federal Information Processing Standard |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| ISO | International Organization for Standardization |
| NPRM | Notice of Proposed Rulemaking |
| NWS | National Weather Service |
| OASIS | Organization for the Advancement of Structured Information Standards |
| OTDOA | Observed Time Difference Of Arrival |
| TTFF | Time To First Fix |
| UTDOA | Uplink Time Difference of Arrival |
| WEA | Wireless Emergency Alerts |
| XML | eXtensible Markup Language |

# 4 Overview of Current WEA Geo-Targeting Capabilities

In a WEA system, the term “geo-targeting” refers to the method used to broadcast the WEA message to a specific geographical area. The method used to identify an Alert Area by the Alert Originator differs from the method used to identify Broadcast Area within the CMSP infrastructure. For example, within the WEA system, the Alert Area may be identified in the form of a list of counties, polygons, or circles identified by the Alert Originator. In the CMSP infrastructure, the Broadcast Area may be identified in the form of sectors whose RF emissions are within the counties, polygons, or circles.

Basically, the CMSP infrastructure determines the sectors that belong to a Broadcast Area. Just to differentiate the two, this document uses the term “Alert Area” to refer to the counties, polygons, and circles defined by the

Alert Originator, and uses the term “Broadcast Area” to refer to the list of sectors defined by the CMSP infrastructure. Within the language of Cell Broadcast Service (CBS), the term “cell” is used to refer to a sector.

NOTE 1: In order to facilitate the development of the figures in this clause, the coverage area of cell sites is shown as hexagons and the coverage area of each cell-sector is shown as one third of the hexagon. However, in the real-world environments, cell sites are not hexagonal in shape, cell-sectors may not be a third of the cell site, and there are not definitive boundaries for the edges of cell sites and cell-sectors. In the real-world environment, the shapes of the cell sites and cell-sectors will vary because these shapes are based upon radio configurations (e.g., power levels, antenna inclinations), radio wave propagation characteristics, and the geographic topology of the coverage area.

NOTE 2: The letters “A”, “B”, and “C” within each hexagon serve as the label for that cell-sector and also designate the location of the centroid of the cell-sector.

## *4.1 Alert Area*

J-STD-101 [Ref 2] specifies that the Federal Alert Gateway passes the Alert Area information to the CMSP Gateway as a combination of one or more of the following items:

- CMAS_geocode
- CAP_geocode
- Polygon
- Circle

J-STD-101 [Ref 2] specifies that the Federal Alert Gateway shall include at least one instance of CMAS_geocode. The inclusion of Alert Area information in other forms is optional. The CMSP may or may not support the Alert Area information in forms other than the CMAS_geocode. In other words, the support of Alert Area in forms other than the CMAS_geocode is optional and is handled according to CMSP policy.

### 4.1.1 CMAS_geocode

An Alert Area in the form of CMAS_geocode is basically an extension of Federal Information Processing Standard (FIPS) code and is identified with 5 characters, uniquely assigned to a county, region, or other equivalent entity. J-STD-101 [Ref 2] states that the first two characters of geocode identify the state or region and the last three characters identify the counties, regions, or equivalent entities. When the Alert Area includes the entire country (USA), the geocode value of “00000” is used. When the Alert Area includes an entire state, the first two characters (which identify the state) is used, followed by three zeroes (000).

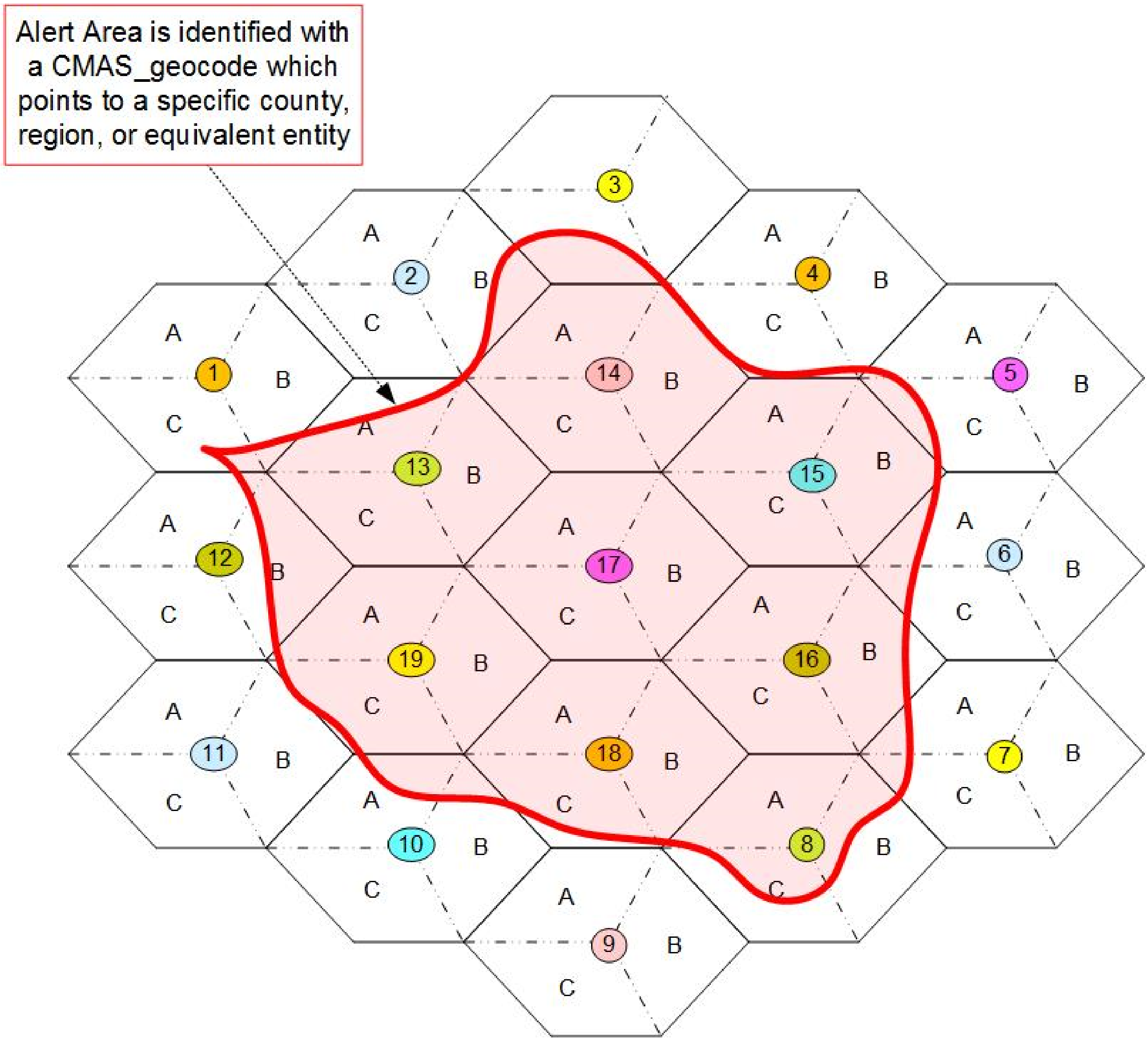



**Figure 4.1 – CMAS_Geocode Can Point to a County, Region, or Equivalent Entity**

The region shown within the red-shaded area is the Alert Area represented by CMAS_geocode.

### 4.1.2 CAP_geocode

An Alert Area in the form of CAP_geocode is passed by the Federal Alert Gateway to the CMSP Gateway if the Federal Alert Gateway receives such information from the Alert Origination in the Common Alert Protocol (CAP). CAP_geocode consists of 6 characters and is represented by PSSCCC where CCC is the code used to identify the counties, regions, or specific entities, SS is the code used to identify the state or region, and P is used to subdivide a county into smaller regions. The contents of the CAP_geocode are defined in the CAP message.

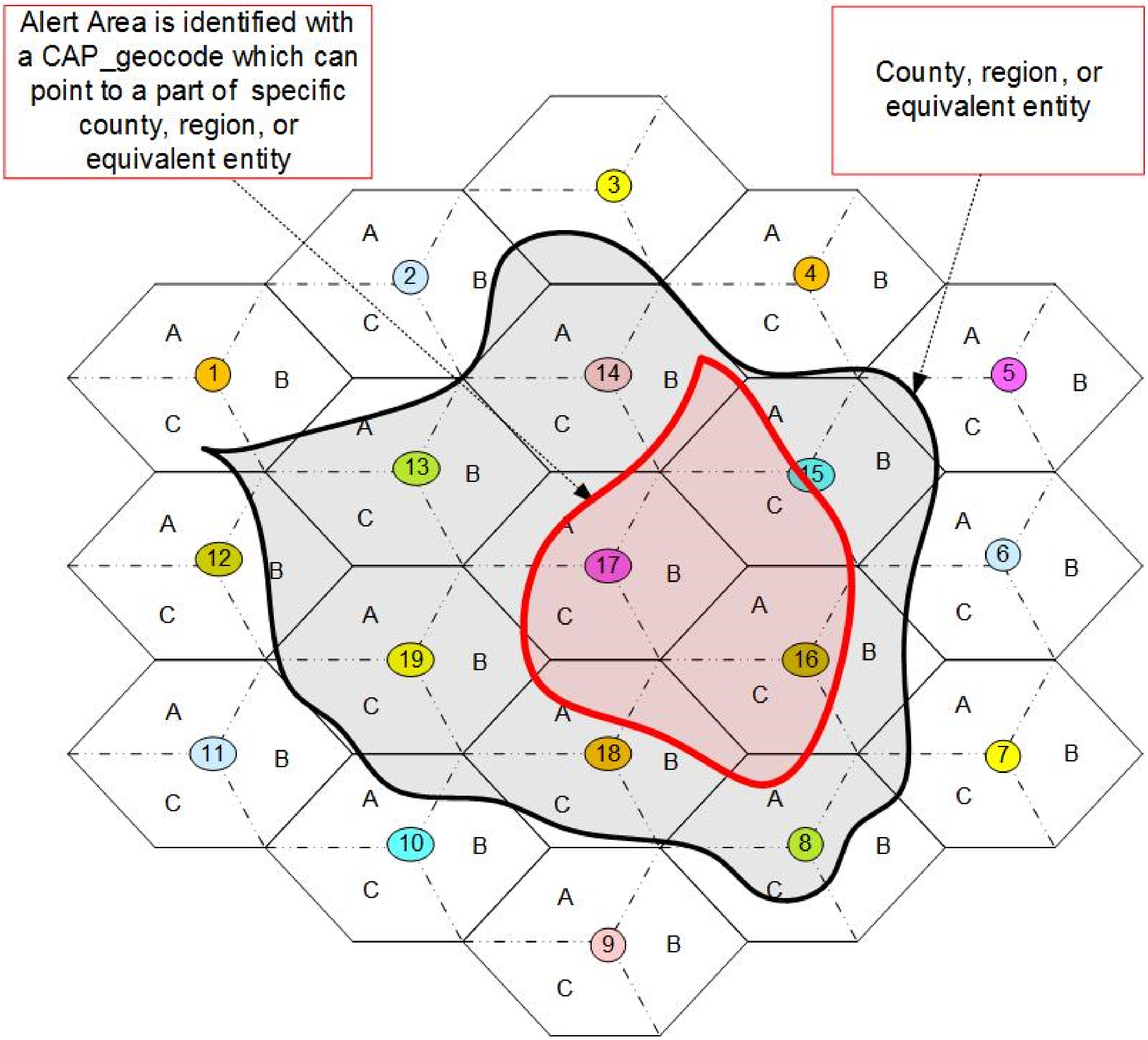



**Figure 4.2 – CAP_Geocode Can Point to Part of County, Region, or Equivalent Entity**

The region shown within the red-shaded area is the Alert Area represented by CAP_geocode. As shown in the figure, it can represent a place within the county.

## 4.1.3 Polygon

An Alert Area in the form of polygon is identified with a series of points with each point identified with a pair of latitude and longitude coordinates, and where the first and last pairs of coordinates are the same values. Additionally, J-STD-101 [Ref 2] states that up to 100 points may be used to specify a polygon as the Alert Area.

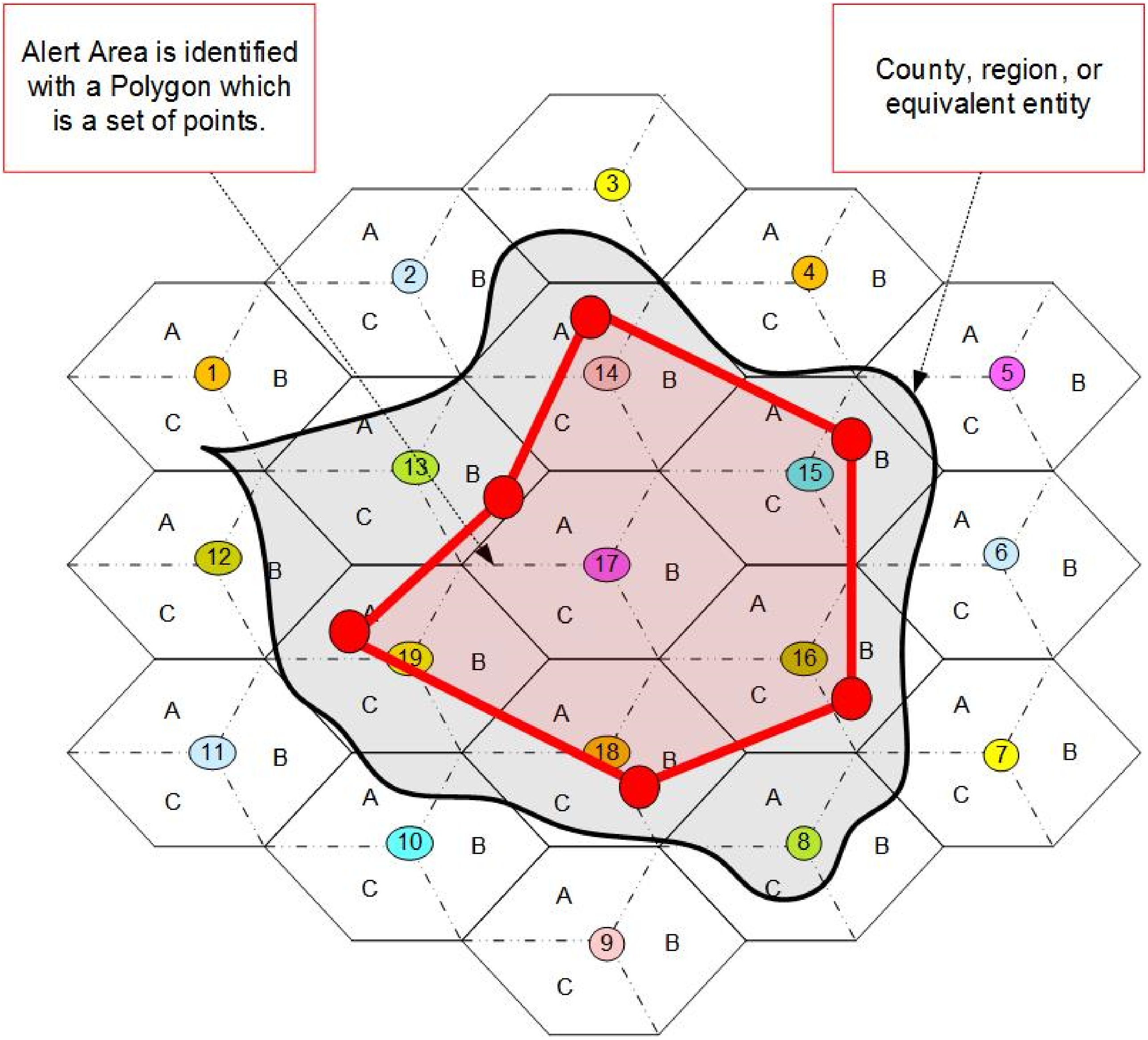



**Figure 4.3 – Polygon is Defined With a Set of Points, Each With a Pair of Coordinates**

The region shown within the red-shaded area is the Alert Area represented by polygon. The mapping of polygon to Broadcast Area is calculated for each polygon based Alert Area provided.

## 4.1.4 Circle

An Alert Area in the form of circle is identified with a point and the radius where the point identifies the center of the circle with a pair of coordinates.

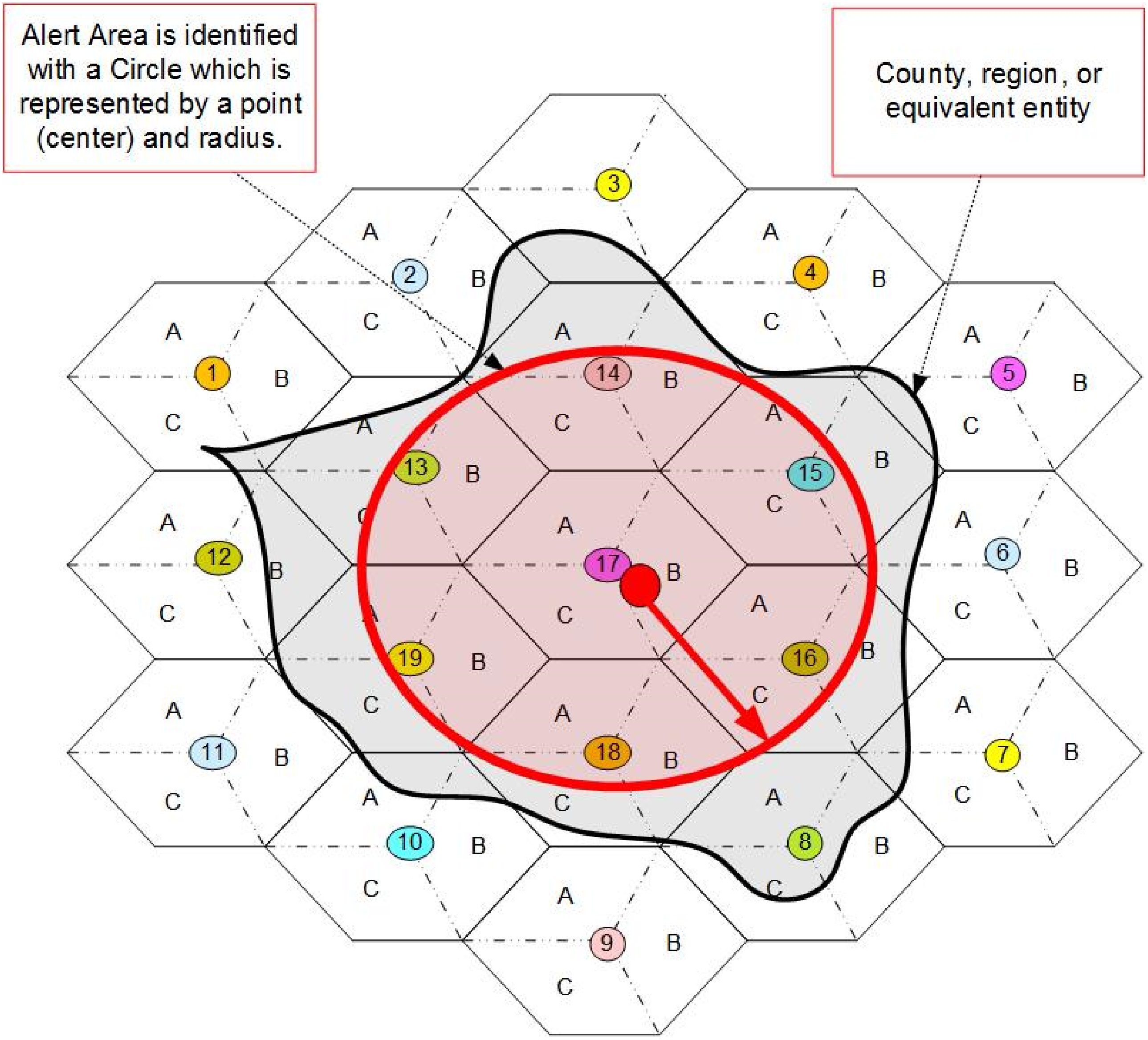



**Figure 4.4 – Circle is Defined With a Point (Center) & Radius**

The region shown within the red-shaded area is the Alert Area represented by circle. The mapping of circle to Broadcast Area is calculated for each circle based Alert Area provided.

## *4.2 Broadcast Area*

Within the CMSP infrastructure, a WEA is broadcast using CBS to a specific area where the specific area is a group of one or more Cells. In other words, the minimum area to which a CBS message can be broadcast is a Cell and maximum area to which a CBS message can be broadcast is a list of many Cells. For CBS, a Cell identifies a Sector.

The CBC determines Cells that belong to the Broadcast Area. The CBC sends the list of Cells to the broadcasting nodes.

A Cell that belongs to a Broadcast Area can be determined in at least three ways:

- Based on the location of the physical tower.
- Based on the geographic center (centroid) of the Sector.
- Based on the radio propagation characteristics of the Cell.

A tower is considered to be within the Alert Area, if the geographical coordinates of the tower lie within the Alert Area. A Sector is considered to be within the Alert Area, if the centroid of the Sector is within the Alert Area. A Cell is considered to be within the Alert Area if the estimated radio propagation coverage area overlaps the Alert Area. There may be other methods implemented to determine the Cells that belong to an Alert Area.

Two examples of Broadcast Area are shown the following figure:

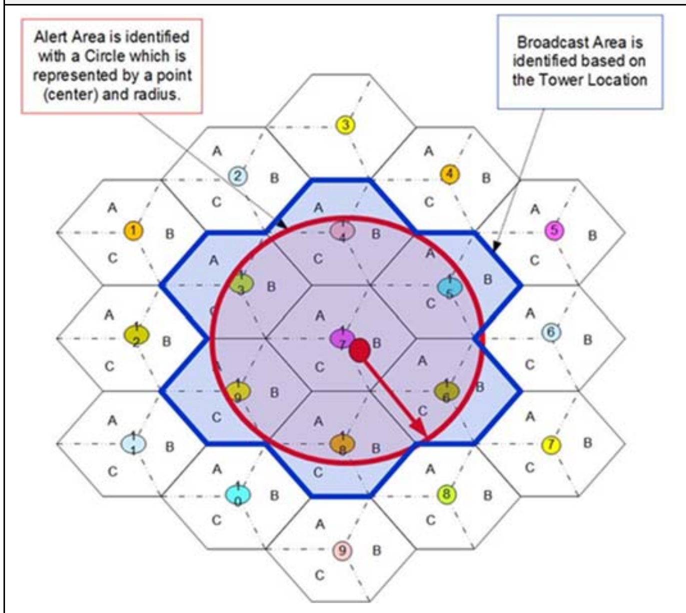
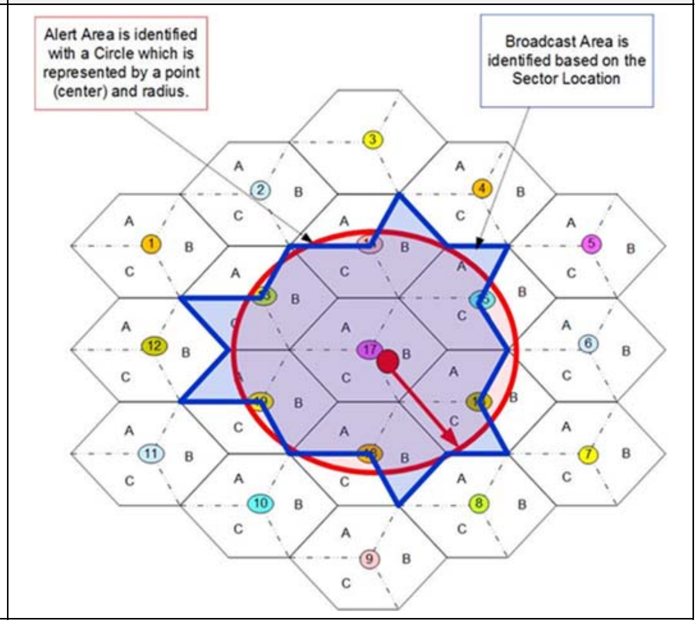
| Center of Tower Within Alert Area | Centroid of Sector Within Alert Area |
| --- | --- |
|  |  |





**Figure 4.5 – Broadcast Area Examples**

In both examples, the region shown within the red-shaded area is the Alert Area and is represented by circle. In the example shown on the left, the mapping of circle to Broadcast Area is calculated based on whether or not center of a tower is within the Alert Area. In the example shown on the right, the mapping of circle to Broadcast Area is calculated based on whether or not the centroid of the sector is within the Alert Area.

There may be other methods deployed by CMSP to calculate the Broadcast Area (e.g., based on the propagation characteristics of a cell).

## *4.3 Centroid*

A Centroid of a two-dimensional region is the arithmetic mean ("average") position of all the points in the Broadcast Area of a Sector and depends on the radio propagation characteristics in the Sector.

Even though radio propagation characteristics are dynamic in nature, due to, for example, weather conditions, the Centroid coordinates need to be stored in the CBC and therefore need to be a (semi-)static approximation.

Determination of Centroid coordinates may be based on a proprietary operator algorithm. Annex A provides an example of a methodology for the calculation of the centroid of a polygon.

# 5 Considerations for WEA Alert Polygons

This clause of this feasibility study investigates the following considerations for WEA alert polygons:

- Maximum Number of Points in Definition of Polygon
- Polygons with Crossing Lines
- Responsibility for Validation of Polygons

- Multiple Polygons and Circles

## 5.1 Maximum Number of Points in Definition of Polygon

In general, the definition of the boundary of polygon is a minimum of 3 points and has an unlimited maximum number of points. However, without a specified maximum of number of points, variations in implementations could occur among CMSPs and among wireless network infrastructure vendors. If such variations occurred, the Alert Originators would be required to know the maximum number of points in a polygon definition for each CMSP and may have to define different polygons for each CMSP.

To provide a uniform consistent environment to the Alert Originators, the maximum number of points in the definition of a polygon was defined during the standardization process to be 100 maximum points (e.g., latitude/longitude pairs). This maximum number of coordinates in the definition of a polygon is stated as the following requirement in the Joint ATIS/TIA CMAS Alert Gateway to CMSP Gateway Interface Specification J-STD-101 [Ref 2]:

> "[JCMAS-C-RQMT-2550] The number of paired values of points (i.e., latitude/longitude pairs) used to define the polygon in the CMAC_polygon element shall be limited to a maximum of 100."
>
> > NOTE: In order to have a closed polygon, the last point in the definition of the polygon must be equal to the first point in the definition of the polygon.

Some potential alert areas could have boundaries defined by one or more geographic features such as rivers, shorelines, ridgelines, etc. Polygons which are defined based on such geographic features could be defined by more than 100 points depending on the geography and the capabilities and granularity of the mapping software of the Alert Originator's systems. Before sending the polygon to the CMSPs as part of the WEA message, the Alert Originator system will need to apply polygon smoothing techniques to reduce the number of points in the definition of the polygon to less than or equal to 100 points with the last point the same as the first point.

## 5.2 Polygons with Crossing Lines

There have been instances where the polygon supplied in an alert generated by an Alert Originator contained crossing or overlapping lines. One such example of a polygon with crossing lines appeared in a polygon supplied in an NWS alert in Tampa, FL, as shown below[9]:

[9] The points on the polygon supplied in this alert were: {27.95,-82.53 27.93,-82.48 27.92,-82.47 27.92,-82.42 27.9,-82.43 27.92,-82.47 27.91,-82.48 27.87,-82.48 27.84,-82.46 27.81,-82.47 27.82,-82.52 27.85,-82.56 27.95,-82.53}.

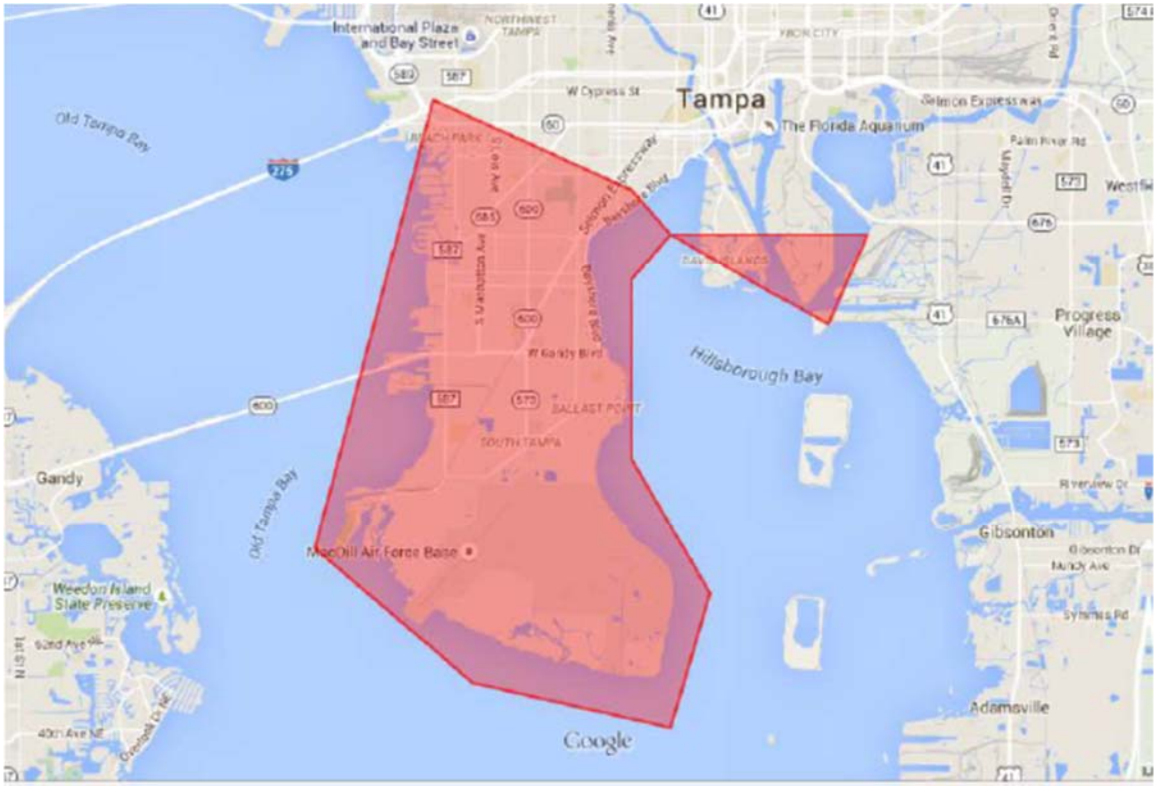



**Figure 5.1 – Example Alert Area with Crossing Lines**

While ideally the Alert Originators will not create a polygon with crossing lines, every once in a while they will inadvertently create a polygon with overlapping points. A polygon with overlapping points (resulting in crossing lines) is not supposed to happen; however, current GIS software does allow Alert Originators to create these polygons. The problem of overlapping points is currently most prevalent along coastal areas where the GIS system tries to approximate coastlines with the polygon. The NWS is working on an update to software that should eliminate the problem (or at least make it much rarer).

## *5.3 Responsibility for Validation of Polygons*

The CMSPs operate on the principle that the information that is provided in the WEA Alert Message is proper and correct.

The Alert Originators and the Alert Originator system have primary responsibility for the validation of the polygons including but not limited to the following:

- Validate that the polygon is a closed polygon with the last point equal to the first point.
- Validate that the number of points defined for the polygon is less than or equal to 100 as specified in clause 5.1.
- Validate that the polygon coordinates contain no more than 3 decimal points. (See clause 7.1.2.)

In addition to the Alert Originator software, FEMA IPAWS may have responsibility for:

- Validating that the Alert Originator is authorized to specify a polygon for the WEA alert area.
- Validating that the polygon coordinates contain no more than 3 decimal points.
- Validating that the specified WEA alert area polygon is within the authorized alerting area of the Alert Originator (e.g., an Alert Originator on the East Coast is not trying to specify an alert area on the West Coast).

The CMSP's infrastructure may choose to validate that the syntax of the polygon is correct. Examples of syntax validation that might be performed by the CMSP infrastructure are as follows:

- Verify that the polygon is a closed polygon with the last point equal to the first point.
- Verify that the number of points defined for the polygon is less than or equal to 100 as specified in clause 5.1.
- Verify that the polygon does not contain crossed or overlapping lines.
- Validate that the polygon coordinates contain no more than 3 decimal points.

## *5.4 Multiple Polygons & Circles*

In this clause, this feasibility study discusses the topic of multiple polygons and circles. In the Common Alerting Protocol, multiple <area> blocks are allowed. Multiple occurrences of <area> are permitted, in which case the target area for the CAP <info> block is the union of all the included <area> blocks. The <area> block MAY contain one or multiple instances of <polygon>, <circle>, or <geocode>. If multiple <polygon>, <circle>, or <geocode> elements are included, the area described by this <area> block is represented by the union of all the included elements.

From J-STD-101 [Ref 2], the Reference Point "C" interface document object model and protocol also allows for one or more <CMAC_Alert_Area> segments. Each alert area specified in the <CMAC_Alert_Area> segment corresponds to one <CMAC_Alert_Info> segment; this means that each alert area specified will broadcast the same alert message. <CMAC_Alert_Area> allows for any combination of alert areas – geocode, polygon, circle – and the target area is the union defined by all <CMAC_Alert_Area> segments (for further details, see J-STD-101 Table 14 [Ref 2]).

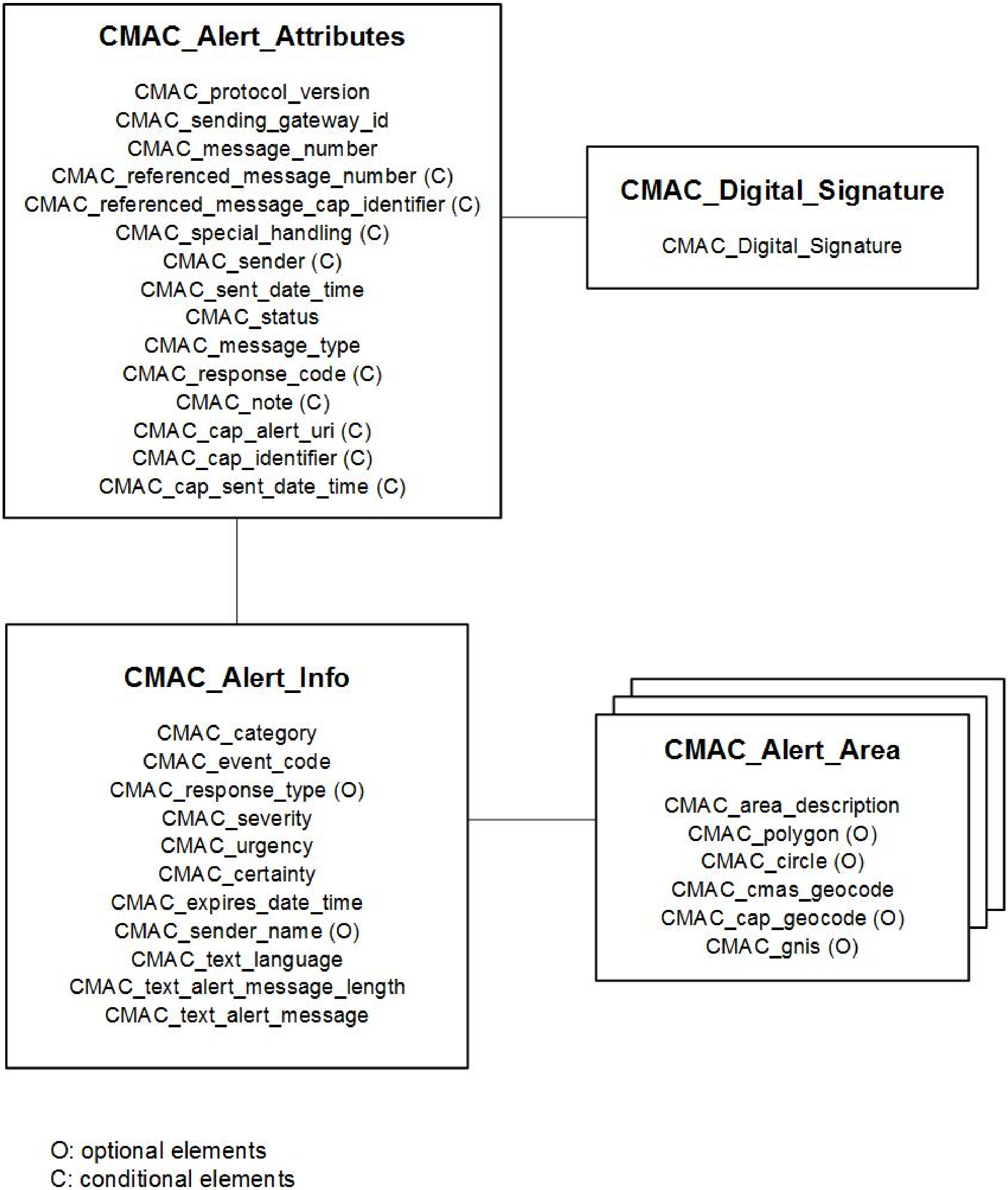



**Figure 5.2 – Reference Point "C" Document Object Model**

The following notes are applicable to this discussion:

1. For simplicity, the majority of the discussions and diagrams are limited to only 2 polygons. The topics discussed in this clause are also applicable to 3 or more polygons.
2. This discussion is also applicable to multiple circles or to the combination of polygons and circles.
3. In the diagrams, polygons could be replaced with circles and circles could be replaced with polygons.

Multiple circles and polygons can occur in the following configurations which are discussed in this clause:

1. Non-Overlapping Polygons & Circles
2. Union of Overlapping Polygons & Circles
3. Nested Polygons & Circles

This clause also discusses the implications for standards, development, and implementation.

### 5.4.1 Non-Overlapping Polygons & Circles

If multiple WEA alert areas are specified, these alert areas could be separate and distinct with no overlap as shown in the following diagram.

Only two polygons are shown but there could be a combination of three or more non-overlapping polygons and/or circles.

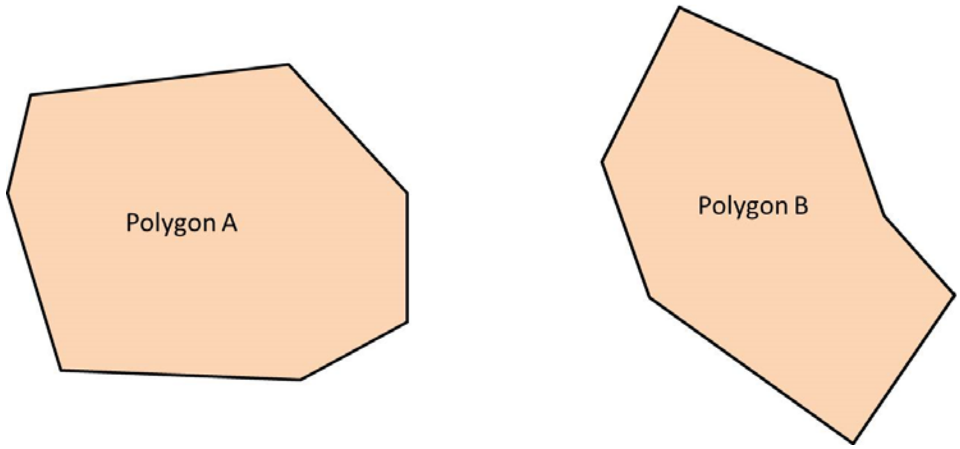



**Figure 5.3 – Non-Overlapping Polygons**

In the WEA Alert Message, the boundaries of each polygon and circle would need to be provided but no association between the polygons or circles are specified. Cell sites in each polygon will broadcast the same WEA Alert Message.

### 5.4.2 Union of Overlapping Polygons & Circles

If multiple WEA alert areas are specified, these alert areas could overlap as shown in the following diagram. The WEA Alert area would be the union of the polygons which would include any point that is located in either polygon.

Only two polygons are shown but there could be a combination of three or more overlapping polygons and/or circles.

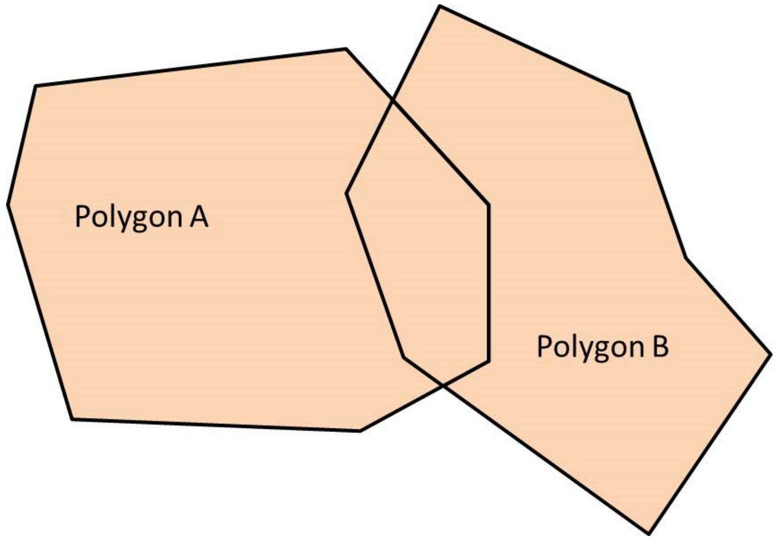



**Figure 5.4 – Union of Overlapping Polygons**

The boundaries of each polygon and/or circle would need to be provided in the WEA Alert Message. The WEA Alert Message desired alert area is the union of these polygons.

### 5.4.3 Nested Polygons & Circles

If multiple WEA alert areas are specified, these alert areas could be nested as shown in the following diagram. The desired WEA Alert area would be the points in Polygon A, since Polygon B is entirely contained within Polygon A.

Only two polygons are shown but there could be a combination of three or more nested polygons and/or circles.

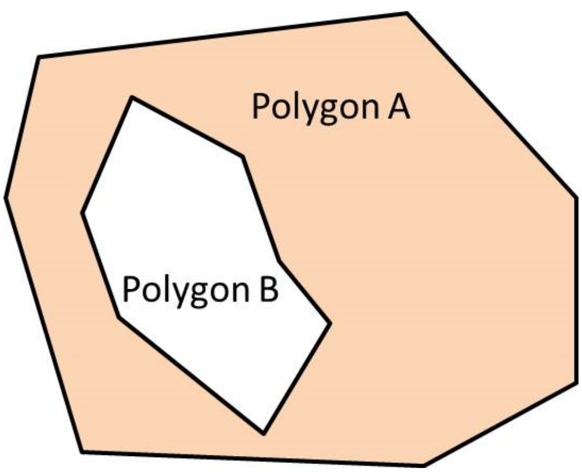



**Figure 5.5 – Nested Polygons**

This nesting of polygons within the same WEA message is undesirable since the Polygon B definition is redundant; both Polygon A and Polygon B will receive the same WEA Alert Message. If such a nesting were to be provided, the boundaries of each polygon and/or circle would need to be provided in the WEA Alert Message. Since Polygon B is fully contained in Polygon A, Polygon A may be used to broadcast the alert message.

### 5.4.4 Nested Polygons with Different WEA Alert Messages in Each Polygon

As described in 6.4.3, there is a possible scenario where alert areas could be nested as shown in the following diagram, and the Alert Originator desires different WEA Alert Messages to be sent to Polygon A and Polygon B:

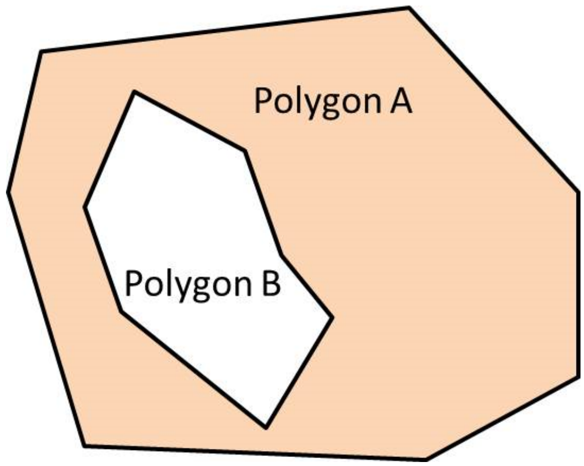



**Figure 5.6 – Nested Polygons with Different Alert Messages**

This scenario is currently not supported in the CAP or CMAC protocols, or within the CMSP infrastructure. The potential scenario for nested polygons would be the situation where one WEA Alert Message is to be broadcast within Polygon B, but a different WEA Alert Message is to be broadcast within Polygon A but outside Polygon B. In this case, two separate WEA Alert Messages must be used, one within the area defining Polygon B and the second defining the area for "Polygon A minus the area of Polygon B". However, the existing CAP and CMAC protocols do not support specifying an alert area as "Polygon A minus Polygon B", so standards work in OASIS and ATIS will be required to support this scenario.

Also, due to the nature of RF propagation, overshoot can be expected from both Polygon B and Polygon A at the border between the two polygons. Alert Originators must account for this overshoot in this scenario as it may result in confusion at the border between polygons. That is, the WEA Alert Message targeted for Polygon B might be received by mobile devices that are in Polygon A, and likewise the WEA Alert Message targeted for Polygon A might be received by mobile devices that are in Polygon B.

### 5.4.5 Implications for Standards Enhancements

The support of multiple polygons or circles is currently supported in the existing alerting standards (CAP and J-STD-101). The existing standards support the cases where the alert area is the union of the supplied alert segments in the associated protocol.

The case that is not supported in the existing protocols is nested polygons where the embedded polygon (Polygon B) is to broadcast one WEA Alert Message, and the area outside the embedded polygon contained in Polygon A is to broadcast a different WEA Alert Message. Common Alerting Protocol (CAP) which is the international standard defined by OASIS and used by the Alert Originator systems and by the FEMA IPAWS, would need to be enhanced to the support the ability to specify an alert area (polygon, circle, etc.) and subtract from that polygon a second embedded smaller alert area (polygon, circle, etc.). These enhancements would also need to be defined in the J-STD-101 CMAC protocol over the Reference Point "C" interface.

The CMSP infrastructure would also need to be enhanced to support this "nesting" geo-targeting, including identification of cell sites. Due to the nature of RF propagation, it can be expected that citizens on the boundaries of the "nested" polygons may receive the message from the "other" polygon.

Completion of the standards changes in OASIS and ATIS can be expected to take several years. Deployment in Alert Originator software, FEMA IPAWS, and CMSP Infrastructure would be required, likely taking an additional several years following standards completion.

### 5.4.6 Implications for Development & Implementation

As described in previous clauses, the current CAP and CMAC protocols support multiple alert areas in a single WEA message. When multiple alert areas are specified, the CMSP infrastructure will treat the multiple alert areas as a single area comprised of the union of the multiple alert areas. The same WEA Alert Message is broadcast in this union of the multiple alert areas.

The CMSP infrastructure will verify that the polygon is a valid polygon – that is, contains no more than 100 points and each polygon does not contain crossing lines or is overlapping with itself. If the CMSP infrastructure determines the polygon is invalid, it will reject the WEA Alert Message request and return an error code per J-STD-101 [Ref 2].

#### 5.4.6.1 Impacts for Nested Polygons with Different Alert Messages

If the nested polygon with different alert messages for each polygon scenario is to be implemented, once standards are complete, the Alert Originator systems would need to be updated to support the generation of the CAP messages with the ability to specify a subset of an alert area where not to broadcast the WEA Alert Message per the enhanced CAP protocol. The FEMA IPAWS system would need to be updated to receive from the Alert Originators this enhanced CAP message with the nested polygons and alerts and to send the enhanced WEA Alert Message with the nested polygons and alerts to the CMSPs. The CMSP infrastructure would need to be updated to receive from FEMA IPAWS the enhanced CAP message with the nested polygons and alerts, to calculate the associated alert area of associated cell sites and to broadcast the WEA Alert Message to the mobile devices. This development effort would require development, testing, and implementation efforts in almost every network entity involved with WEA Alert Messages. The effort and duration of these enhancements could be at least as much as the effort and duration for the development of the initial WEA alert system and which took several years after standardization efforts had been completed.

# 6 Considerations for Overshooting or Undershooting WEA Alert Broadcast Areas

This clause describes the overshooting and undershooting scenarios and provides some illustrations to describe why such overshooting and undershooting could occur.

An overshooting occurs if the Broadcast Area is larger than the Alert Area and an undershooting occurs if the Broadcast Area is smaller than the Alert Area. In some situations, for a particular alert broadcast, both overshooting and undershooting may occur.

The following illustrates the two examples where overshooting and undershooting are occurring:

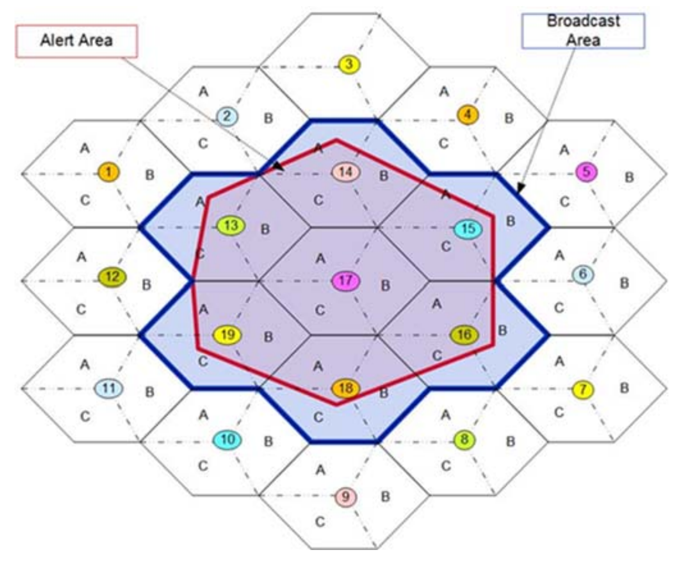
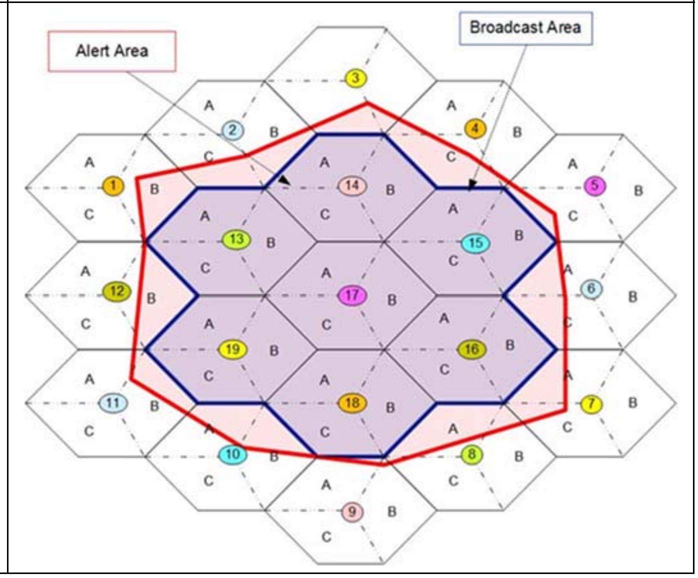
| Overshooting | Undershooting |
| --- | --- |
|  |  |

**Figure 6.1 – Examples of Overshooting & Undershooting**

In the example shown on the left side of the above figure, the WEA Broadcast Area is larger than the Alert Area and hence, there is a overshooting. In the example shown on the right side of the above figure, Broadcast Area is smaller than the Alert Area and hence, an undershooting occurs. In both examples, the Broadcast Area is determined based on the location of the tower (i.e., Evolved NodeB [eNB]).

Alert Area is the area identified by the Alert Originator, and in some situations an Alert Area itself may be larger than the actual area to which the alert applies. For example, an entire county may be specified as an Alert Area while the affected area may not be applicable to the entire county. Therefore, the overshooting and undershooting is not really based on relationship between an Alert Area and Broadcast Area. One may have to consider the actual area to which the alert applies. Also, in some situations, a part of the affected area may have no cellular coverage by the CMSP and its roaming partners and, hence, an undershooting is bound to happen. The following sub-clauses illustrate a few examples to further understand the reasons behind overshooting and undershooting.

NOTE 1: In order to facilitate the development of the figures in this clause, the coverage area of cell sites are shown as hexagons and the coverage area of each cell-sector is shown as one third of the hexagon. However, in the real-world environments, cell sites are not hexagonal in shape, cell-sectors may not be a third of the cell site, and there are not definitive boundaries for the edges of cell sites and cell-sectors. In the real-world environment, the shapes of the cell sites and cell-sectors will vary because these shapes are based upon radio configurations (e.g., power levels, antenna inclinations), radio wave propagation characteristics, and the geographic topology of the coverage area.

Note 2: The letters “A”, “B”, and “C” within each hexagon serve as the label for that cell-sector and also designate the location of the centroid of the cell-sector.

## *6.1 Warning Area & Desired Area*

To illustrate the problem of overshooting and undershooting, two new terms, Warning Area and Desired Area, are introduced along with the terms introduced in clause 4, Alert Area and Broadcast Area. Warning Area is the actual area to which WEA is in effect. Desired area is the list of cell-sectors affected due to the WEA. In comparison, an Alert Area is the area specified by the Alert Originator as WEA affected area and the Broadcast Area is the area to which the alert is broadcast by the CMSP.

Also for the purpose of illustration, a hypothetical region consisting of two counties (named County A and County B) are considered (see the following figure), and in the subsequent examples illustrated in this clause, a WEA affects users of these two counties. For the purpose of illustration, a cell-sector is considered to be within the county if a part of that cell-sector belongs to the county. Also, as shown in the following, some cell-sectors may be part of more than one county.

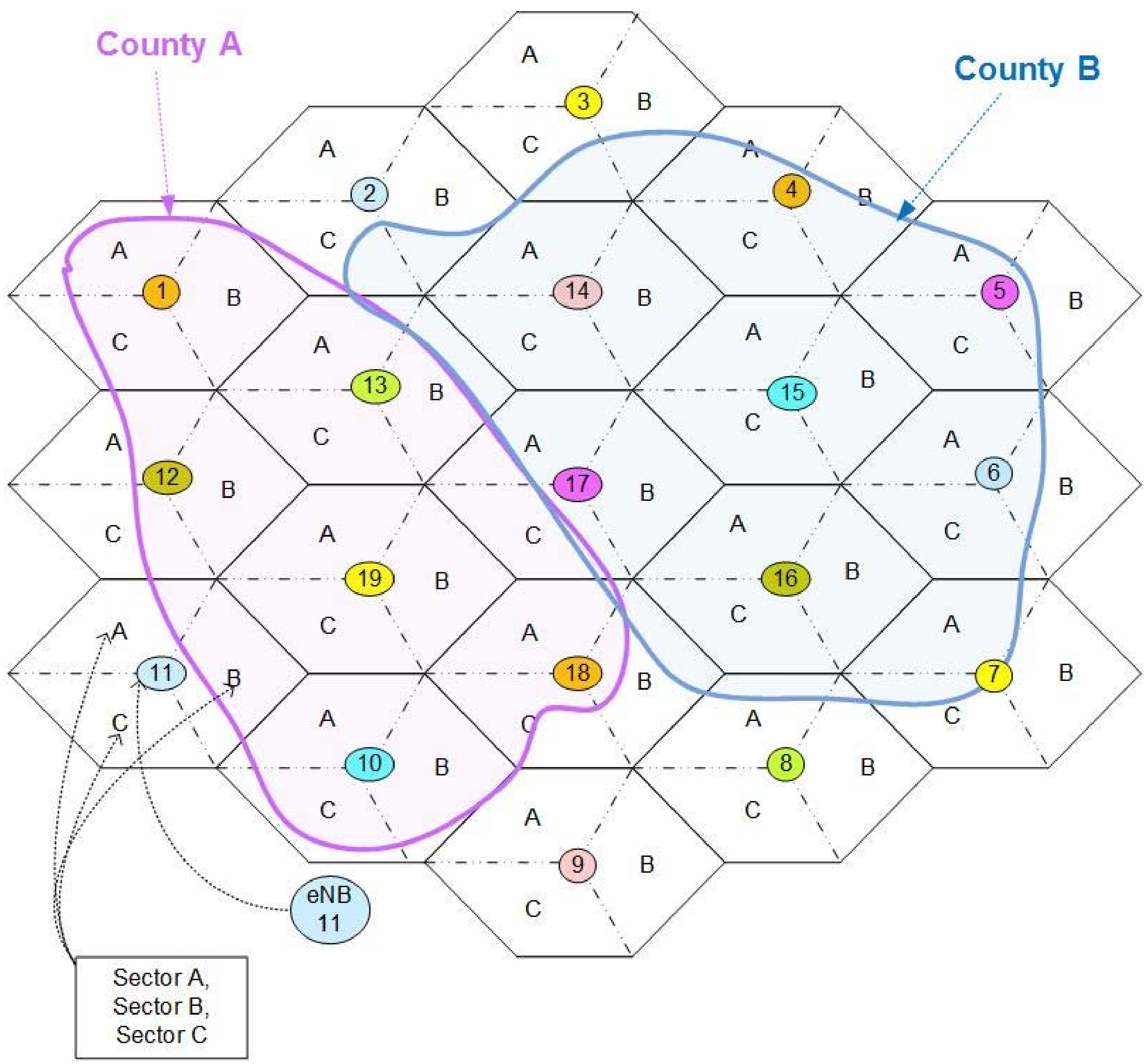



**Figure 6.2 – Hypothetical Region Consisting of Two Counties – County A & County B**

The above figure shows 19 eNBs, each with 3 sectors identified as A, B, and C. In this illustration, as can be seen in the above figure, the following cell-sectors are outside the two county boundaries:

- eNB 2, cell-sector A.
- eNB 3, cell-sector A.
- eNB 8, cell-sector C.
- eNB 9, all three sectors.
- eNB 11, cell-sector C.

The methods used to determine the Alert Area and Broadcast Area in the current geo-targeting method are described in clause 4. This illustration takes only a part of those variables.

### 6.1.1 Warning Area

The figure below shows an example where a WEA is affecting the users of two counties shown in Figure 6.1. The red-shaded area within the solid red lines is the Warning Area.

Even though the Warning Area appears to be a polygon, the Alert Originators may choose the entire county or a part of the county as an Alert Area. Or, alternatively, the Alert Originators may provide the coordinates of the polygon to identify the Alert Area. Other possible methods are not included in this illustration.

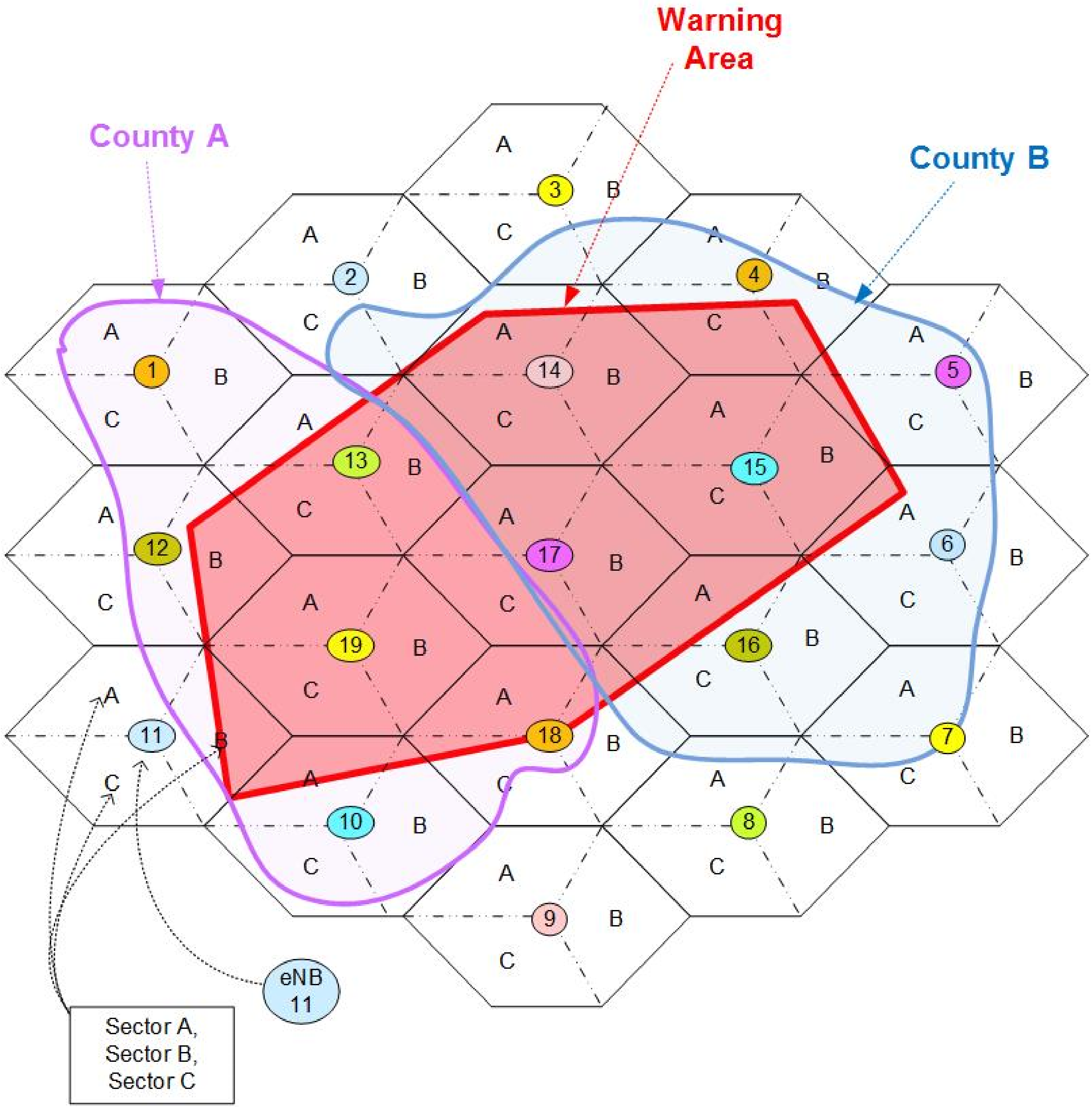



**Figure 6.3 – Warning Area Affecting Users of Two Counties**

### 6.1.2 Desired Area

Since a WEA cannot be broadcast to part of a cell-sector, all users within a cell-sector receive the WEA if at least a part of that cell-sector lies within the Warning Area boundary. The following figure shows the Desired Area as compared to the Warning Area shown in Figure 6.3 above.

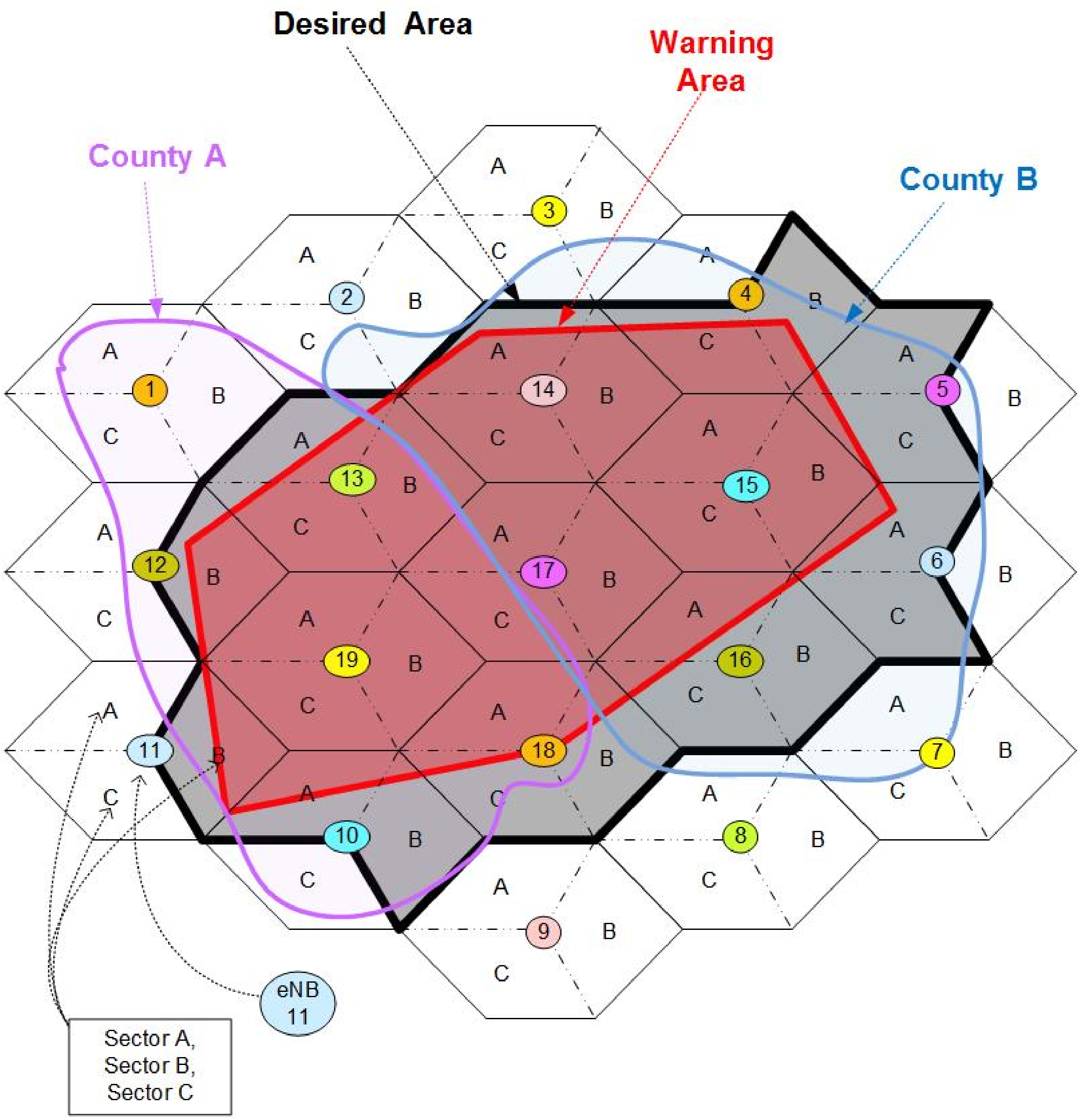



**Figure 6.4 – Desired Area for WEA Broadcast**

The cell-sectors in the Desired Area are the same as the cell-sectors in the Warning Area, except that the entire cell-sector is included in the Desired Area.

This illustration uses the entire cell-sector for the broadcast if a part of the cell-sector is within the Warning Area. That is why the Desired Area appears to be larger than the Warning Area. Also, the concept of Desired Area is for illustration purposes only and as such it does not come into the picture of WEA broadcast.

## *6.2 Alert Area & Broadcast Area*

The examples shown here consider the following cases:

- Alert Area is identified based on county boundary.
- Alert Area is identified based on a polygon.

- Alert Area is covered by only one cell site.
- Broadcast Area based on the physical location of eNB.
- Broadcast Area based on the geographical centroid of the cell-sector.

As explained earlier, the Alert Area may be identified through other means as described in clause 4 and the Broadcast Area may also be performed through other means described in clause 4. But, the purpose of this illustration is to give a general idea and therefore, the illustration is limited to the above bulleted cases.

## 6.2.1 Alert Area at County Level

In this case, the entire county is identified as the Alert Area. So, the CMSP would distribute the alert to the entire county. The Broadcast Area can be determined based on the physical location of the eNB or the geographical centroid of the cell-sector. Both cases are illustrated below.

### 6.2.1.1 Broadcast Area

#### 6.2.1.1.1 Based on eNB Physical Location

An eNB is considered to be within the Broadcast Area if the physical location of that eNB is within the county (i.e., Alert Area). The following figure illustrates the Broadcast Area for the Warning Area shown in Figure 6.3.

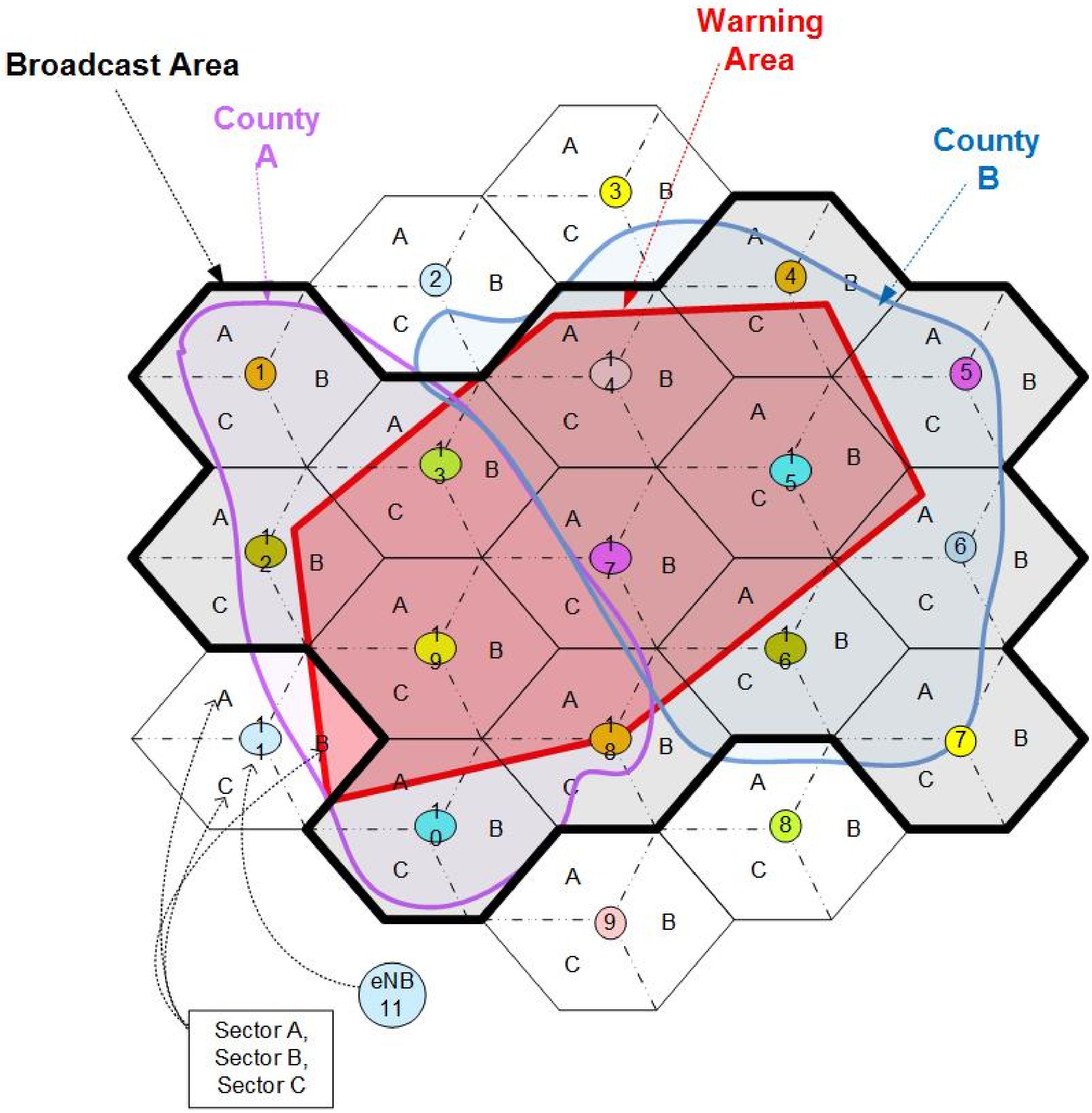



**Figure 6.5 – Broadcast Area Determined Based eNB Location**

Certain users within the county (e.g., eNB-11, cell-sector B) may not receive the WEA because the physical location of the eNB-11 is outside of the county boundary. That is a case of undershooting. But, the above figure shows more of an overshooting case as it is evident that many sectors are outside of the Warning Area.

#### 6.2.1.1.2 Based on Geographical Centroid of the cell-sector

A cell-sector is considered to be within the Broadcast Area if the geographic centroid of the cell-sector is within the county. The following figure illustrates the Broadcast Area for the Warning Area shown in Figure 6.3.

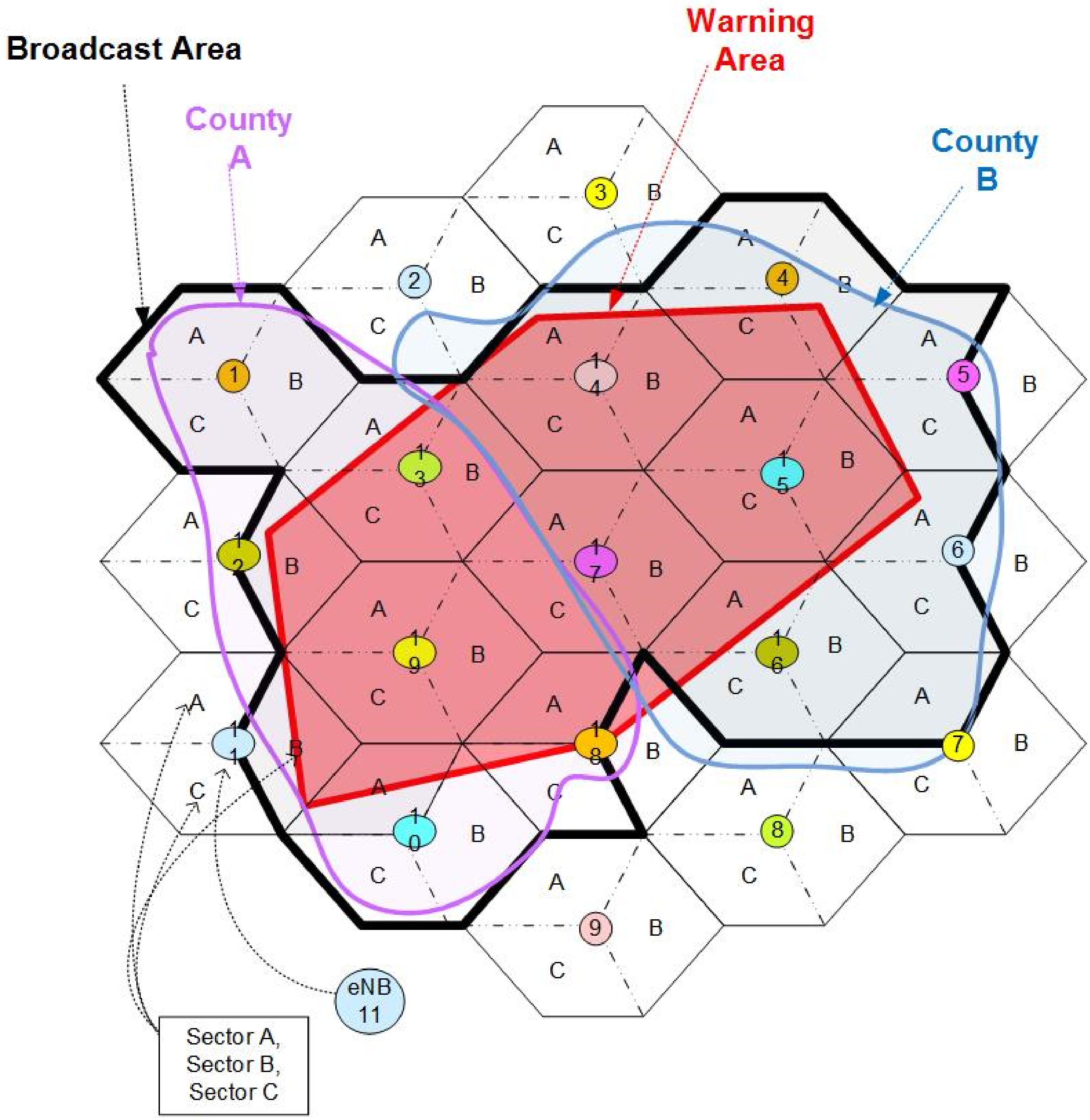



**Figure 6.6 – Broadcast Area Determined Based Cell-Sector Centroid Location**

Certain users within the county may not receive the WEA because the geographical centroid of the cell-sector they are in is outside of the county boundary.

### 6.2.1.2 Comparison

The following figure gives an overview of the Desired Area to the Broadcast Area associated with the two approaches.

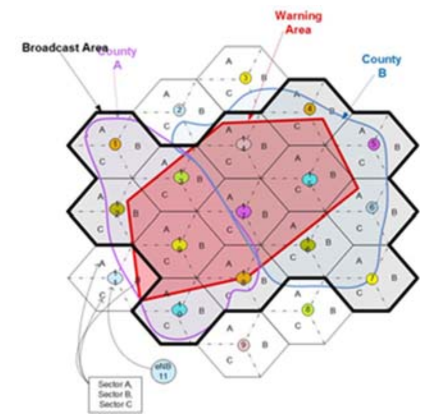
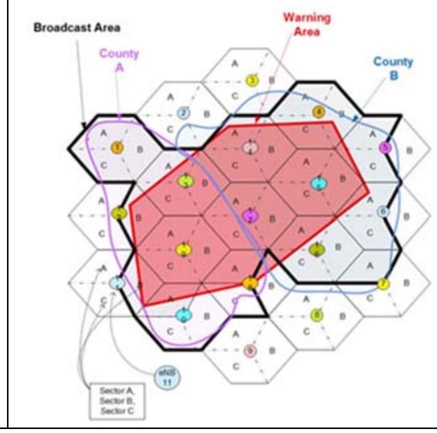
| Desired Area | Broadcast Area | |
|---|---|---|
| | • With eNB Location | • With Cell-Sector Centroid |
|  |  |  |

**Figure 6.7 – A Comparison**

The table below compares the cell-sectors of the Broadcast Area with the Desired Area.

**Table 6.1 – Cell-Sectors in Warning Area, Desired Area & Broadcast Area**

| eNB | Cell-Sectors | | | |
|---|---|---|---|---|
| | • Warning Area | • Desired Area | Broadcast Area | |
| | | | • eNB | • Cell-sector |
| 1 | | | A, B, C | A, B, C |
| 4 | B*, C* | B, C | A, B, C | A, B, C |
| 5 | A*, C* | A, C | A, B, C | A, C |
| 6 | A*, C* | A, C | A, B, C | A, C |
| 7 | | | A, B, C | A |
| 10 | A*, B* | A, B | A, B, C | A, B, C |
| 11 | B* | B | | B |
| 12 | B* | B | A, B, C | B |
| 13 | A*, B, C* | A, B, C | A, B, C | A, B, C |
| 14 | A*, B*, C | A, B, C | A, B, C | A, B, C |
| 15 | A, B, C | A, B, C | A, B, C | A, B, C |
| 16 | A*, B*, C* | A, B, C | A, B, C | A, B, C |
| 17 | A, B, C | A, B, C | A, B, C | A, B, C |
| 18 | A, B*, C* | A, B, C | A, B, C | A, C |
| 19 | A, B, C | A, B, C | A, B, C | A, B, C |

NOTE: A "*" next to the cell-sector (e.g., A*) indicates that only a part of the cell-sector lies within the Warning Area. The cell-sectors in the Desired Area are same as the cell-sectors in the Warning Area except that the entire cell-sector is included in the Desired Area. Broadcast Area is determined if the physical location of the eNB or the centroid of the cell-sector is in the county A or County B because Alert Area specified by the Alert Originator is at a county level.

### 6.2.2 Alert Area Polygon

In this case, the Alert Area is identified with a polygon. For purpose of this illustration, in this case, the Alert Area and Warning Area are one and the same because the Warning Area shown in Figure 6.3 is also a polygon. The CMSP would distribute the alert to the cells that are in the polygon. The Broadcast Area can be based on the physical location of the eNB or the geographical centroid of the sector. Both cases are illustrated below.

#### 6.2.2.1 Broadcast Area

##### 6.2.2.1.1 Based on eNB Physical Location

An eNB is considered to be within the Broadcast Area if the physical location of that eNB is within the polygon (i.e., Alert Area). The following figure illustrates the Broadcast Area for the Warning Area shown in Figure 6.3.

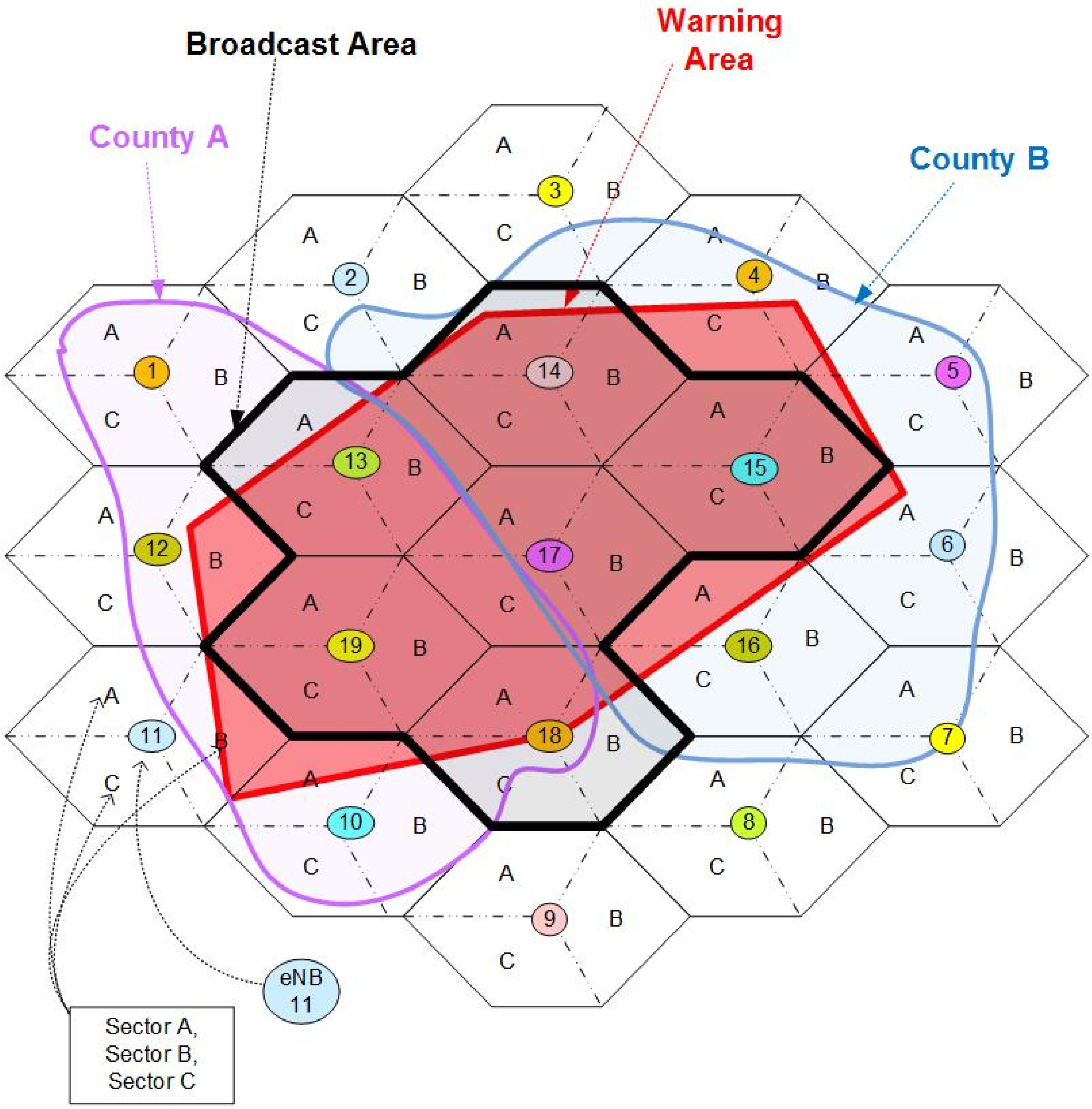



**Figure 6.8 – Broadcast Area Determined Based eNB Location**

#### 6.2.2.1.2 Based on Geographical Centroid of the Cell-Sector

A cell-sector is considered to be within the Broadcast Area if the geographic centroid of the cell-sector is within the polygon. The following figure illustrates the Broadcast Area for the Warning Area shown in Figure 6.3.

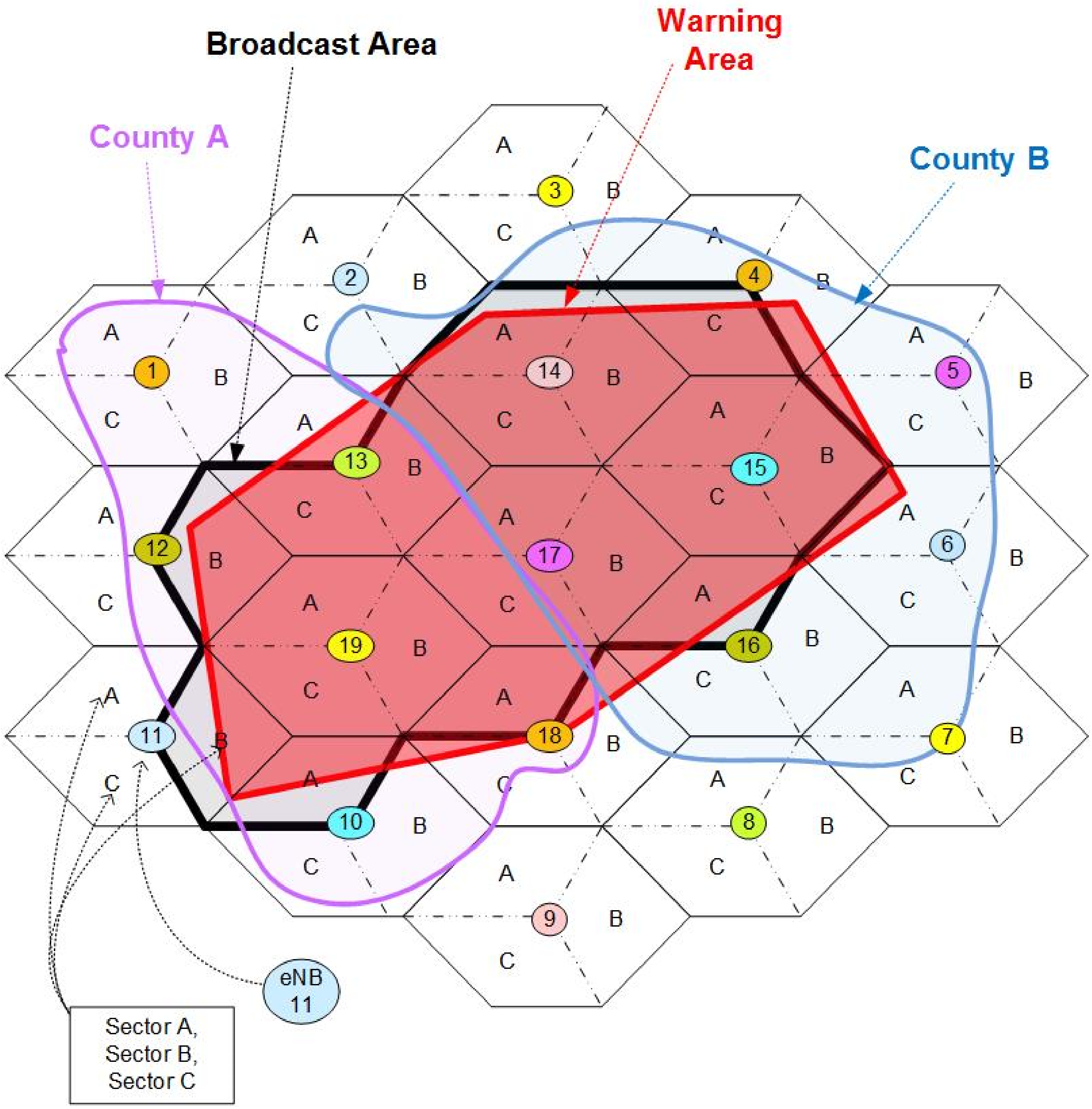
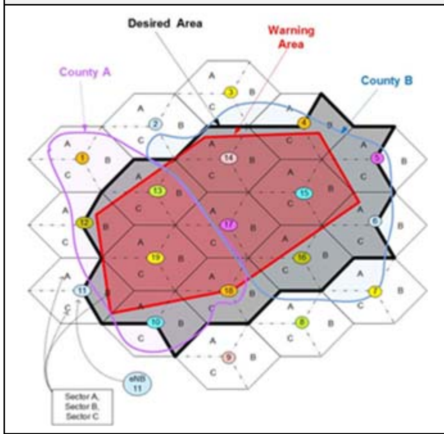


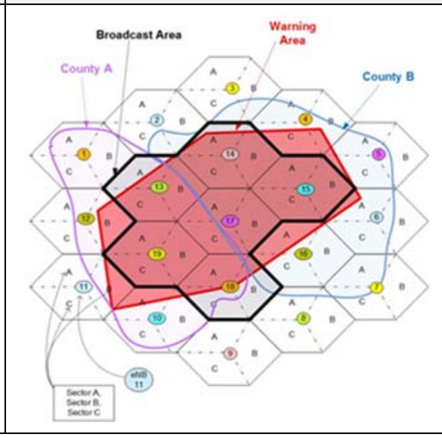

**Figure 6.9 – Broadcast Area Determined Based Cell-Sector Centroid Location**

## 6.2.2.2 Comparison

The following figure gives an overview of the Desired Area to the Broadcast Area associated with the two approaches.

| Desired Area | Broadcast Area | |
|---|---|---|
| | • With eNB Location | • With Cell-Sector Centroid |



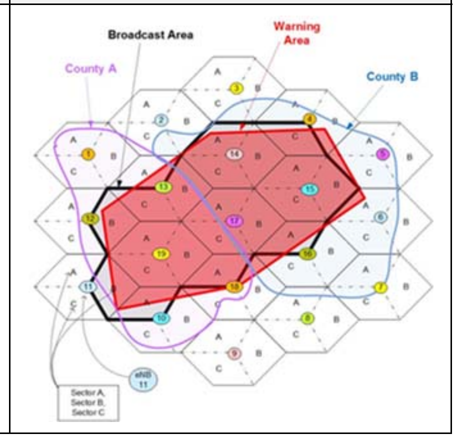




**Figure 6.10 – A Comparison**

The table below compares the cell-sectors of the Broadcast Area with the Desired Area.

**Table 6.2 – Cell-Sectors in Warning Area, Desired Area & Broadcast Area**

| eNB | Cell-Sectors | | | |
|---|---|---|---|---|
| | • Warning Area | • Desired Area | Broadcast Area | |
| | | | • eNB | • Cell-sector |
| 1 | | | | |
| 4 | B*, C* | B, C | | C |
| 5 | A*, C* | A, C | | |
| 6 | A*, C* | A, C | | |
| 7 | | | | |
| 10 | A*, B* | A, B | | A |
| 11 | B* | B | | B |
| 12 | B* | B | | B |
| 13 | A*, B, C* | A, B, C | A, B, C | B, C |
| 14 | A*, B*, C | A, B, C | A, B, C | A, B, C |
| 15 | A, B, C | A, B, C | A, B, C | A, B, C |
| 16 | A*, B*, C* | A, B, C | | A |
| 17 | A, B, C | A, B, C | A, B, C | A, B, C |
| 18 | A, B*, C* | A, B, C | A, B, C | A |
| 19 | A, B, C | A, B, C | A, B, C | A, B, C |

NOTE: A "*" next to the cell-sector (e.g., A*) indicates that only a part of the cell-sector lies within the Warning Area. The cell-sectors in the Desired Area are same as the cell-sectors in the Warning Area except that the entire cell-sector is included in the Desired Area. Broadcast Area is determined if the physical location of the eNB or the centroid of the cell-sector is in the polygon because Alert Area specified by the Alert Originator as a polygon.

### 6.2.3 Alert Area Covered by Only One Cell Site

In this case, a WEA affects a region which happens to be covered by only one cell site (e.g., boomer cells). The Alert Area may be within the cell site coverage area or part of the Alert Area may be outside the cell site coverage area. For the purpose of illustration, a circle is chosen to represent the Alert Area which also happens to be the Warning Area. Three different cases are illustrated for this scenario:

- Cell site is outside of the Alert Area.
- Cell site is inside the Alert Area.
- Part of the Alert area is outside of the cells-site coverage area.

For the purpose of illustration, a hypothetical region is chosen as shown below which is covered by only one cell site (i.e., eNB).

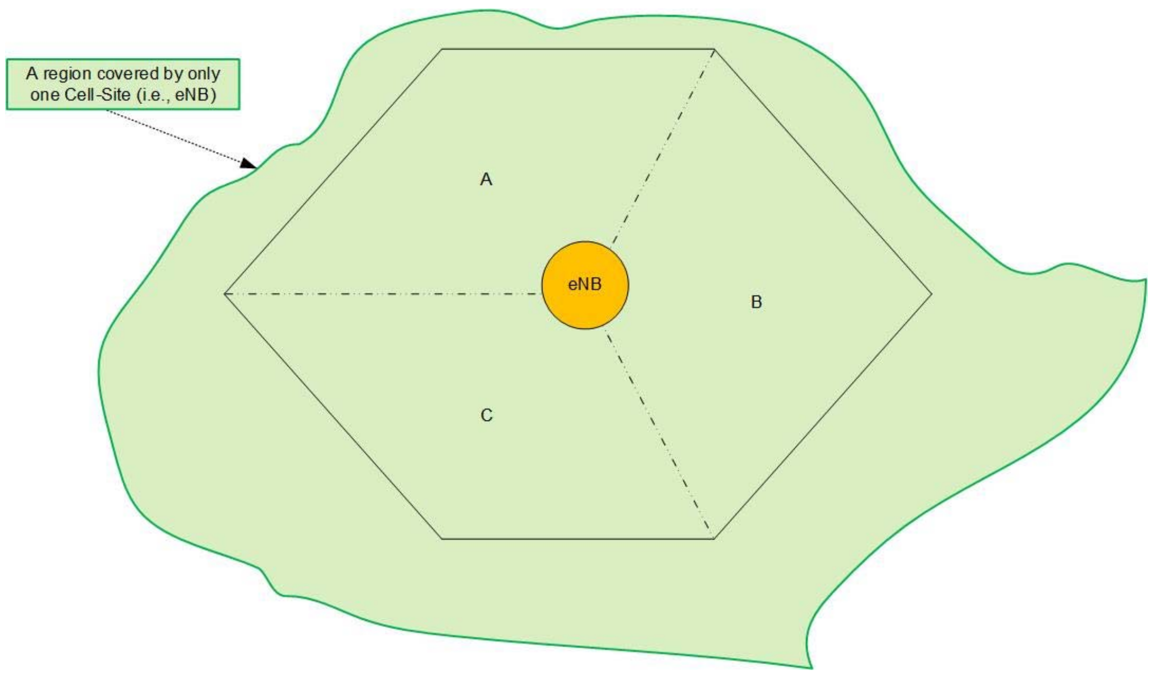



**Figure 6.11 – Region Covered by Only One Cell site**

As shown in Figure 6.11, the cell site has three cell-sectors identified as A, B, and C. In the illustration below, cell site is represented by an eNB.

#### 6.2.3.1 Cell Site Outside the Alert Area

Figure 6.12 illustrates three examples where the Alert Area happens to be within an eNB coverage area, but the eNB itself is outside of the Alert Area.

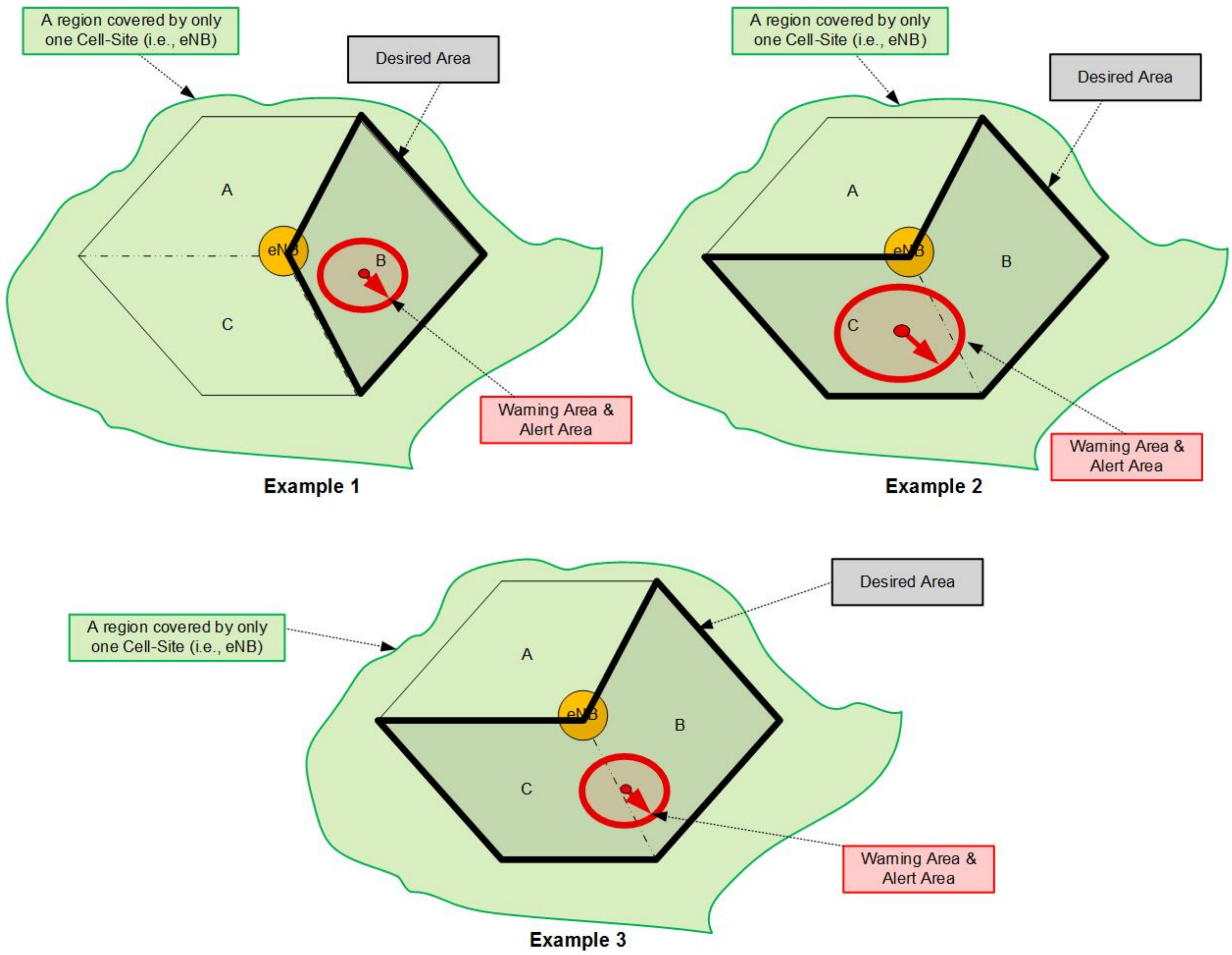



**Figure 6.12 – Cell Site Outside the Alert Area**

In example 1, the Alert Area happens to be in cell-sector B. In example 2, the Alert Area happens to be in cell-sectors B and C. In example 3, the Alert Area happens to be in cell-sectors B and C. The difference between examples 2 and 3 is the fact that in example 3, neither of the two cell-sector centroids are within the Alert Area, whereas in example 2, the centroid of cell-sector C happens to be in the Alert Area.

As described before, Desired Area consists of the cell-sectors if at least a part of that cell-sector happens to be in the Warning Area (in this example, the circle).

#### 6.2.3.1.1 Broadcast Area – Based on eNB Location

With this approach, the Broadcast Area is determined based on the location of the eNB. Since in the illustration, the eNB is outside of the Alert Area, WEA is not broadcast to any of the cell-sectors. And therefore, the case of undershooting occurs.

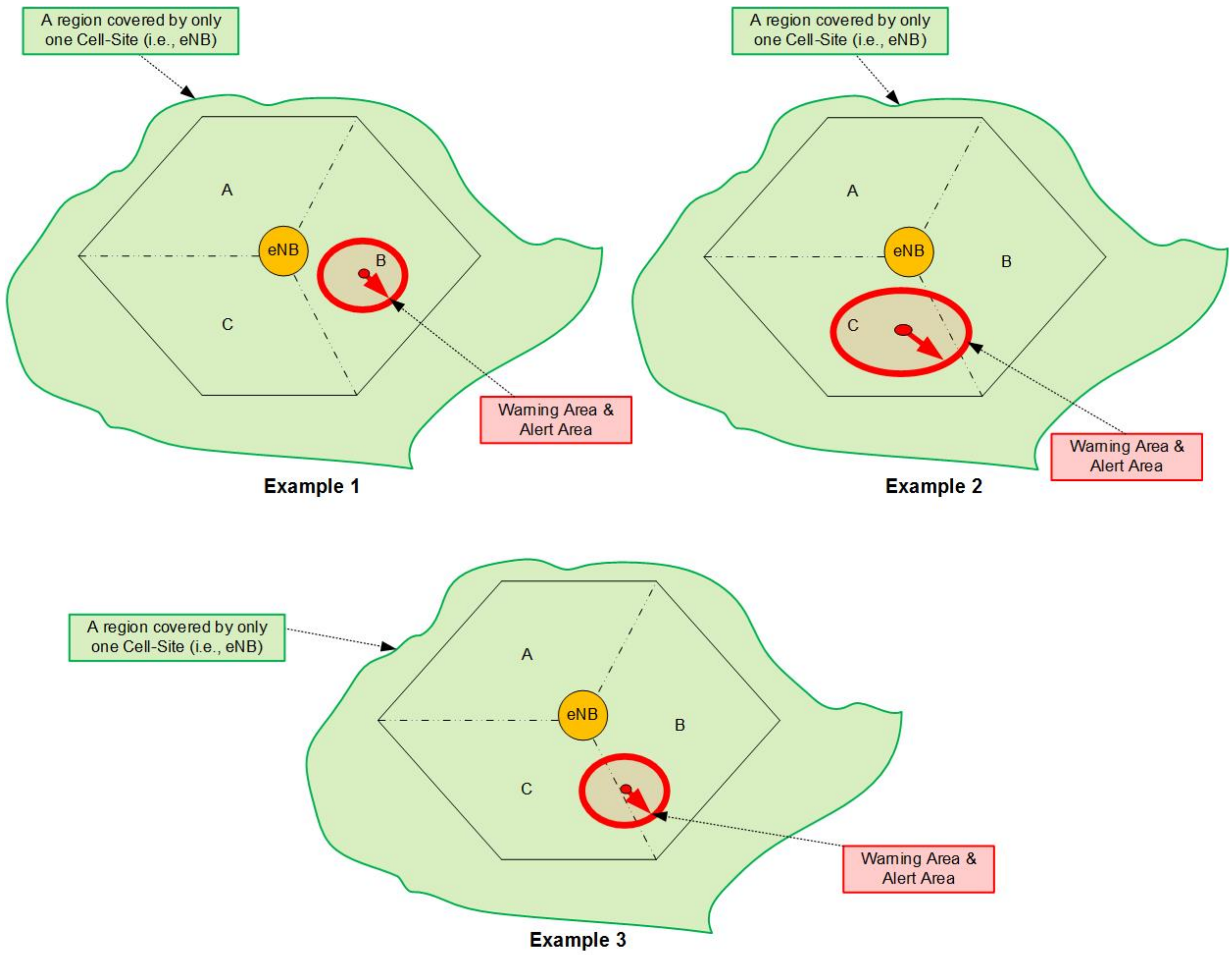



**Figure 6.13 – Broadcast Area Based on eNB Location (no broadcast)**

Basically, as shown in Figure 6.13, there is no Broadcast Area for all three examples.

#### 6.2.3.1.2 Broadcast Area – Based on Centroid of the Cell-Sector

With this approach, the Broadcast Area is determined based on the centroid of the cell-sector.

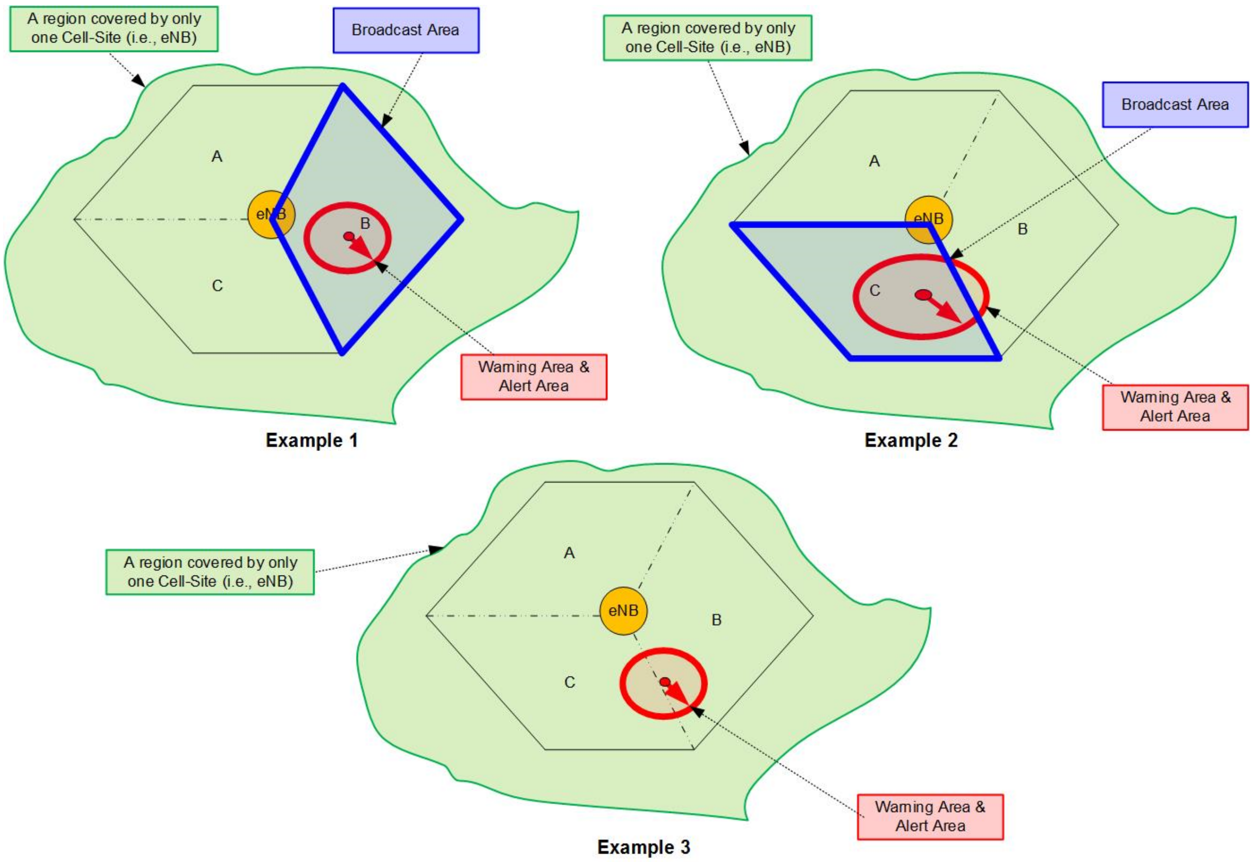



**Figure 6.14 – Broadcast Area Based on Centroid of Cell-Sector**

In example 1, since the centroid of cell-sector B happens to be within the Alert Area, the Broadcast Area happens to be same as the Desired Area (see Figure 6.12). But, still there is an overshooting since the Broadcast Area is larger than the Warning Area.

In example 2, only the centroid of cell-sector C happens to be within the Alert Area and hence, the Broadcast Area happens to include just the cell-sector C whereas the Desired Area happens to include both cell-sectors B and C (see Figure 6.12). The example has both overshooting and undershooting.

In example 3, neither of the two centroids (i.e., of cell-sectors B and C) happen to be within the Alert Area and therefore, there is no Broadcast Area. The case has undershooting.

#### 6.2.3.1.3 Comparison

Figure 6.15 compares the Broadcast Area with that of Desired Area for the three examples:

| | Desired Area | Broadcast Area | |
|---|---|---|---|
| | | • With eNB Location | • With Cell-Sector Centroid |
| Example 1 | | | |
| • Example 2 | | | |
| • Example 3 | | | |

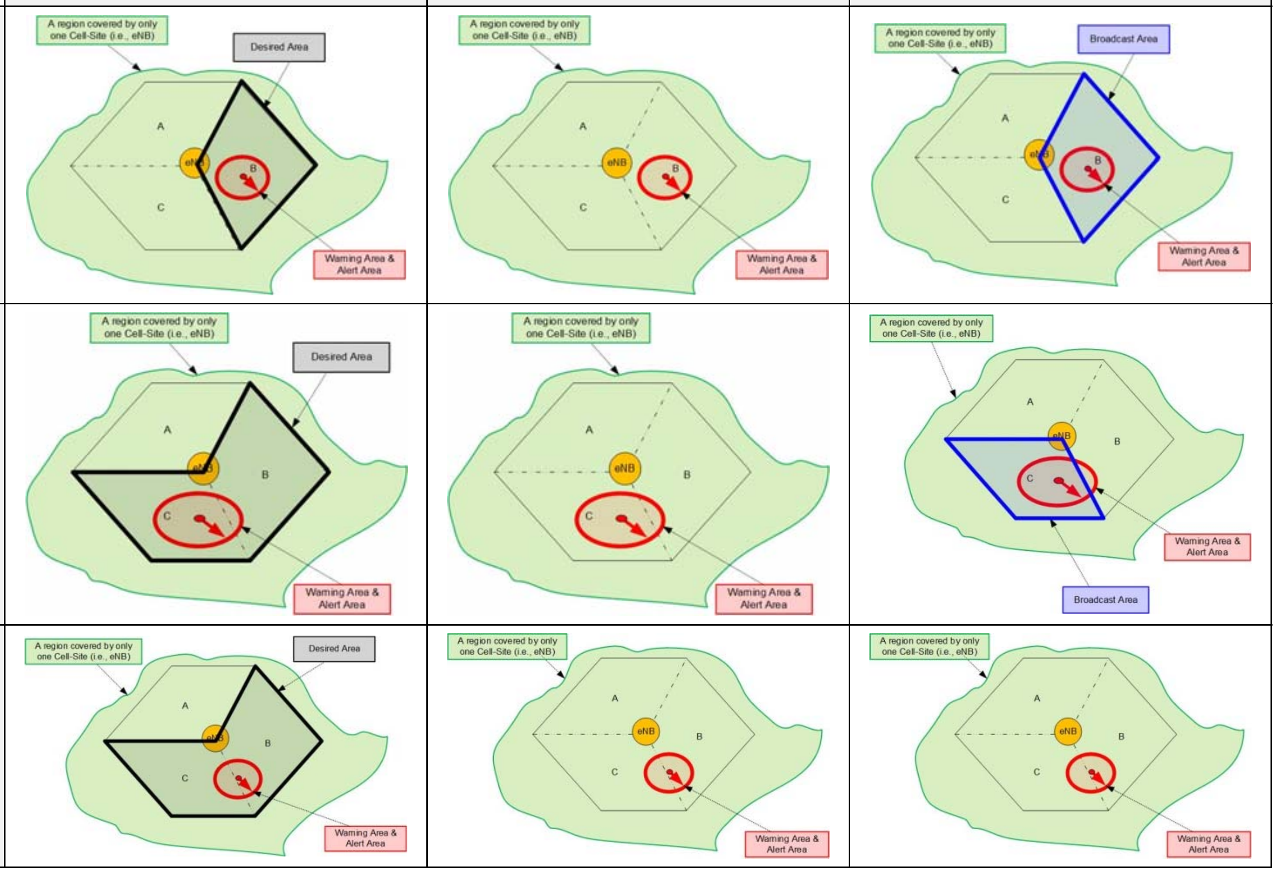



**Figure 6.15 – Comparison**

As shown in Figure 6.15, with eNB location based Broadcast Area determination, undershooting happens in all three examples. With cell-sector centroid based Broadcast Area determination, overshooting happens in example 1, undershooting happens in example 3, and both overshooting and undershooting happen in example 2. But, in example 1, with cell-sector centroid based Broadcast Area determination, the Broadcast Area happens to be same as the Desired Area.

### 6.2.3.2 Cell Site Inside the Alert Area

The Figure 6.16 illustrates two examples where the Alert Area happens to be within an eNB coverage area, with eNB also being inside of the Alert Area.

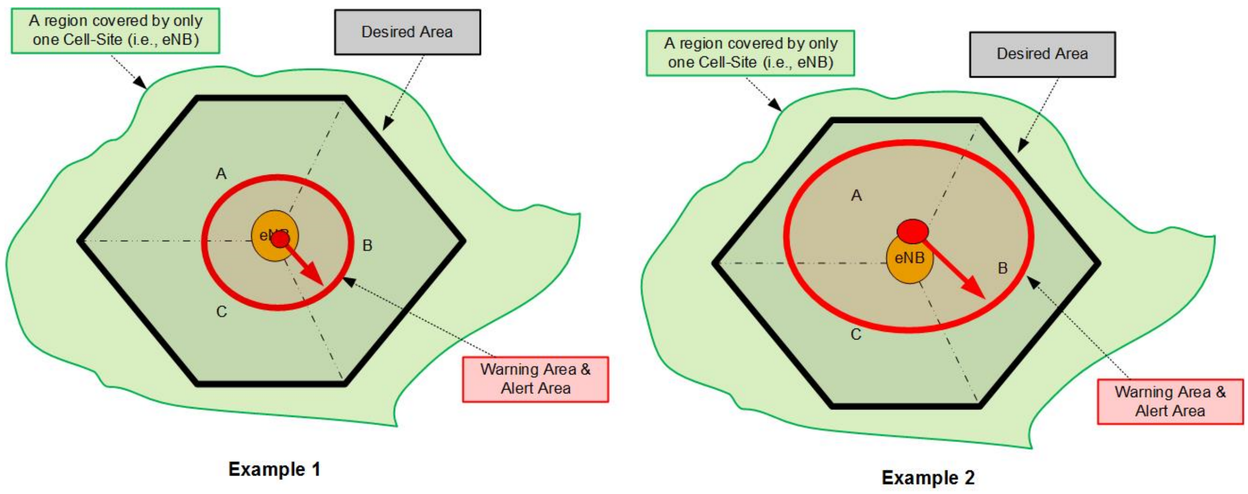



**Figure 6.16 – Cell Site Inside the Alert Area**

In both examples, the Alert Area covers all three cell-sectors. In example 1, none of the centroids of the three cell-sectors is within the Alert Area, whereas in example 2, the centroids of cell-sectors A and B happen to be within the Alert Area.

#### 6.2.3.2.1 Broadcast Area – Based on eNB Location

With this approach, the Broadcast Area is determined based on the location of the eNB. Since in the illustration, the eNB is inside the Alert Area, WEA is broadcast to all three cell-sectors.

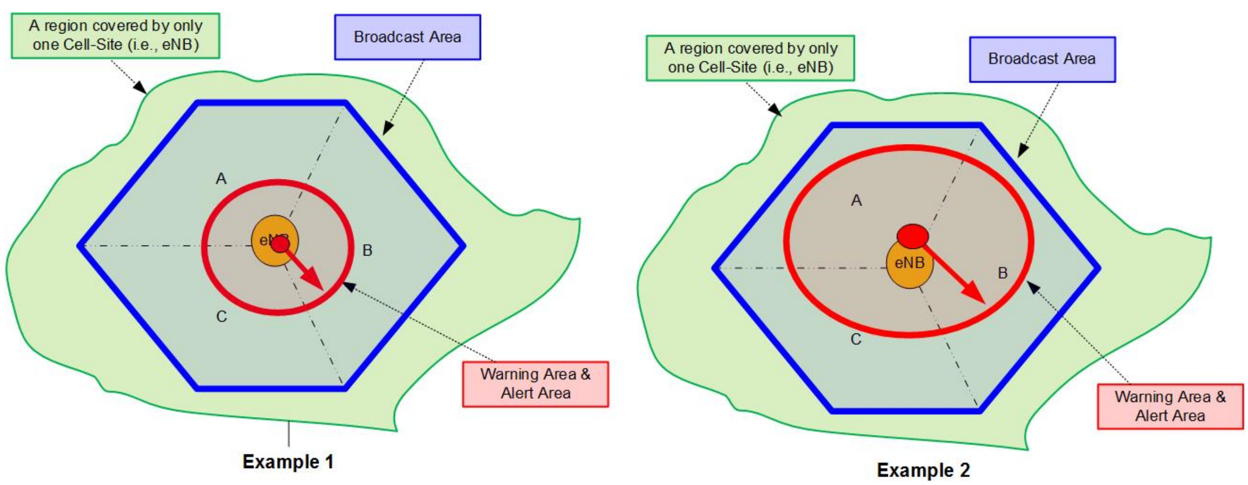



**Figure 6.17 – Broadcast Area Based on eNB Location (all three cell-sectors)**

Basically, as shown in Figure 6.17, alert is broadcast in all three cell-sectors. As seen, the Broadcast Area happens to be same as the Desired Area (see Figure 6.1), but still larger than the Warning Area/Alert Area and hence, the case of overshooting happens.

#### 6.2.3.2.2 Broadcast Area – Based on Centroid of Cell-Sector

With this approach, the Broadcast Area is determined based on the centroid of the cell-sector.

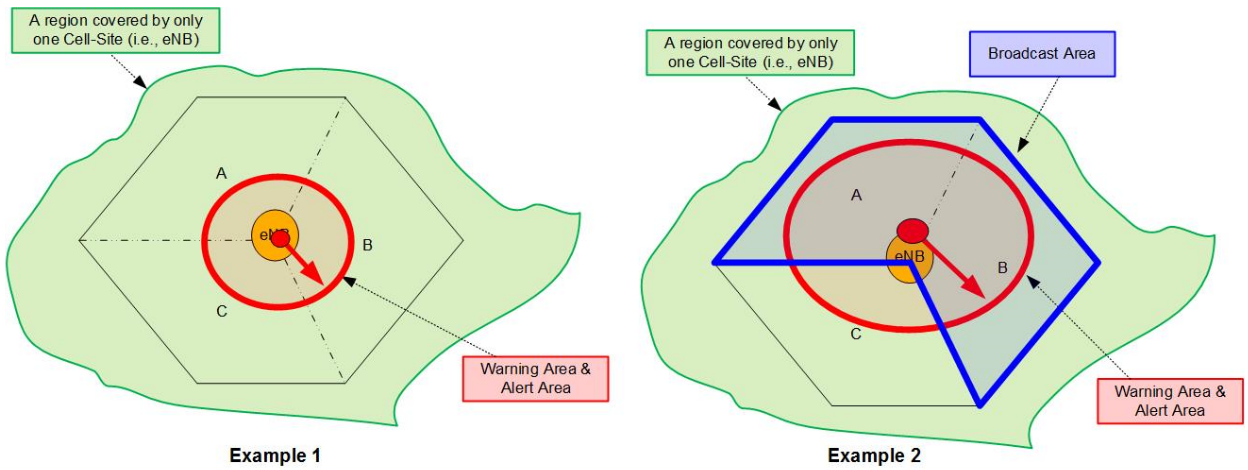



**Figure 6.18 – Broadcast Area Based on Centroid of Cell-Sector**

In example 1, since none of the centroid of the three cell-sectors is within the Alert Area, there is no WEA broadcast. In example 2, the Broadcast Area includes cell-sectors A and B. In example 1, there is a case of undershooting. In example 2, both overshooting and undershooting happens.

### 6.2.3.2.3 Comparison

Figure 6.19 compares the Broadcast Area with that of Desired Area for the two examples:

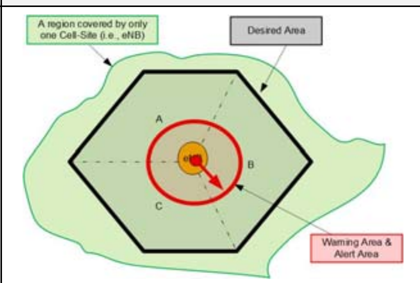
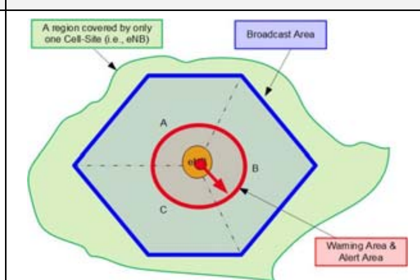
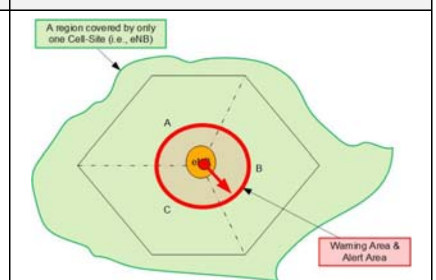
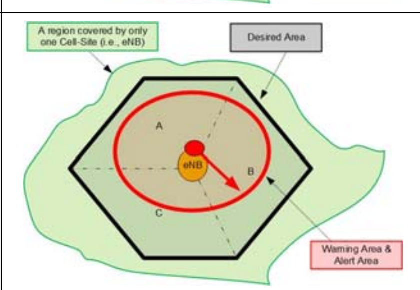
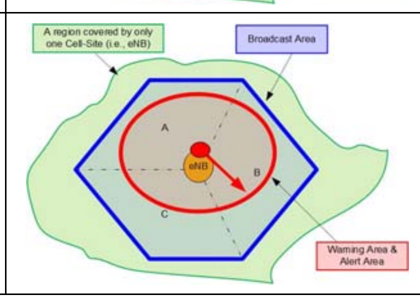
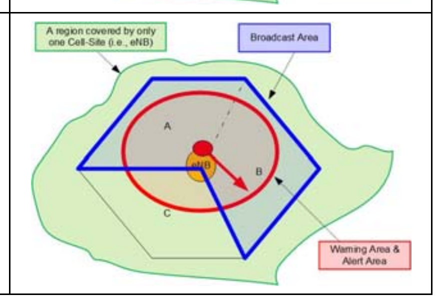
| | Desired Area | Broadcast Area | |
|---|---|---|---|
| | | • With eNB Location | • With Cell-Sector Centroid |
| **Example 1** |  |  |  |
| **Example 2** |  |  |  |

**Figure 6.19 – Comparison**

As shown in Figure 6.19, with eNB location based Broadcast Area determination, overshooting happens in both examples. With cell-sector centroid based Broadcast Area determination, undershooting happens with example 1 since there is no broadcast, and overshooting and undershooting happen with example 2.

## 6.2.3.3 Part of the Alert Area is Outside of the Coverage Area

Figure 6.20 illustrates an example where the Alert Area happens to be within an eNB coverage area, but part of the Alert Area happens to be outside the eNB coverage.

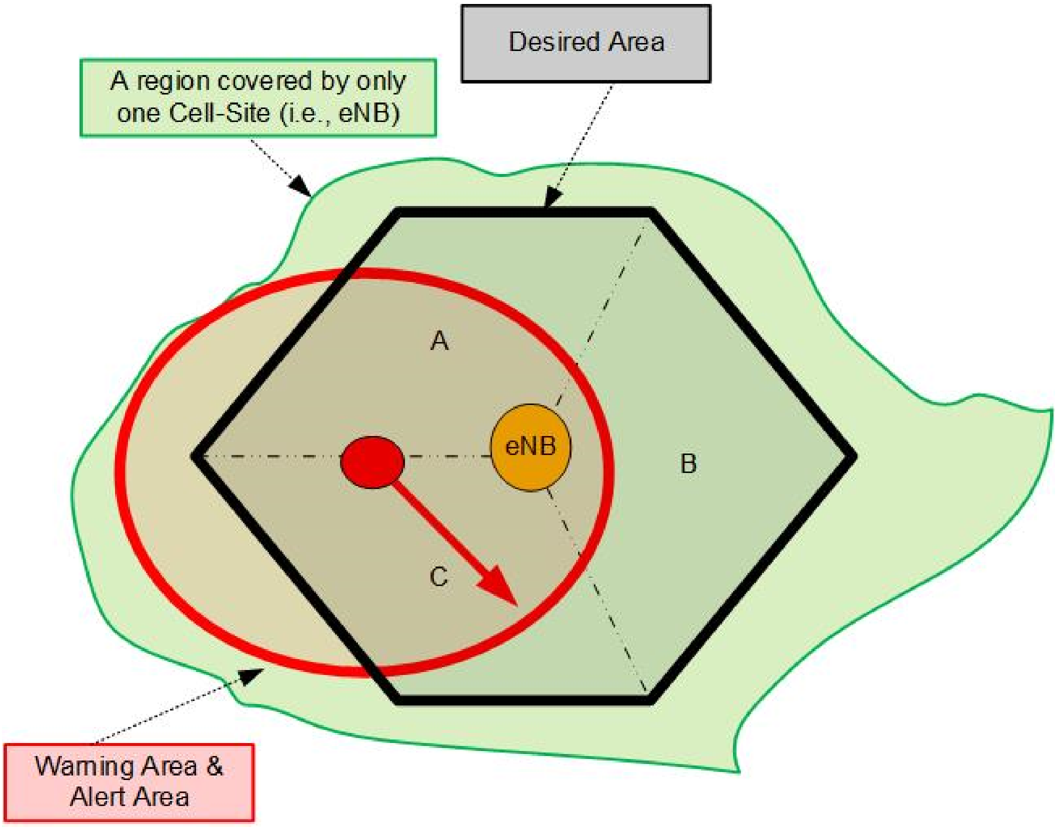



**Figure 6.20 – Part of Alert Area Outside Cell Site Coverage**

In the example, the Alert Area includes part of three cell-sectors and a part of an area which is outside of the eNB coverage.

#### 6.2.3.3.1 Broadcast Area – Based on eNB Location

With this approach, the Broadcast Area is determined based on the location of the eNB. Since in the illustration, the eNB is inside the Alert Area, WEA is broadcast to all three cell-sectors.

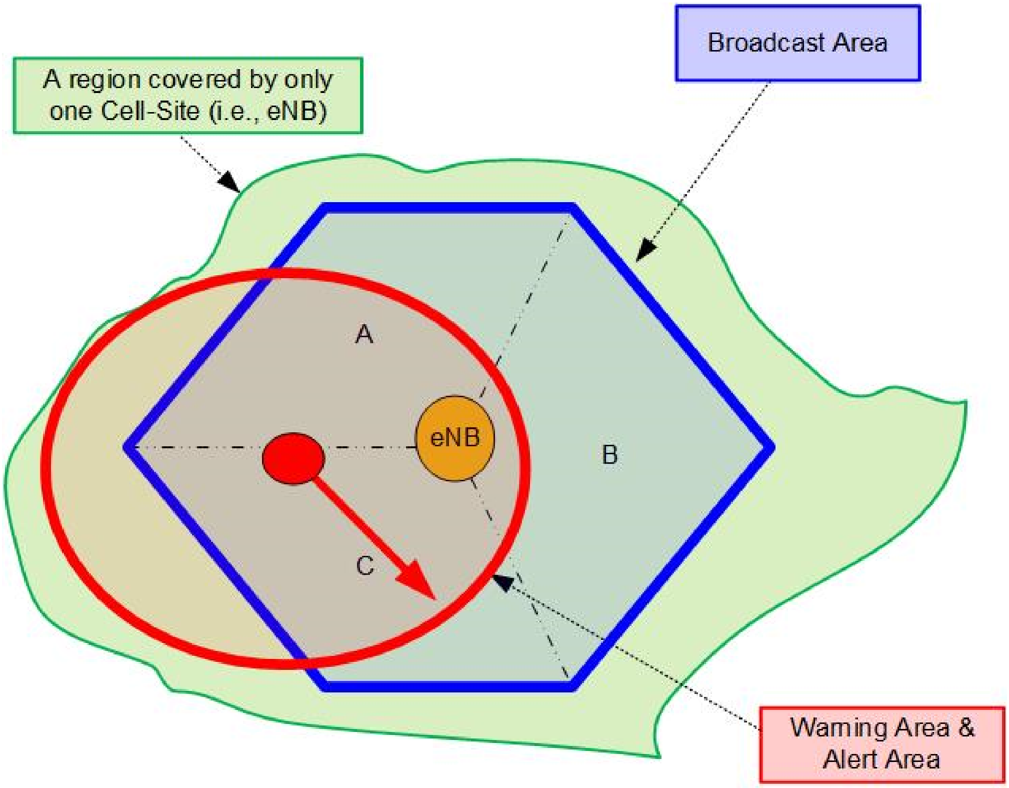



**Figure 6.21 – Broadcast Area Based on eNB Location**

Basically, as shown in Figure 6.21, the alert is broadcast in all three cell-sectors. As seen, the Broadcast Area happens to be same as the Desired Area (see Figure 6.20). But, WEA is not broadcast in the entire Warning Area. Therefore, there is undershooting. But, there is also a case of overshooting because the Warning Area includes only a part of the three cell-sectors.

#### 6.2.3.3.2 Broadcast Area – Based on the Centroid of the Cell-Sector

With this approach, the Broadcast Area is determined based on the centroid of the cell-sector.

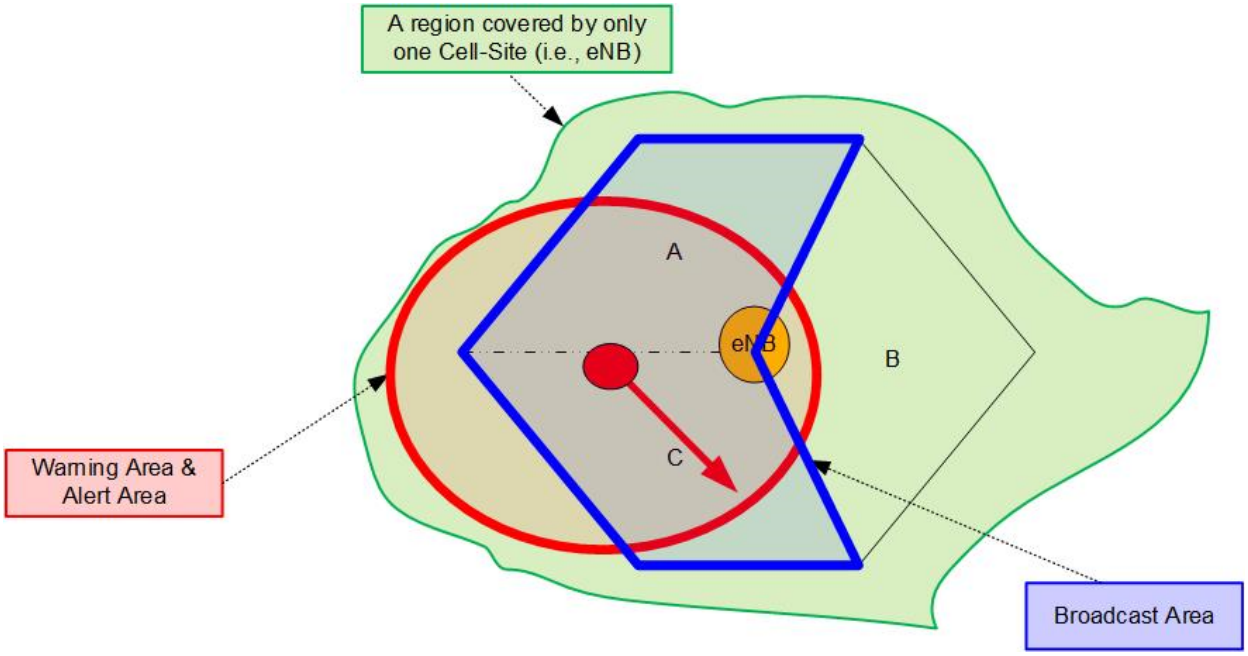



**Figure 6.22 – Broadcast Area Based on Centroid of Cell-Sectors**

Since the centroid of cell-sector B is not within the Alert Area, no alert is broadcast to that cell-sector. But, WEA is not broadcast to the entire Warning Area. Therefore, there is undershooting due to no broadcast outside of the eNB coverage area and no broadcast in cell-sector B. But, there is also a case of overshooting because the Warning Area includes only a part of the other two cell-sectors where the broadcast is made.

#### 6.2.3.3.3 Comparison

Figure 6.23 compares the Broadcast Area with that of Desired Area for the two examples:

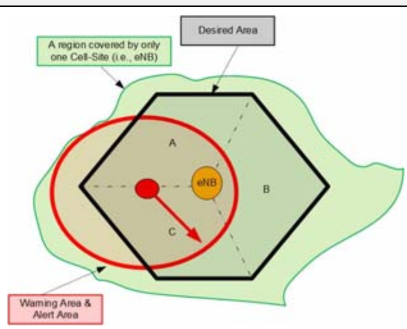
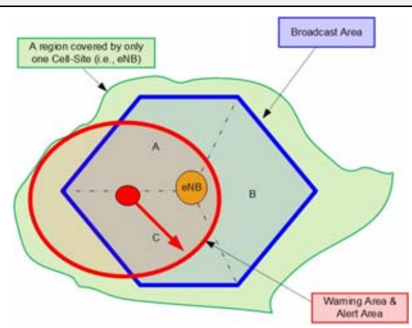
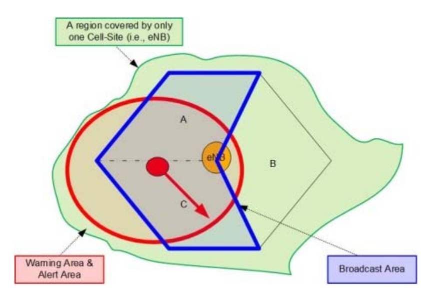
| **Desired Area** | **Broadcast Area** | |
|---|---|---|
| | • **With eNB Location** | • **With Cell-Sector Centroid** |
|  |  |  |

**Figure 6.23 – Comparison**

As shown in Figure 6.23, there is undershooting since for a part of the Warning Area, there is no cellular coverage. With eNB location based Broadcast Area determination, there is also over-shooting. With cell-sector centroid based Broadcast Area determination, there is also undershooting in cell-sector B.

# 7 Considerations for Mobile Device Assisted WEA Alert Geo-Targeting

This clause describes the feasibility and considerations for the mobile device assisting in the geo-targeting of WEA Alert Messages. Mobile-assisted geo-targeting implies the WEA Alert Message is broadcast to the best approximation of the polygon supplied by the Alert Originator, with the mobile device deciding if the WEA Alert Message is to be presented to the mobile device user based on the location of the mobile device in relation to the alert polygon. The following are the considerations which are discussed in this clause:

- Mobile device must know the WEA Alert Area polygon or circle coordinates.
- How are multiple active alerts handled?
- Determining mobile device location.
- Impact on CMSP network resulting from WEA related positioning requests.
- Mobile device location accuracy and confidence levels.
- Discussion of crowd sourced location services.
- Subscriber privacy.
- Liability.

## *7.1 Obtaining WEA Alert Polygon or Circle Coordinates*

For the mobile device to assist in the geo-targeting of the WEA Alert Message, the mobile device must have the polygon or circle coordinates that are associated with the WEA alert area in order to determine if the mobile device is located within the alert polygon or circle, and then decide if the WEA Alert Message is to be presented to the mobile device user based on its determination of its location within the polygon. However, how the mobile device obtains the polygon coordinates is problematic, as defined in the following clauses.

### 7.1.1 Number of Alert Areas in an Alert

According to the CAP [Ref 3], each alert “info” element may contain one or more ”area” segments, and each “area” segment may have one or more “polygon” or “circle” elements. This potentially makes the alert area very complicated, as a single alert message can have one or more polygons or circles defining the alert area for that message. To complicate it further, each polygon or circle may or may not overlap. If they overlap, then the alert area is the union of the overlapping polygons or circles. Each polygon or circle is defined by the lat/lon coordinates that define that polygon or lat/lon/radius of the circle.

For a polygon, a minimum of 3 coordinate pairs must be present. However, depending on the shape of the polygon and the geography of the alert area, many more coordinate points may be needed to describe the alert area. CAP eXtensible Markup Language (XML) does not place a bound on the number of coordinates. However, J-STD-101 [Ref 2], does place a maximum of 100 paired values of points (i.e., latitude/longitude pairs) per CMAC_polygon element may be specified in the polygon. J-STD-101 [Ref 2] also allows for multiple CMAC_Alert_Area segments corresponding to each CAP “area” segment that is provided by the Alert Originator.

Allowing for multiple alert areas, each of which may contain up to 100 coordinate pairs, implies a significant amount of information needs to be available at the mobile device if it is to provide mobile-assisted geo-targeting. In addition, the mobile must perform the “union” of these coordinates to identify the alert area.

### 7.1.2 Representing Lat/Lon Coordinates

ISO 6709 Standard [Ref 4] representation of geographic point location by coordinates is the international standard for representation of latitude, longitude, and altitude for geographic point locations. Each coordinate pair requires 13 characters assuming northern latitudes (e.g., 36.13,-114.62). Also, a delimiter character is also needed between each pair.

As an example of the number of characters to define a polygon, if an alert contains 2 polygons each of which have 10 coordinate pairs, a total of 20 coordinate pairs need to be obtained by the mobile device. 20 coordinate pairs will require (20 lat/lon pairs x13 characters per pair) +19 delimiter characters=279 characters.

The Alert Originator may not be constrained on the number of decimal points provided in the polygon, and thus define unrealistic polygons. For example, the NWS issued an alert in Virginia on October 19, 2015 and defined the polygon with 13 decimal positions as follows:

| | | |
|---|---|---|
| | 36.7647861421581,-80.0430500348257 | 36.766565984832447,-80.042516633550576 |
| | 36.768257031925927,-80.041642236444176 | 36.769817651384031,-80.0404483753001 |
| | 36.771209424089164,-80.038964445934965 | 36.77239809020417,-80.037226987480679 |
| | 36.77335439095512,-80.035278782930533 | 36.774054787852741,-80.033167802595955 |
| | 36.774482042529577,-80.0309460262064 | 36.774625638857017,-80.028668161365673 |
| | 36.774482042469813,-80.0263902963742 | 36.774054787775356,-80.024168519873314 |
| | 36.773354390942458,-80.0220575397456 | 36.772398090023643,-80.0201093349315 |
| | 36.771209423702992,-80.018371876623547 | 36.769817651117123,-80.016887947014183 |
| | 36.768257032153763,-80.015694085652427 | 36.76656598476454,-80.014819689037338 |
| | 36.764786142004461,-80.014286287639351 | 36.76296132407866,-80.014107016002455 |
| Polygon(s) | 36.761136462539064,-80.014286287572162 | 36.759356493470712,-80.014819689025 |
| | 36.7576652504323,-80.015694085553861 | 36.756104384014549,-80.016887947384362 |
| | 36.754712336825527,-80.018371876697358 | 36.75352339687629,-80.020109334837485 |
| | 36.752566848496549,-80.022057539401217 | 36.751866255325858,-80.024168519794713 |
| | 36.751438874401089,-80.026390296369669 | 36.751295234981932,-80.028668161057084 |
| | 36.751438874582014,-80.030946026173751 | 36.751866255255905,-80.0331678025513 |
| | 36.752566848404769,-80.035278782684529 | 36.753523396785063,-80.0372269877928 |
| | 36.75471233713138,-80.038964445689928 | 36.756104383922455,-80.040448375041365 |
| | 36.757665250099983,-80.041642236444 | 36.759356493805889,-80.042516633517721 |
| | 36.761136462813887,-80.043050034730271 | 36.762961323831441,-80.043229306520473 |
| | 36.7647861421581,-80.0430500348257 | |

**Figure 7.1 – Example NWS Polygon**

The following description defines what each decimal position signifies. For example, the sixth decimal position is about 4 inches. The ninth decimal position would be microns. The example above with 13 decimal positions would put it into the sub-atomic scale.

The wikilena web page[10] contains the following description from William Huber on the significance of each decimal degree digit:

[10] Available at: < http://wikilena.blogspot.com/2015/01/decimal-places-precision-and-accuracy.html >. (Last visited October 28, 2015)

Using these ideas we can construct a **table of what each digit in a decimal degree signifies:**

- The **sign** tells us whether we are north or south, east or west on the globe.
- A nonzero **hundreds digit** tells us we're using longitude, not latitude!
- The **tens digit** gives a position to about 1,000 kilometers. It gives us useful information about what continent or ocean we are on.
- The **units digit** (one decimal degree) gives a position up to 111 kilometers (60 nautical miles, about 69 miles). It can tell us roughly what large state or country we are in.
- 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.
- The **sixth decimal place** is worth up to 0.11 m: you can use this for laying out structures in detail, for designing landscapes, building roads. It should be more than good enough for tracking movements of glaciers and rivers. This can be achieved by taking painstaking measures with GPS, such as differentially corrected GPS.
- The **seventh decimal place** is worth up to 11 mm: this is good for much surveying and is near the limit of what GPS-based techniques can achieve.
- The **eighth decimal place** is worth up to 1.1 mm: this is good for charting motions of tectonic plates and movements of volcanoes. Permanent, corrected, constantly-running GPS base stations might be able to achieve this level of accuracy.
- The **ninth decimal place** is worth up to 110 microns: we are getting into the range of microscopy. For almost any conceivable application with earth positions, this is overkill and will be more precise than the accuracy of any surveying device.
- **Ten or more decimal places** indicates a computer or calculator was used and that no attention was paid to the fact that the extra decimals are useless. Be careful, because unless you are the one reading these numbers off the device, this can indicate low quality processing!

by William Huber (http://gis.stackexchange.com/users/664/whuber)

The conclusion is that WEA Alert polygon coordinates should use no more than 3 decimal places.

### 7.1.3 Broadcasting Coordinates to Mobile Device

As described in the ATIS Feasibility Study for LTE WEA Message Length [Ref 5], there is a maximum limit of 360 characters that may be broadcast in one WEA Alert Message to the mobile device using the GSM 7-bit coding. One consideration is to use the LTE broadcast to send the coordinates to the mobile device.

There are two ways to consider sending the coordinates:

1. Broadcast the coordinates as part of the WEA Alert Message broadcast.
2. Broadcast the coordinates using a separate WEA message.

#### 7.1.3.1 Broadcast Coordinates as Part of the WEA Alert Message Broadcast

If the coordinates are broadcast as part of the WEA Alert Message broadcast, the coordinates will take away from the displayable text available in the WEA Alert message. Since there is a maximum proposed limit of 360 characters [Ref 5], each lat/lon coordinate pair will require 13 characters from the displayable text. The minimum number of coordinate pairs to define a polygon is 3, which requires 41 characters. With this minimum number of coordinates, the number of displayable characters is reduced to 319 displayable characters available to the Alert Originator. However, most polygons in an alert message have more than 3 lat/lon pairs; typically the number of pairs is 5-15 in an alert message, which requires 65-195 characters.

Thus, the more coordinate points in the polygon, the less displayable characters will be available. This is undesirable as Alert Originators, DHS S&T research, and FCC CSRIC recommendations look to maximize the number of displayable characters available to Alert Originators.

Other issues include defining how the mobile device would parse the displayable characters and the non-displayable coordinates so that only the displayable text is presented to the user.

Carnegie Mellon University proposed a method to compress polygon coordinates [Ref 7] to between 9.7% and 23.6% of original length, depending on characteristics of the specific polygons, reducing original polygon lengths from 43-331 characters to 8-55 characters. Further study is needed to determine if such compression techniques are applicable to WEA and enhanced WEA-capable mobile devices. In addition, any compression technique must be standardized globally as part of the 3GPP Public Warning System to support roaming.

Thus, broadcasting the coordinates as part of the WEA Alert message without compression is not feasible and compression techniques need further study.

#### 7.1.3.2 Broadcast Coordinates in Separate WEA Broadcast Message

If the coordinates are broadcast as part of a new WEA message, it is possible that the entire 360 characters may be used. This would allow for 25 coordinate pairs to be broadcast, which is less than the maximum 100 coordinate pairs allowed by J-STD-101 [Ref 2]. In addition, there must be overhead so that the mobile device can correlate the coordinates with the WEA Alert Message. There will also be a delay as the mobile device will have to receive both the WEA Alert Message and the WEA coordinates prior to processing and displaying the alert.

If there are multiple polygons associated with the WEA Alert Message as described in clause 7.1.1, this further complicates the broadcast of the coordinates. How does the mobile device know how many coordinate pairs it should be looking for? How many WEA messages are needed to broadcast this? How does the mobile device know how many messages there are broadcasting the polygon information?

The overall complexity of this solution makes the feasibility uncertain.

### 7.1.4 Using WEA Supplemental Text to Obtain Coordinates

The techniques of the ATIS Feasibility Study for WEA Supplemental Text [Ref 6] may be applicable as methods for the mobile device to obtain the WEA alert area. But, there is a key difference in obtaining supplemental information than from obtaining the WEA alert area polygon. Supplemental alert information such as instructions, pictures, maps, etc., can be obtained and presented after the text of the WEA Alert Message is presented to the mobile device user. However, for mobile device assisted geo-targeting functionality, the WEA alert area polygon must be obtained before the WEA Alert Message is presented to the mobile device user and this implies that there will be a delay in the presentation of WEA Alert Messages whenever mobile device assisted geo-targeting is used.

Consequently, the presentation of the WEA Alert Message on the mobile device has become a two-step operation with the first step being the receipt of the WEA Alert Message text and the second step being obtaining the polygon or circle of the alert area. This process remains a two-step process even if Cell Broadcast is used to provide both the text message and the polygon or circle of the associated alert area.

Since mobile device assisted geo-targeting has changed the presentation of the WEA alert from a one-step operation of just receiving the WEA text message to a two-step operation of receiving the WEA text message and the associated polygon or circle, the following additional situations will need to be resolved and appropriate instructions have to be implemented in the mobile device:

- How long should the mobile device delay the presentation of the WEA alert text message while attempting to obtain the associated WEA alert area polygon or circle?
- What should be the action of the mobile device if the WEA alert area polygon or circle cannot be obtained

for any reason?

## 7.2 Multiple Active Alerts

The possibility exists that an event will result in multiple WEA Alert Messages being active at the same time with each WEA Alert Message have different alert areas. For example, a tornado alert could have one alert area based upon the projected direction of the tornado whereas a flash flood alert from the same storm could have a different alert area based upon the downstream direction of the streams and rivers.

Consequently, the mobile device would have to obtain the separate WEA alert area polygon or circle for each WEA Alert Message.

## 7.3 Determining Mobile Device Location

For mobile device geo-targeting to function, the mobile device must first determine its current location. The determination of the current location could delay the presentation of the WEA Alert Message by seconds or even minutes. The following situations need to be resolved and appropriate instructions have to be implemented in the mobile device:

- What positioning modes (e.g., mobile device based, no network assist) does the mobile device use to determine its current location?
- How long should the mobile device wait while attempting to determine its current location [e.g., acceptable Time To First Fix (TTFF)]?
- What should be the action of the mobile device if the mobile device location cannot be determined or cannot be determined within the time limit? For example: Display the WEA Alert Message.
- Determine which takes regulatory precedence – user privacy settings in the form of disabling some or all location services or geo-targeted WEA alerts.

## 7.4 Impact on CMSP Network Resulting from WEA Related Positioning Request

Current positioning technologies which CMSPs can deploy can be categorized based on what roles the mobile device and the CMSP network take to produce a position. There are various combinations of mobile device based, mobile device assisted, network based, and network assisted. This discussion further divides positioning technologies into those which are network based/network assisted or no network involvement in position determination.

For any network based or network assisted positioning technology (e.g., Assisted Global Positioning System [GPS]/Assisted Global Navigation Satellite System [GNSS], Observed Time Difference Of Arrival [OTDOA], Uplink Time Difference of Arrival [UTDOA]), the CMSP infrastructure deployed to support CMSP provided location services is provisioned to support a location service peak traffic load of the normal everyday traffic with some defined margin. However the CMSP location service infrastructure will not have been sized for exceptional location service demand which would be expected if the mobile device used its location to determine if a WEA Alert Message was to be presented to the user. As well as the location request load, there will be additional network traffic to handle all the exchange of positioning assistance and positioning measurement data. Additional traffic and request load multipliers would be experienced if multiple positioning technologies had to be accessed based on reliability requirements (e.g., GPS and OTDOA).

The following issues would need further development if network based or network assisted positioning technologies were used for mobile device based selection of geo-targeted WEA alerts:

- Develop traffic loading models to forecast geo-location traffic demand for various WEA alerts.
- Identify cost recovery mechanisms for expanded CMSP location service infrastructure to handle the forecast demand since no commercial applications are expected to benefit from this expansion.
- Model and forecast the impact of scenarios where particular positioning technologies are weak (e.g., GPS

is generally not usable indoors in urban structures).

For mobile device based positioning without network assistance, the only currently readily available technology is GPS/GNSS. However, without network assistance (providing ephemeris and almanac), the time to acquire a GPS position can be over 13 minutes for a cold start (no or expired GPS related data in the mobile device) and up to 30 seconds for a warm start (some initial GPS related data in the mobile device (recent almanac, rough location, and system time).

The following issues would need further development if mobile device based positioning without network assistance were to be used for mobile device based geo-targeted WEA alert selection:

- Develop the expected service behavior with TTFF of up to 30 seconds (the majority of mobile devices are likely to go into a warm start if a mobile device location were required by a received WEA Alert Message).
- Model and forecast the impact of scenarios where mobile device based GPS positioning is weak (e.g., GPS is generally not usable indoors in urban structures).

## *7.5 Mobile Device Location Accuracy & Confidence Levels*

Mobile device location positioning is described with accuracy and confidence levels. Consequently, the geo-targeting of the mobile device location with the WEA Alert Message polygon or circle would also have an associated accuracy and confidence level. As a result, it is possible that the mobile device geo-targeting algorithms could indicate that the mobile device is located outside the alert area when the mobile device is actually located within the WEA alert area. The following situations need to be resolved and appropriate instructions have to be implemented in the mobile device:

- What are the minimum accuracy and confidence level values for a mobile device location calculation to be used for mobile device assisted geo-targeting?
- What should be the action of the mobile device on the presentation of the WEA Alert Message if the mobile device location does not meet the minimum accuracy and confidence level values for mobile device assisted geo-targeting?

## *7.6 Discussion of Crowd Sourced Location Services*

Often questions come up regarding crowd sourced location services and mapping applications available on smartphones that can show where the mobile device is, and may, in some cases (especially indoors) be more accurate than the CMSP's location services. The questions are usually in the form of either why can't the CMSP location service provide as much location accuracy as the crowd sourced or why can't the crowd sourced location services be used for a particular public safety service (e.g., WEA, 911).

If a decision were made to explore and develop the use of crowd sourced location services for mobile device based geo-targeting WEA alerts, since crowd sourced location services are generally not deployed to network/public safety availability and reliability requirements, the following issues would need to be resolved:

- Enhance crowd sourced location services to network and public safety accuracy, reliability, and availability performance levels.
- Develop cost recovery mechanisms for both CMSPs and crowd sourced location service providers.
- Resolve data traffic loading during large scale WEA alerts to access the cloud based crowd sourced location services (see further the discussion of URL usage in section 5.5 of the WEA supplemental text study [Ref 6]).
- Resolve potential interaction issues between multiple crowd sourced location services when the user has their own preferred crowd sourced location service and mapping application and the WEA alert presentation application may use a different location service and/or mapping application.
- Resolve potential interaction conflicts between a mobile device based WEA geo-targeted alert and the user's privacy preference settings.

## 7.7 Subscriber Privacy

On smartphones, there are many different apps which provide services based upon mobile device location. For example, these apps can easily answer a query such as "where is the closest coffee shop?"

For these types of smartphone app queries, the mobile device location is provided by the location services functionality provided on the smartphone platform or other smartphones apps. For a popular OEM smartphone provider and for a popular search engine provider, the location of the device is continuously monitored and recorded in order to be able to quickly and accurately respond to queries such as "where is the closest coffee shop?" The mobile device user approved this location tracking and recording when the user accepted the "terms and conditions" of the smartphone OEM platform or the installed app.

However, many people have concerns about the government or an agent acting on behalf of the government continuously monitoring and tracking a mobile device's location. Consequently, other techniques for the determination of mobile device location may necessary for mobile device assisted geo-targeting. For these other techniques, there would be delays in the calculation of the mobile device location and consequently delays in the presentation of the WEA Alert Message (see clause 7.3).

## 7.8 Liability

With the use of mobile device assisted geo-targeting, there may be possibility for a reduction in the overshooting and undershooting of WEA Alert Messages. However, because of the inaccuracies in determination of the mobile device location (see clause 7.4), there is also the possibility that mobile device assisted geo-targeting could make the wrong decision regarding the presentation of a WEA Alert Message. Specifically, the geo-targeting calculation could indicate that the mobile device is outside the alert area when the mobile device is actually within the alert area polygon or circle and based upon these calculation results the WEA Alert Message is not presented.

What are the liability issues and concerns associated with this type of mobile device assisted geo-targeting miscalculation and the resultant action of not presenting the WEA Alert Message?

# 8 Conclusions & Recommendations

## 8.1 Conclusions

This feasibility study provides a detailed analysis of the current WEA geo-targeting capabilities, considerations for WEA alert polygons, and considerations for undershooting or overshooting of WEA alert broadcast areas. The following are the conclusions of these studies:

1. Alert Originators should always expect some amount of overshoot or undershoot of the WEA alert broadcast area as compared to the provided WEA alert polygon. The locations, shapes, and sizes of the cell sites and cell-sectors will vary based on factors such as radio configurations (e.g., power levels, antenna inclinations), radio wave propagation characteristics, and the geographic topology of the coverage area.
2. The current FCC rules allow for WEA Alert Messages to be geo-targeted to the county level. However, recognizing this may have significant overshoot; in order to minimize the degree of overshoot and undershoot of the WEA alert broadcast area, the major wireless CMSPs have been and continue to use any alert-originator specified WEA alert polygon to select the cell sites that map to the best approximation of that polygon for the broadcast of the WEA Alert Message. The major wireless carriers revert to county level WEA alert broadcasting when the WEA alert polygon is not provided by the Alert Originators.
3. The DHS S&T Research Paper "Wireless Emergency Alerts Cell Radio Frequency (RF) Propagation Algorithm Operational Assessment" [Ref 8] was presented to the ATIS working group developing this feasibility study. The ATIS working group concluded that the algorithms already in use by the major CMSPs for the determination of the WEA alert broadcast area already meet or exceed the results of this research paper, and no additional insight is gained through this research paper.

4. Regarding the topic of polygons with crossing lines; this is not a common occurrence. Overlapping polygons is an Alert Originator issue. The problem of overlapping points in a polygon is currently most prevalent along coastal areas where the GIS system tries to approximate coastlines with the polygon. The NWS is currently working on an update to its software which should eliminate the problem in their systems.
5. In clause 5.4.4, a new concept of nested polygons is described which is currently not supported by the existing WEA implementations. The Alert Originator community should be surveyed to determine the value of nested polygons for WEA Alert Messages. This concept is nested polygons with different WEA Alert Messages in each polygon. If this new concept were to be determined a valuable enhancement in a future version of WEA, additional standardization and product development work would be required. It is estimated that the standardization effort would take 18 to 24 months followed by another 18 to 24 months for product development and testing. This new concept would also impact all of the major WEA stakeholders – Alert Originators, FEMA IPAWS, and the CMSP infrastructure.

Additionally, this feasibility study investigated mobile device assisted WEA alert geo-targeting. As discussed in clause 7, there are many challenges for the support of mobile device assisted WEA geo-targeting such as the following:

- **How are coordinates of the alert polygon or circle to be sent to the mobile device?** This feasibility study examined the following options for sending the coordinates to the mobile device and none of these options were found to be feasible:
  - Broadcast coordinates as part of the WEA Alert Message broadcast.
  - Broadcast coordinates in separate WEA broadcast messages.
  - Using WEA Supplemental Text to obtain coordinates.
- **Handling of multiple alert areas.** A WEA Alert Message may have multiple polygons or circles. Additionally, there could be multiple alerts at the same time in the same general geographic area and each of these alerts could have different alert areas due to the nature of the alert. Consequently, not only will multiple alert text messages have to be broadcast to the mobile devices, but multiple sets of associated polygon coordinates need to be delivered to the mobile devices and the mobile devices will need to maintain an association between the multiple alerts and the multiple alert areas.
- **Size of polygon.** Per J-STD-101 [Ref 2], there is a limit of 100 polygon coordinates per alert area. The amount of data being broadcast for the polygon coordinates could be up to 5 times larger than the size of the actual displayable text of each alert message, even considering compression techniques. Consequently, the vast majority of the capacity that might be utilized for the broadcast of the polygon coordinates would delay the presentation of the WEA Alert Message to the mobile device user and could delay the broadcast of any other alerts for an incident which requires multiple different WEA alert types to be broadcast.
- **Number of decimal places.** As indicated in clause 7.1.2, there have been instances where Alert Originators are specifying polygon coordinates with an unrealistic number of decimal places. Alert Originator software should limit the number of decimal places to 3 maximum for polygon coordinates.
- **Coordinate compression.** Further study is needed to determine the applicability of compression techniques to WEA polygon coordinates. In addition, any compression techniques must be standardized globally.
- **Determination of mobile device location.** For mobile device geo-targeting to function, the mobile device must first determine its current location. However, that may not always be possible especially if the mobile device user has disabled the location services to conserve battery life or for privacy reasons. Failure to obtain mobile device location within a short period of time raises several mobile device behavior issues which would need to be resolved. (See clause 7.3)
- **Mobile device location accuracy and confidence levels**. The geo-targeting of the mobile device location with the WEA Alert Message polygon or circle would need to have an associated accuracy and confidence level. Depending on the level of the accuracy and confidence of the mobile device location, it is possible that the mobile device geo-targeting algorithms could indicate that the mobile device is located

outside the alert area when the mobile device is actually located within the WEA alert area.

- **Subscriber privacy.** Subscriber privacy is a concern especially if the mobile device geo-targeting algorithms have the perception of the government or an agent acting on behalf of the government viewed as continuously monitoring and tracking a mobile device's location. When WEA was first deployed, this government tracking was a concern raised by various groups.[11,12,13]
- **Liability.** The liability issues and concerns associated with mobile device assisted geo-targeting miscalculation and the resultant action of not presenting the WEA Alert Message needs to be understood and addressed, perhaps at the Congressional level through amendments to the WARN Act.

Related to mobile device assisted WEA alert geo-targeting are the following conclusions from the DHS S&T research paper "Comprehensive Testing of Imminent Threat Public Messages for Mobile Devices: Updated Findings" [Ref 8]:

- "None of the map elements tested had a statistically significant effect on message outcomes, and focus group participants varied widely in their reactions to the tested maps. Maps can be useful in message personalization, but the role they play varies based on message length."
- "Adding maps to shorter 90 and 140-character messages seemed to help increase message understanding, but adding maps to longer messages decreased message understanding."

  NOTE: The conclusion of the ATIS feasibility study on LTE WEA message length [Ref 5] is 360 displayable characters.

- "Consequently, maps should not be used in WEA messages without further research examining the best way to craft such maps, as well as how they may impact message personalization and other outcomes."
- "Specifically, additional research is needed to determine how to best communicate hazard and receiver location in maps associated with WEA messages. Future research also should examine the extent to which humans are able to process text and visual information in an emergency context."

In summary, WEA is a voluntary service and there is no funding for enhancements. There will always be some amount of overshoot or undershoot of the WEA alert broadcast area even if mobile device assisted geo-targeting were to be implemented. However, since mobile device assisted geo-targeting has many major technical issues and challenges, the current CMSP infrastructure based calculation of the WEA alert broadcast area continues to be the best solution for WEA geo-targeting. In the current CMSP infrastructure based methodology, the major CMSPs strive to minimize both the overshoot and the undershoot of the broadcast area so that subscribers within the alert area will be capable of receiving the alert message while attempting to avoid the alerting of subscribers outside of the alert area. However, in order to achieve this objective, the Alert Originators must provide polygons or circles with each WEA Alert Message.

## *8.2 Recommendations*

Based on the technical analysis of this feasibility study and considering all factors, ATIS recommends the following:

1. Participating CMSPs should perform geo-targeting below the county level (most implementations already support this). Polygon/circle geo-targeting is the preferred granularity. A polygon/circle specifying the alert area should be included in every WEA message. It is recommended that 47 CFR §10.450 be modified as follows:

   **§10.450 Geographic targeting.**

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[11] Available at: < http://www.usatoday.com/story/news/nation/2013/09/03/wireless-emergency-alert-system-flaws/2757875/ >.

[12] Available at: < http://forum.xda-developers.com/showthread.php?t=1098821 >.

[13] Available at: < http://offgridsurvival.com/governmentcellphonealerts/ >.

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 to the alert area as specified by the Alert Originator. A Participating CMS Provider must transmit any Alert Message that is specified by a geocode, circle, or polygon to an area not larger than the provider's approximation of coverage ~~**for the Counties or County Equivalents with which**~~ of that geocode, circle, or polygon intersects. If, however, the propagation area of a provider's transmission site exceeds the geocode, circle, or polygon, ~~**a single County or County Equivalent**~~ a Participating CMS Provider may transmit an Alert Message to an area not exceeding the propagation area. If, however, the propagation area of a provider's transmission site is less than the geocode, circle, or polygon, a Participating CMS Provider may transmit an Alert Message to the coverage area.

2. The current CMSP infrastructure based calculation of the WEA alert broadcast area using polygons continues to be the best solution for WEA geo-targeting.
3. Mobile device assisted geo-targeting has many major technical issues and challenges, and should not be considered as an enhancement to geo-targeting of WEA messages.
4. The latitude and longitude coordinates for Alert Area polygons and circles should be limited to three (3) decimal places.
5. The Alert Originators and FEMA IPAWS need to evaluate potential new functionality for nested polygons with different WEA Alert Messages in each polygon (clause 5.4.4) for development in regulations, standards, and CMSP infrastructure.
6. Alert Originator software must be enhanced so that overlapping polygons are not permitted.

The conclusion of this feasibility study does not recommend any modifications to the existing WEA rules or standards beyond changing 47 CFR 10.450 to support geo-targeting below the county level, in line with existing implementations. If, through FCC action, corresponding rule changes are made, or if other recommendations specified in this feasibility study are adopted through WEA stakeholder consensus, implementation of those changes will require the Alert Originator and cellular industry to undertake necessary standards changes to OASIS, ATIS, and 3GPP standards, followed by modifications to the “A” and “C” interfaces between the Alert Originator systems and the FEMA IPAWS Federal Alert Gateway and the CMSP Gateway, and modifications to CMSP infrastructure and mobile devices. Related enhancements by the Alert Originator procedures and equipment will also be required for some of these items.

# Annex A: Calculation of Polygon Centroid

(informative)

This informative annex describes the methodology for the calculation of the centroid of a polygon.

As described in clause 4, the determination of centroids may be needed in the calculation of the alert and coverage areas. In 1988, Paul Bourke of the University of Pennsylvania School of Engineering and Applied Science defined the equations for the calculation of the centroids of polygons[14]. These equations have been the basis for the centroid calculation procedures in C++, JAVA, and other programming languages.

If each point of the polygon is defined as a coordinates ($x_i$, $y_i$), then the equations for the calculation of the centroid coordinate ($C_x$, $C_y$) would be as follows:

$$C_x = \frac{1}{6A}\sum_{i=0}^{n-1}(x_i + x_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

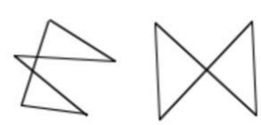
$$C_y = \frac{1}{6A}\sum_{i=0}^{n-1}(y_i + y_{i+1})(x_i y_{i+1} - x_{i+1} y_i)$$

Where A in the above equations is the signed area of the polygon as calculated by the following equation:

$$A = \frac{1}{2}\sum_{i=0}^{n-1}(x_i y_{i+1} - x_{i+1} y_i)$$

These equations do not work for polygons with crossing lines. The Paul Bourke paper[14] states the following:

> The only restriction that will be placed on the polygon for this technique to work is that the polygon must not be self intersecting, for example the solution will fail in the following cases.



[14] Paul Bourke, Calculating The Area And Centroid Of A Polygon, University of Pennsylvania School of Engineering and Applied Science, July 1988.