WEA Precise Geo-Targeting Using Hybrid Technology

The WARN Act and Local, State and Federal public safety agencies request improvements to geo-targeting of alerts. Specifically, Public Safety requests the ability to determine geo-granularity based on the type of alert for target area within a city block. In order to achieve this level of specificity we recommend WEA leverage the location-based technology within mobile devices. With the device, WEA can significantly enhance alert accuracy down to sub cell sector level by using both network based and device based geo-targeting algorithms. A small team of 3-4 engineers working on a proof of concept for this solution determined that these changes can be done using existing WEA systems, standards, and devices and can provide a demonstration within 90 days.

Comtech (formerly TeleCommunication Systems) is implementing a hybrid geo-targeting solution that uses both the network based geo-targeting algorithm down to the cell sector level accuracy and a mobile device application capable of determining its own precise location to perform a precise geo-targeting for a WEA alert. This solution therefore consists of two steps. The first step is performed in the CBC where the alert area polygon is used to determine what cell sectors are affected by a particular alert. Once the cell sectors are determined, CBC submits the alert along with the alert area polygon points to the mobile devices that are covered by the selected cell sectors. Cell sector based geo-targeting is important as it will limit the cell broadcast to only the concerned area as well as to avoid under-alerting subscribers in the desired alert area. The second step is performed in the mobile device application layer where it determines if the device is located inside the alert targeted area. In the future this application/software can be an imbedded app/software at either the operating system or application layer in the device.

Figure 1 Hybrid Solution Map below illustrates the importance of the hybrid system to lower under-alerting by including those towers in the area that could have users located in the polygon. Then the mobile device, with its GPS coordinates determines if it is inside or outside the target area polygon and alert the user within the defined alert area/polygon.

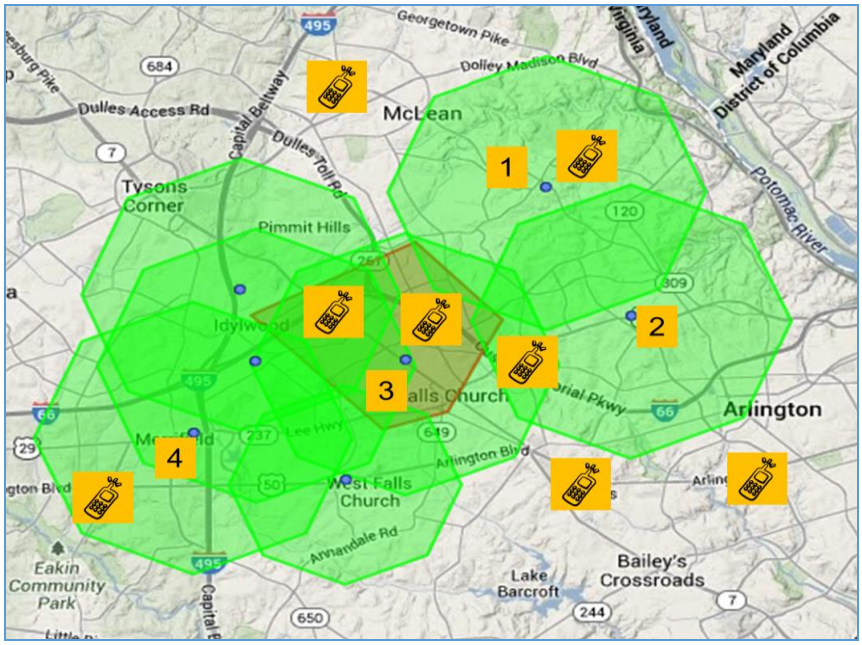

Figure 1 Hybrid Solution Map

To add the device's ability to geo-fence alert messages with WEA will require software changes to the wireless network and wireless device. These changes are supported by existing 3GPP standards and existing capabilities in the device. As a result of these standards and capabilities already existing, the cost and time to implement them into WEA are low. For the proof of concept effort, modification to the existing CBC software and a new CB App interface in the device will take approximately 90 days to write, test and deploy. The device App that handles geo-targeting using GPS location after the reception of a CB message is already written. For the production hybrid solution, the software changes can be summarized as follows:

Network: Expand the Alert Message to Convey the Alert Polygon to the Device

CBC: Using the existing 3GPP standard 23.041 and 23.038 cell broadcast that can concatenate up to fifteen pages. To add further capacity, 3GPP Standards 23.041 and 23.042 can be used to compress the file at the CBC.

Device: Introduce an App in the device (either as a native App or downloadable) to monitor the CB reception, receive the alert message and alert polygon and perform self-geo-targeting and alerting the user.

For the purpose of the proof of concept, the team is using an existing legacy version of cell broadcast where WEA message is limited to 90 characters. Changes for the CBC consist of using two WEA messages to deliver the same alert. The first message will carry the actual WEA message and the second alert will convey the alert target polygon to the device.

In the device, a function will be introduced to receive the alerts from the radio network and an API is provided to call the geo-targeting App to perform geo-targeting and to alert the user based on the existing J-STD-100, device behavior standard.

In this example we use two cell broadcasts to increase the total characters of alphanumeric text to 180. (If compression is used, decompression software would also need to be added). There are two Apps. The first App shall be responsible for CB API interface management. It shall monitor the CB channel, consolidate the messages received for the same alert and send a single message that has both the alert text and polygon coordinates to the second component over an API. The second App shall be responsible for the reception and processing of the formatted alert message and perform self-geo-targeting and alert the user. The following diagram in Figure 2 shows the high level architecture of the App.

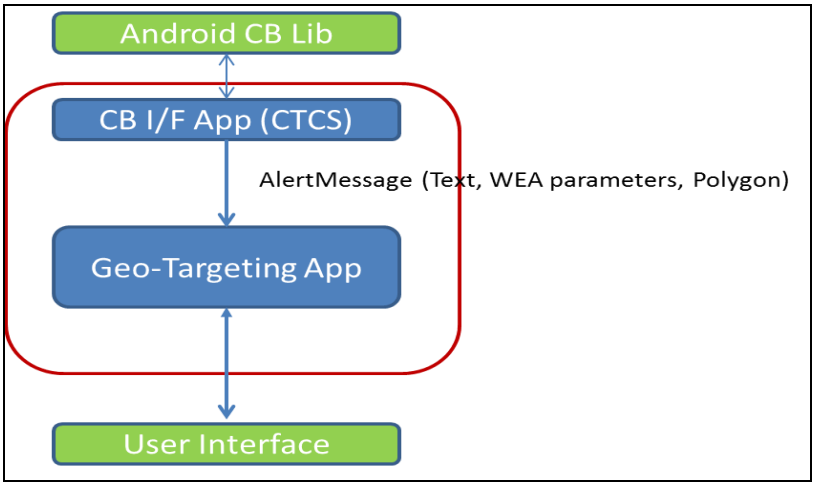

Figure 2 App High Level Architecture

Figure 3 is a call flow showing how alerts are processed using the hybrid solution proof of concept.

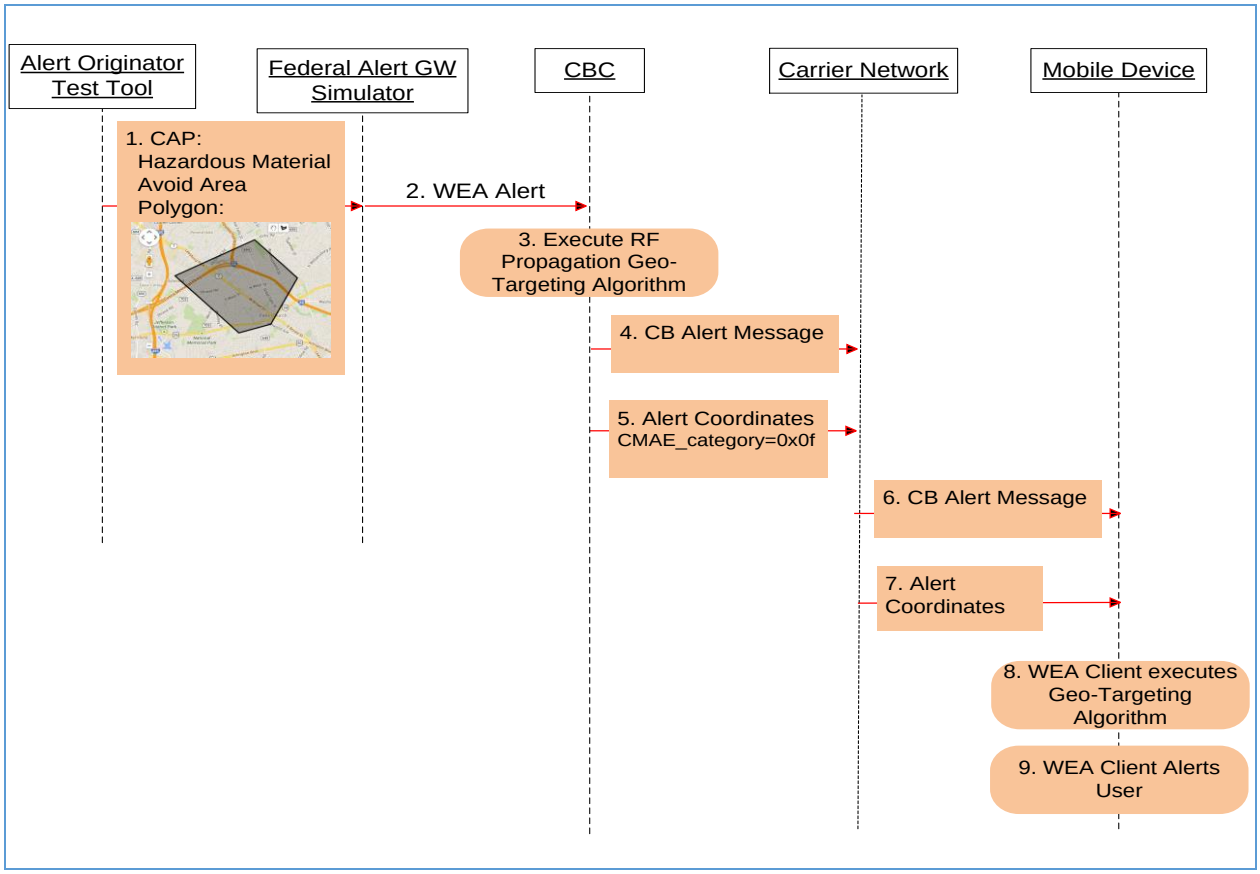

Figure 3 Cell Broadcast Alert Call Flow

1. The Alert Originator tool is used to define the alert message and the area to be targeted based on the CAP 1.2 standard. The alert area is defined by drawing a polygon over the map where the alert is targeted.
2. The alert message is submitted and is received at the Federal Alert GW simulator. The Federal Alert GW simulator validates the message; converts the CAP message to the J-STD-101 "C" interface message and sends it the CMSP GW/CBC.
3. Upon the reception of the "C" interface message, the CBC executes the enhanced geo-targeting by comparing the target area polygon to the cell tower RF propagation polygons previously imported in the database.
4. The results of the execution outputs a list of the cell tower sectors whose RF propagation touches or overlaps the targeted area polygon. The CBC formulates the CB Alert message with the alert MessageID and sends it to the carrier' radio network with the list of the targeted cell tower sectors.
5. The CBC formulates the alert area polygon with up to 6 LAT/LON points and sends the Alert Coordinates message to the radio network using the same MessageID as in step 4.
6. The carrier network delivers the alert message to the handset as soon as it receives.
7. The carrier network delivers the alert area polygon coordinates message to the handset as it receives.

Note: Either CB Alert Message or Alert Coordinates message can be received in the handset first.

8. Upon the reception of the messages from the carrier network, the mobile device WEA CB I/F App shall process the messages as follows:
    a. The WEA client shall distinguish the CB Alert Message from the Alert Coordinates message by checking the value of the alert category parameter. If the category indicates "additional info", then the content of the message is Alert Coordinates, otherwise, it is the regular CB Alert Message.
    b. If CB Alert message is received first, the WEA client shall wait for the Alert Coordinates message before proceeding to step 9.
    c. If the Alert Coordinates message is received first, WEA Client can proceed to perform geo-targeting as in step 9.
    d. In either case, a configurable timer shall be set to wait for the other message. If the pending message is not received within the timeout, an error shall be displayed to the user indicating the missing message (either the CB message or the Coordinates message)
    e. Once both messages are received, the CB I/F App will formulate them into a single message containing both the WEA text, parameters (e.g. alert category), and alert area polygon and send the WEA message to the Geo-Targeting App by calling the AlertMessage function.

9. Using its GPS or Wifi based location, the mobile device Geo-Targeting App determines if its LAT/LON coordinate is inside the target area polygon. If so, it will alert the user according to the WEA mobile device behavior specification J-STD-100 (i.e. WEA alert tone, vibration and cadence). Otherwise no alert will be emitted to the user. If it is outside the target area, no alert will be generated.

Minimizing Under and Over Alerting

The goal of the hybrid solution is to minimize over-alerting and under-alerting with an approximate precision or margin of error of 11 meters (Polygon is defined with 4 decimals for latitude and longitude). This means that if an alert is delivered to the targeted area, the mobile device may miss or receive the unintended alert when it is situated less than 11 meters of the target area boundary. The following figures illustrate the expected results in the field.

Figure 4 shows an expected result of a hybrid solution for a small target area that is less than a square mile. The indicated target area has an approximate area of 0.8 square mile with a perimeter of 4.25 miles. The borders of the target area are shaded in blue indicating the uncertainty area having 11 meters in width that represents a margin of error of WEA alert reception. This uncertainty area will produce a theoretical value of 3.63% of margin of error with respect to this target area. This means that all handsets that are located at least 5.5 meters from the border and inside the target area will receive the alerts, those that are at least 5.5 meters outside the border will not receive the alert and the handsets that are at the border may experience over-alert or under-alert.

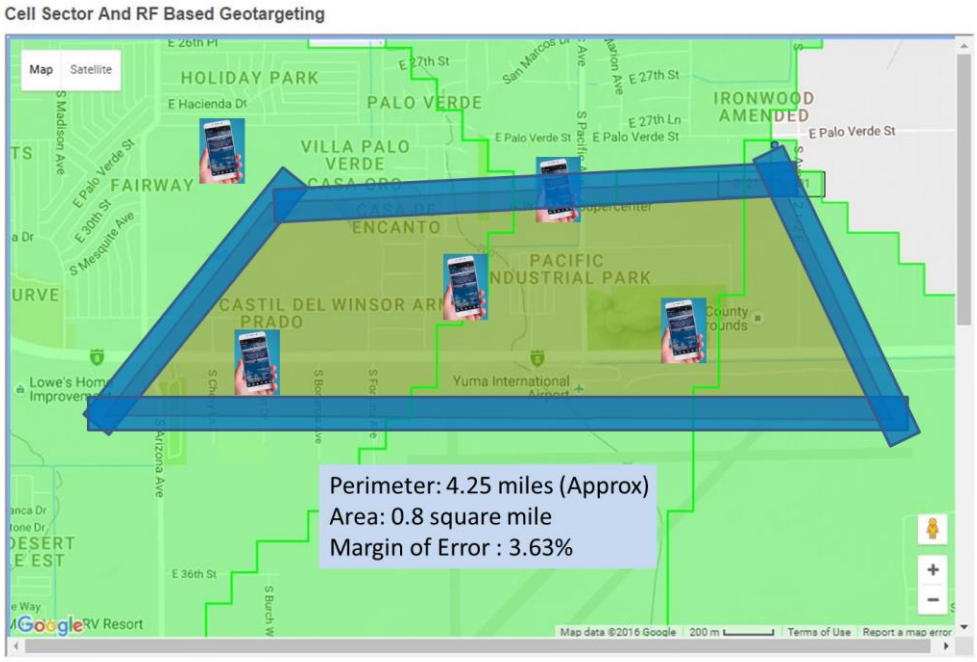

Figure 4 Small Target Area Expected Result

Figure 5Figure 4 shows another example of an expected result of a hybrid solution for a medium size target area that has an approximate area of 13.7 square miles with a perimeter of 18.1 miles. In this case the uncertainty area around the border is 0.124 square miles which should produce a theoretical value of 0.9% of margin of error with respect to this target area. Note that the areas in green represent impacted coverage of cell sector RF footprints resulting from executing the cell sector RF based geo-targeting algorithm. Legacy WEA capable mobile devices should receive the alert if they are located in the green area at the time of alert delivery. Mobile devices with geo-targeting App installed will only be alerted if they are inside the target area.

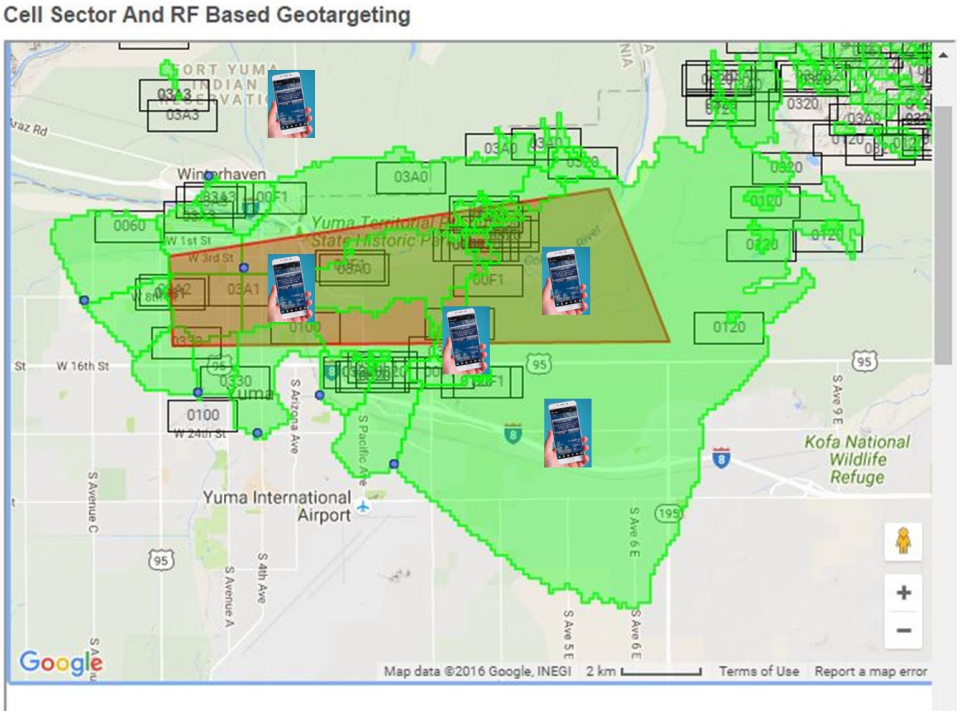

Figure 5 Result Medium Size Target Area Expected Result

As the alert target area increases, the margin of error becomes smaller as shown in the following table.

Perimeter (miles)	Target Area (sq miles)	Uncertainty Area	Margin of Error
4.25	0.8	0.029	3.63%
18.1	13.7	0.124	0.9%
43	110	0.294	0.3%

Assumptions

The intention of the proof of concept is to show that it is technically and economically feasible to implement a fine granular hybrid solution using existing technology in a short period of time. As such, it is not designed to cover all alert cases. With this in mind, the following assumptions shall be made

- The research project shall be conducted using the existing TCS WEA CMSP GW and CBC, code as the base.

- The research project shall be conducted using the Comtech TCS/PGAlert Alert Originator test tool as well as the Federal Alert Gateway simulator.
- The Air interface technology shall be CDMA
- The mobile device shall be Android OS based
- The accuracy shall be limited to the 4th decimal place of the latitude and longitude coordinates allowing precision range of up to 11 meters.
- The alert message shall contain only one target area polygon of 6 vertices.
- The research project is estimated to take 90 days based on the assumption that the changes are based on the technical effort and are not impacted by administrative issues.

Impact on the Wireless Network

For the proof of concept solution, the only impact to the wireless network is to double the size of message. This is achieved by sending the same 90-chars CB message twice. One to allow display of the normal WEA alert and the other is not displayable and is inhibited at the device.

For the full production version of hybrid solution, the additional payload to carry the polygon will require the CB to increase its message length to an additional 120 chars to support an 8-vertice polygon without compression. Therefore, a message length of 280 chars should be sufficient to support a typical WEA alert with an 8-vertice polygon.

To prevent the handset from querying the carriers network for location determination, the handset should be limited to use its local most recent GPS or Wifi information only for geo-targeting. In most cases, the most recent location information is usually current location as the device updates its location continuously throughout the day.

Conclusion

The technical feasibility of adding the device to WEA has not been disputed on the record of the FCC's NPRM 15-91. However, there are questions on the timeline to implementation assuming the need for new standards. As the changes to WEA to enable device based are software changes at the CBC and handset and a significant portion of this software is already written, we plan to demonstrate a device based WEA using existing technology and standards in 90 days.