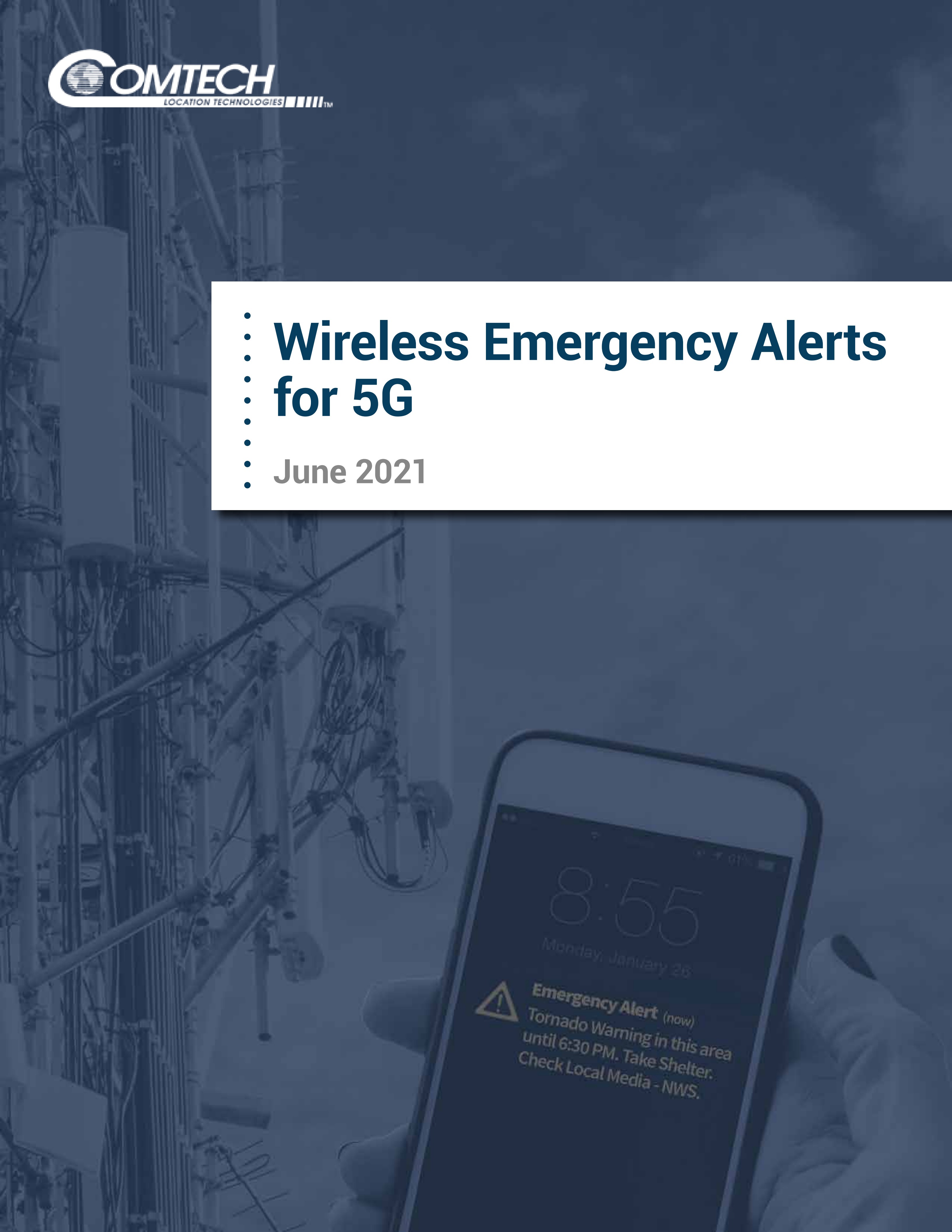
COMTECH LOCATION TECHNOLOGIES

Wireless Emergency Alerts for 5G

June 2021



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Introduction

As a result of widespread mobile phone use, the latest development in standardized alerting technology emerged to deliver geo-targeted emergency alerts to the public using cell broadcast technologies over cellular networks. Emergency alerts can now reach the public with mobile phones almost anywhere, at any time. Beginning in 2008, the US has taken the lead in using cell broadcast technology to develop advanced emergency alerts service using cellular networks known as Wireless Emergency Alerts (WEA), deployed in 2012. Several other developed countries followed suit to provide emergency wireless service—more commonly known as the public warning system (PWS) in Europe—to the public. In 2014, Canada also adopted the technology; they developed and deployed the Canadian version of WEA called Wireless Public Alert Service (WPAS) in April 2018. WEA began when 2G technology was still widespread in the majority of mobile networks in North America. Since then, mobile technology has evolved to 3G, 4G, and most recently 5G, in less than 12 years. This rapid change presented a challenge for WEA, as a public safety service, to support all of the technologies within the same system.

To understand how WEA is implemented in 5G, it is necessary to understand how WEA was implemented in previous technologies, or better yet, how WEA is implemented in general. The majority of the overall system, however, remains unchanged, with the exception of the last mile where air interface is situated.

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WEA System Architecture

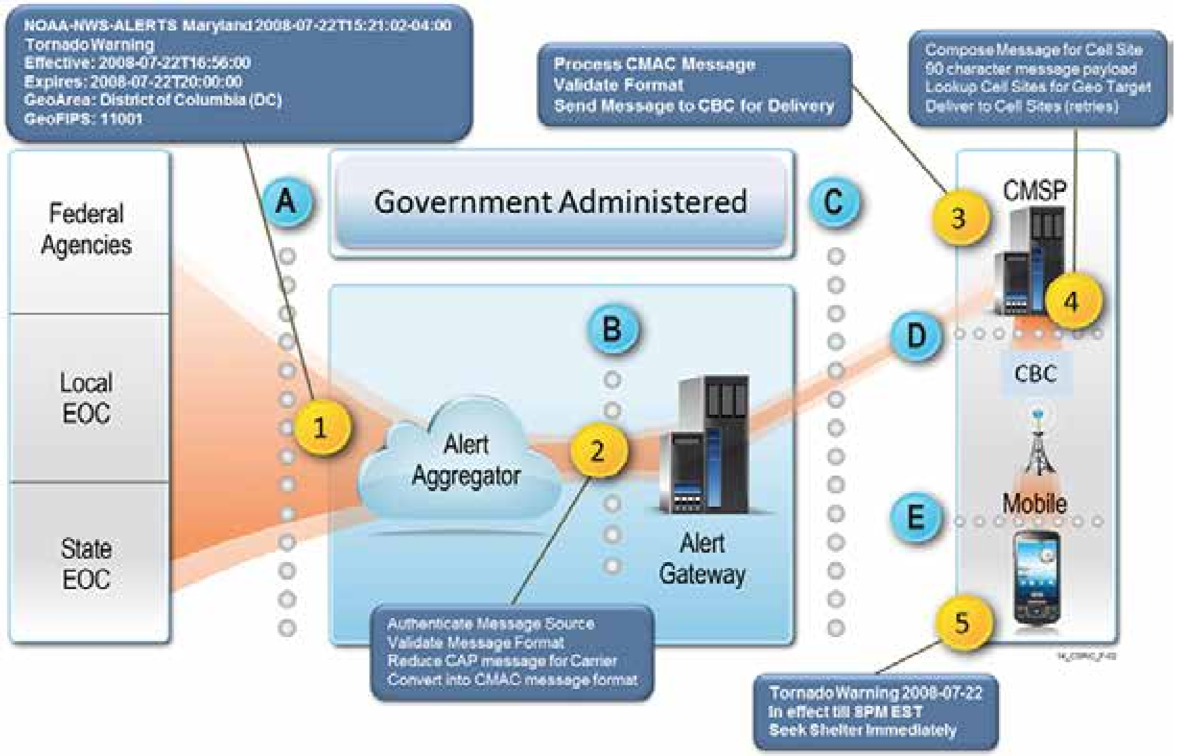

Figure 1 *- Wireless Emergency Alerts System. SOURCE: Comtech Telecommunications Corp.*

Figure 1 shows the WEA system architecture based on standards developed by the Alliance for Telecommunications Industry Solutions (ATIS), a standards organization.

Entities from reference points A to C are government owned and operated. The carriers are responsible for entities after point C, including the Commercial Mobile Service Provider (CMSP), the Cell Broadcast Center (CBC) and the radio networks.

There are currently five types of emergency alert messages that are delivered to the public:

Message ID	Type of Alert
4370	Presidential-Level Alert
4371-4372	Extreme Threat to Life and Property
4373-4378	Severe Threat to Life and Property
4379	AMBER (Child Abduction Emergency)
4397	Public Safety Message

The Message IDs are defined by the standards organization to identify each type of message. The message ID is used by the system to provide appropriate treatment for each type of message as they are delivered to the handset; for instance, a Presidential-Level alert message type cannot be opted out by the recipients and the system must give priority in terms of delivery speed over any other message type.

Typical Message Flow

WEA message delivery over wireless mobile system's cell broadcast technology is quite straightforward. The emergency alert issuer submits a single message to the mobile networks which then performs geo-targeting – determining which cell tower antennas (AKA cell sectors) are located inside the alert target area and broadcast the alert to all the targeted cells/sectors simultaneously. Figure 2 describes the delivery of a WEA message under normal operating conditions. Note that a WEA alert message does not preempt an active voice or data call on the mobile device.

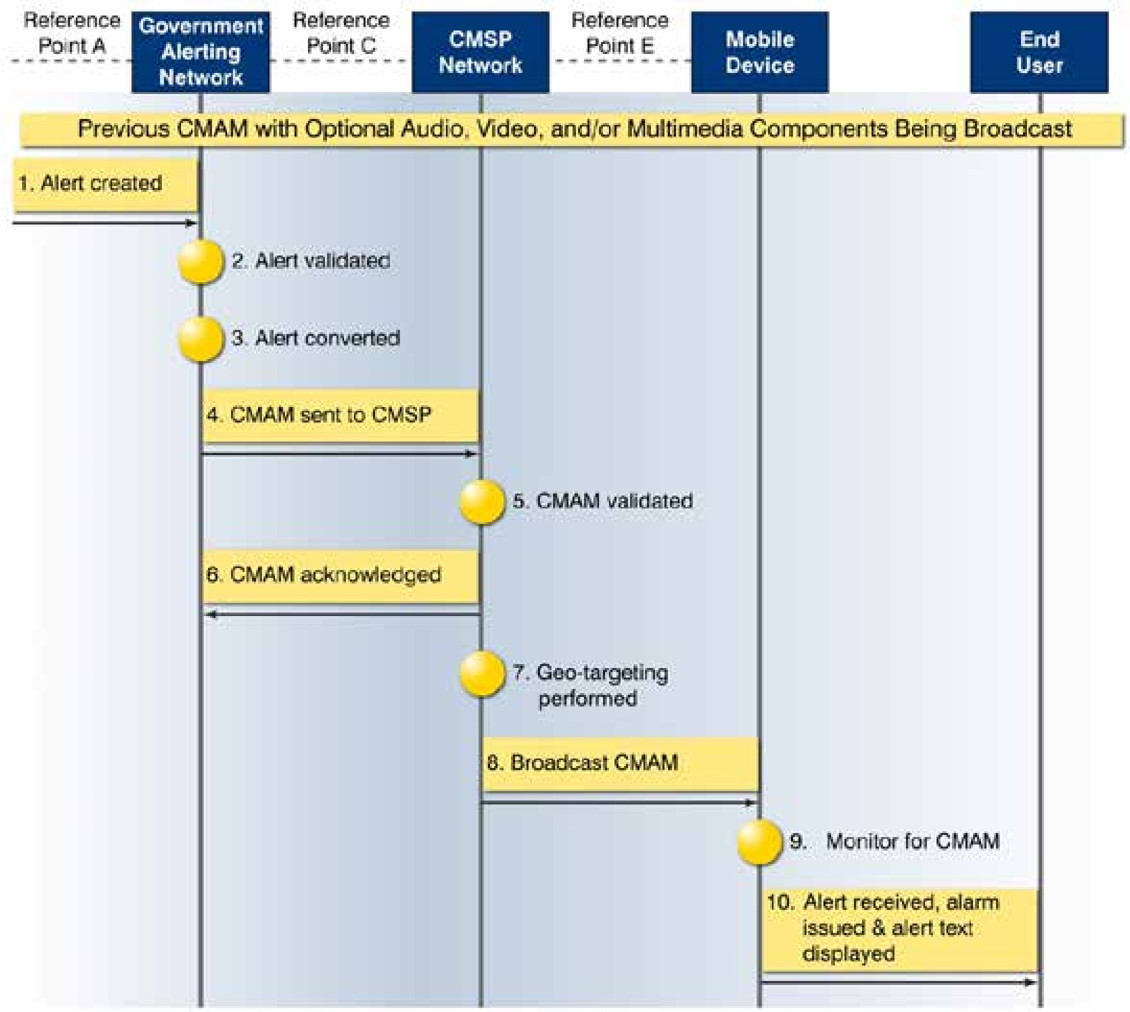

Figure 2 *- Normal WEA Alert Message Flow*

Messsage Flow

Figure 2 is a generic message flow and technology agnostic, i.e., it can be used to describe WEA message delivery on any cellular technology from 2G to 5G.

Geo-Targeting

A key functionality that any WEA system must provide is called geo-targeting. When an alert is issued by the alert issuer, an alert text is defined along with one or more *alert target areas*, usually in terms of circles or polygons. Typically, the alert issuer uses a tool to draw the alert target area on a map to define the area where the emergency alert is targeted. Figure 3 and Figure 4 show samples of the result of using an alert generating tool to define target alert areas. The images show the affected cell sites and coverages providing an approximation where the alert would reach the public. When the defined alert message along with the alert target area reaches the WEA system, it identifies the cell tower sectors (cell IDs) that are located within the boundary of that alert target area. This process occurs in step 7 of Figure 2. The result of step 7 outputs a list of cell sectors that the WEA system must deliver to the radio networks instructing them to deliver the alert to those cell sectors.

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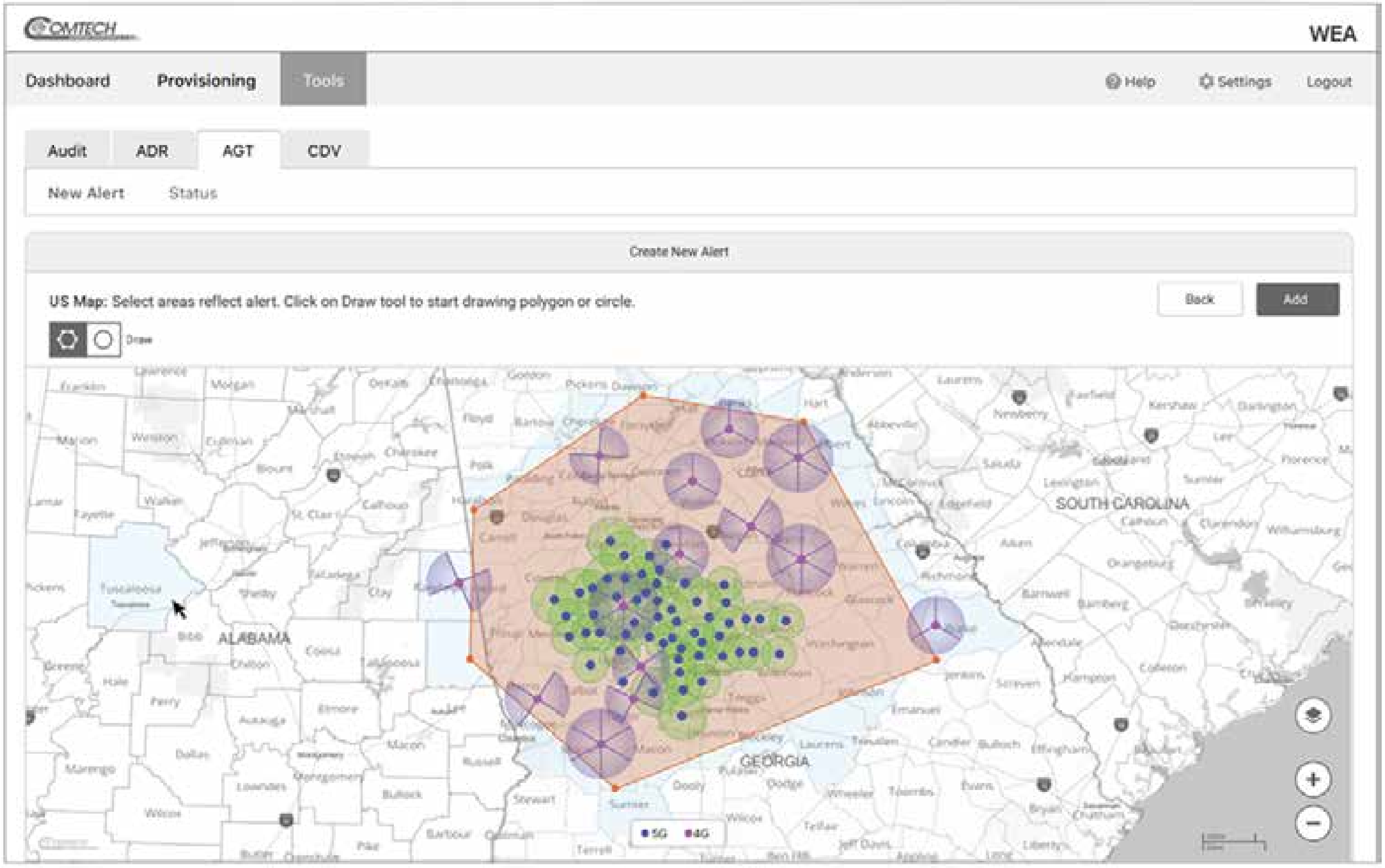

Figure 3 *- Target Area with Cell Coverage View - Polygon*

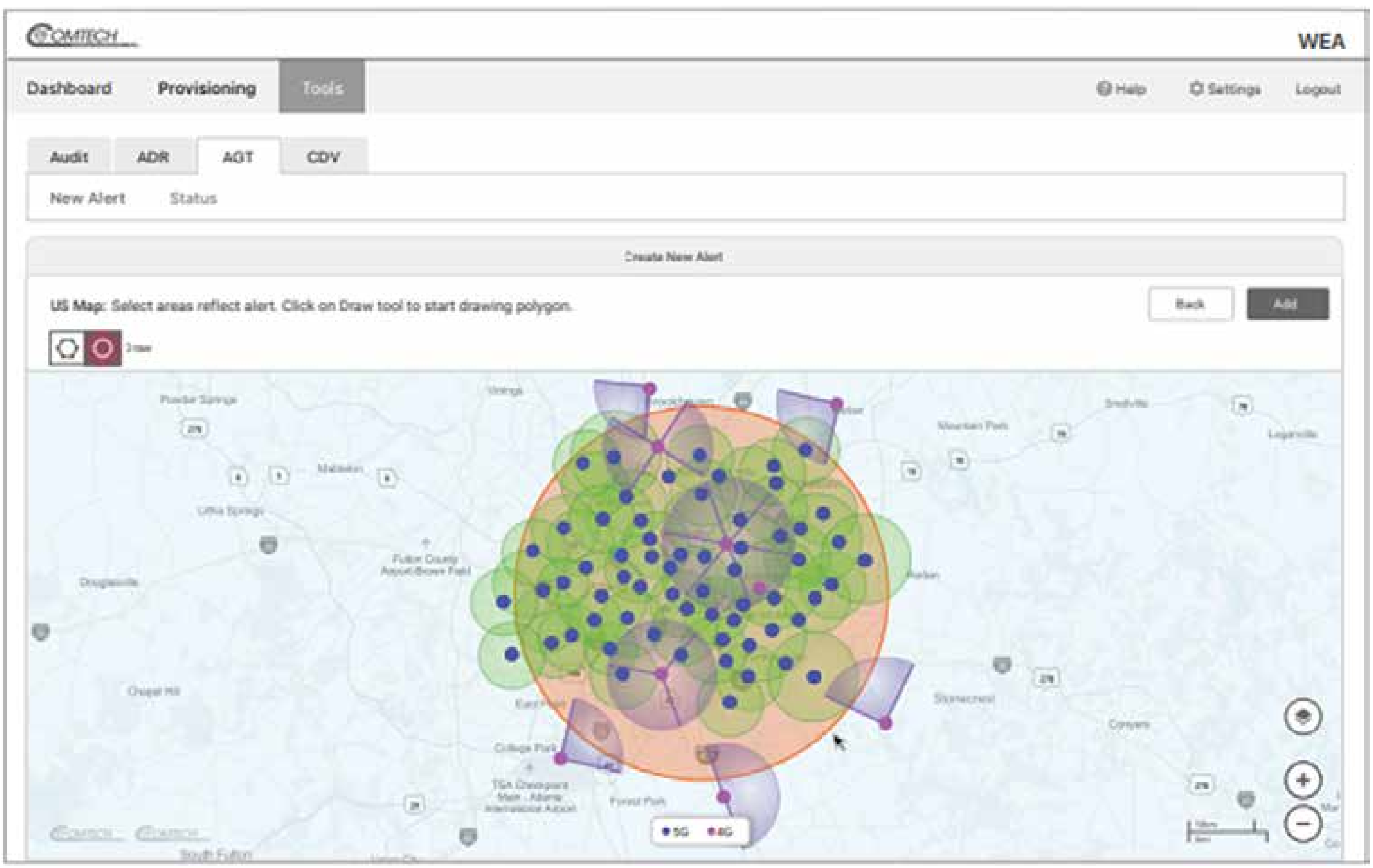

Figure 4 *- Target Area with Cell Coverage View - Circle*

Step number 8 is where the details differ for different technologies. This is where the CBC sends a WEA message to different radio access nodes (RAN) depending on which technology WEA is being used. For 2G (GSM), CBC would send the message to the Base Station Controller (BSC), to Radio Network Controller (RNC) for 3G, to Mobility Management Entity (MME) for 4G, and finally to Access and Mobility Management Function (AMF) for 5G.

Figure 3 illustrates what protocols and standards being used as the alert traverses the system from the alert issuer to the recipient.

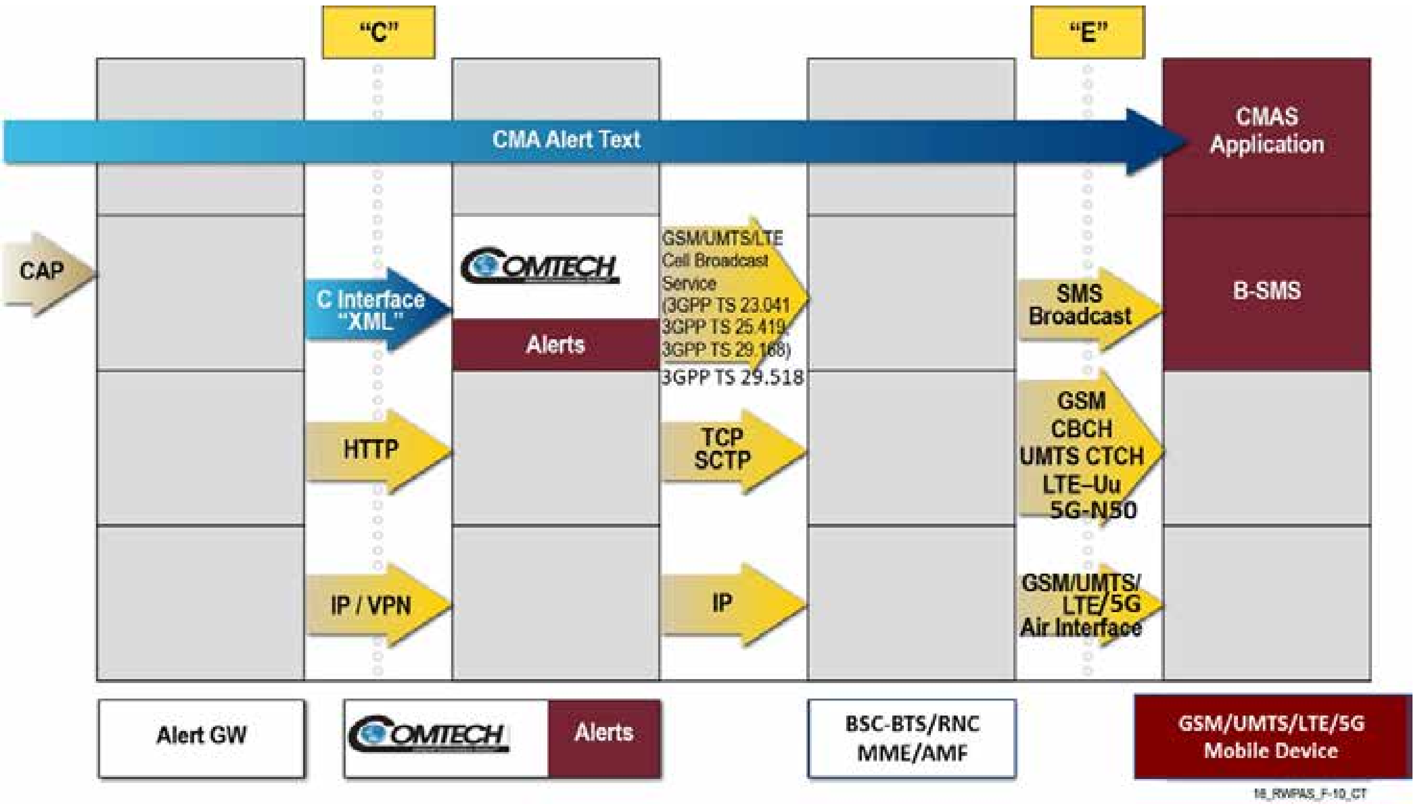

Figure 5 *- WEA Protocol Layers Traversal*

5G Entrance

The introduction of 5G technology provides enormous benefits to mobile applications including significantly higher capacity by tenfold from 4G's and up to 100 times 4G's speed. 5G provides low delivery latency, with much higher density of devices serviceable per geographical area. This has become possible due to the use of the Orthogonal Frequency Division Multiplexing (OFDM) technique to modulate the available radio frequency. This technique allows more efficient use of available frequency bandwidth and reduces radio interference, both common issues in crowded wireless communication applications.

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5G is based on Service Based Architecture (SBA), which provides a modular framework where applications can be deployed and leverage the services and components of other functions to complete a desired function through the use of common Application Programming Interfaces (APIs). In 5G, the term Network Nodes has evolved to become Network Function.

The 3GPP defines a Service-Based Architecture, whereby the control plane functionality and common data repositories of a 5G network are delivered by way of a set of interconnected Network Functions (NFs), each with authorization to access each other's services. In 5G SBA, every Network Function acts as a service producer and a service consumer for each NF. All NFs communicate with each other using one of two mechanisms:

- **Request-Response** mechanism - A consumer NF (e.g., CBCF) requests a producer NF (e.g., AMF) for services over HTTP/2 request, and the producer NF complies.
- **Subscribe-Notify** mechanism - A consumer NF subscribes to certain events of the producer NF, and the producer NF notifies the consumer NF once the particular event occurs.

One important operational impact to WEA in 5G is the expected increase of cell sites due to the deployment of small cells into the network. An increase of small cells will also improve position accuracy without the use of device-based geofencing[1] in many use cases since cell broadcast does not require the high precision that many location-based services require. Small cells have a range slightly higher than Wi-Fi, with a typical range of 15 to 200 meters outdoors and 10 to 25 meters indoors. With this range, targeted alerts will become much more accurate and significantly reduce over-alerting.

From an operation standpoint, the increase of the number of small cells would require more provisioning efforts into the WEA database and maintaining of the cell data information. The new interface that carries the list of cell IDs from the CBC to the network need to be updated to allow the increased number of cell ids to be transferred.

The 5G Network Functions and Interfaces for WEA

For 5G, a new NF called Access and Mobility Management Function (AMF) was introduced. AMF is responsible for the mobility management function and UE registration in 5G. The CBC interfaces with the AMF to deliver alerts to the cell towers connected to the AMF. The 3GPP standards organization offers two methods to implement WEA in 5G. The first option (Figure 4) is to use the PWS-IWF interworking function as a new node that interfaces the LTE-based CBC to the new AMF. The second option (Figure 5) is to have a new CBCF that interfaces the AMF directly.

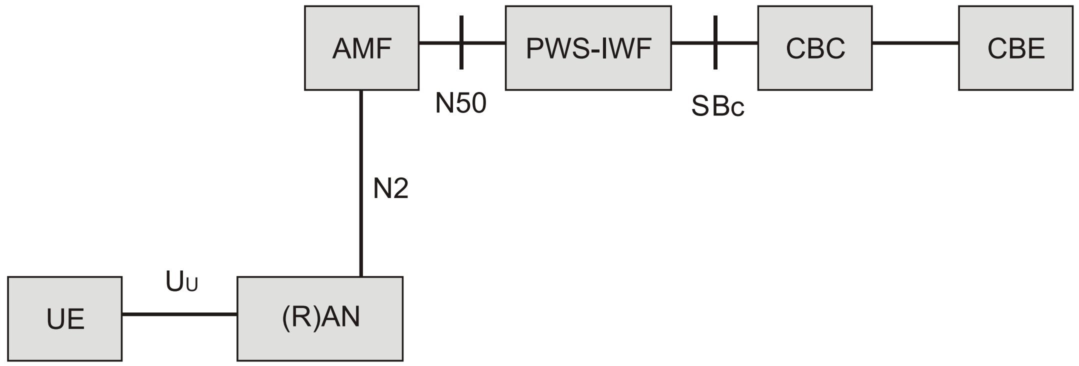

Figure 6 *- 5G WEA Option Based on PWS-IWF. SOURCE – 3GPP TS 23.041 V16.4.0 (2020-06)*

[1] Device-Based Geo-Fencing is the capability of the location-aware mobile device to determine, using its own position, if it is currently located inside an alert target area at the time of the alert reception. The user will only be notified if the device determines that it is located inside the alert target area.

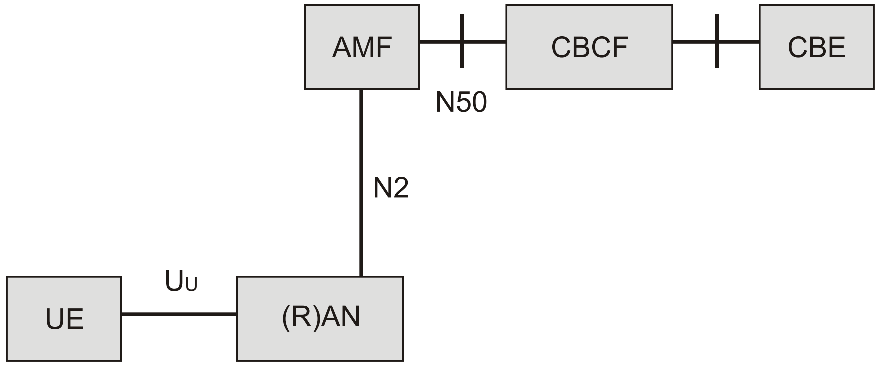

Figure 7 *- 5G WEA Option Based on CBCF. SOURCE – 3GPP TS 23.041 V16.4.0 (2020-06)*

Ultimately, both options require implementation of the N50 interface to the AMF. The N50 interface is defined by a new 3GPP technical specification, 3GPP TS 29.518, which specifies the service-based subscription method to request service from the AMF. The transport used is HTTP/2, as defined in IETF RFC 7540.

CBCF uses both Request-Response and Subscribe-Notify operations over HTTP/2 to request services from the AMF. The Request-Response operation (NonUeN2MessageTransfer) is used by the CBCF to send the POST command to the AMF to carry the Warning Request Transfer Procedure to initiate the broadcasting procedure to the RAN (gNB). The POST command carries the list of targeted cell IDs/sectors that the AMF uses to instruct the gNB to broadcast the emergency alert information to all the mobile devices currently located in the targeted cell/sectors. The Subscribe-Notify operation (NonUeN2InfoSubscribe) is used by the CBCF primarily to request the AMF to notify it of the final outcome of broadcasting procedures from the gNBs (i.e., which cells successfully received the alerts and which cells did not). Once the AMF receives the broadcasting results from the gNBs, it relays the results back to the CBCF.

Summary

The WEA system, like the majority of network applications, continues to evolve alongside the cellular air interface technology. On average, air interface technology is replaced approximately every 10 years, beginning with 1G back in the early 1980s to 5G in the late 2020s. WEA was introduced in 2012 while 2G and 3G were still in use; it has had to evolve to adapt to the many changes of the last decade to support different air interface technologies, from 2G to 5G.

Fortunately, WEA architecture was designed in a modular fashion; changes to the air interface do not affect the entire system, only the interface to the radio networks. Some vendors' CMSP/CBC designs, such as Comtech's WEA, went further in terms of flexibility, allowing multiple air interfaces to coexist in the same component without the need to deploy separate CBCs to support separate air interfaces.

In 5G, CBC has evolved to solely a network function CBCF. It is simply the consumer of one of the many services offered by AMF using the REST-based API to request the needed service. The interfaces to the RAN have been simplified using the more robust and secure HTTP/2 methods to request the AMF to send cell broadcast emergency alerts to the mobile handsets and to obtain results of the broadcasted procedures from the gNBs.

Thanks to air interface technique improvements in 5G, more alerts can be delivered faster and more efficiently to people in harm's way, ultimately resulting in more lives being protected.

Glossary of Terms

AMF	Access and Mobility Management Function
API	Application Programming Interfaces
ATIS	Alliance for Telecommunications Industry Solutions
BSC	Base Station Controller. 2G RAN.
CBC	Cell Broadcast Center
CBCF	Cell Broadcast Center Function
CMAS	Commercial Mobile Alert System. Used interchangeably with WEA.
CMSP	Commercial Mobile Service Provider. FCC term for mobile carrier.
GSM	Global System for Mobile Communications. 2G standards developed by the European Telecommunications Standards Institute.
IWF	Interworking Function
MME	Mobility Management Entity.
NF	Network Functions
OFDM	Orthogonal Frequency Division Multiplexing
PWS	Public Warning System
RAN	Radio Access Nodes
RNC	Radio Network Controller. 3G RAN.
SBA	Service Based Architecture
WEA	Wireless Emergency Alerts.
WPAS	Wireless Public Alert Service. Canadian equivalent of WEA.

About Comtech Location Technologies

The Location Technologies group of Comtech Telecommunications Corp. is a leading provider of precise device location, mapping, public safety, and messaging solutions. Sold around the world to mobile network operators, government agencies, and Fortune 150 enterprises, our platforms allow you to locate, map, track, and message.

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