Communications Security, Reliability and Interoperability Council

CSRIC

June, 2018

WORKING GROUP 2
Comprehensive
Re-imagining of Emergency Alerting

Final Report – Comprehensive Re-imagining of Emergency Alerting

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1 Results in Brief

1.1 Executive Summary

The CSRIC VI Working Group 2 Report on a Comprehensive Re-imagining of Emergency Alerting examines the various current and future methods for disseminating emergency alert information to the public. The subject encompasses a wide range of emergency information sources, many techniques of disseminating alerts through networks, a growing number of presentation methods, and a disparate user population with different language needs and abilities to perceive audio and visual media. The committee explores the common threads and makes recommendations on moving forward.

Although the process of moving forward may involve technological advances under development or nearing deployment, the committee also looked at one of the earliest of the alerting technologies, the Emergency Alert System. Recommendations are made for continuing to improve this system, which notably has some intentionally lower-complexity aspects to further the FCC's and FEMA's responsibilities in providing Presidential communications and continuity of government tasks.

The committee makes recommendations in the areas of improved geotargeting, multimedia, increased resiliency, redundancy, and accessibility. It also recommends extending outreach to encourage better integration of emergency warning systems to consumer electronics for personal, home, and in-vehicle use.

2 Definitions

Activate: *(verb)* Describes the process of originating the transmission of the EAS header codes, attention signal, emergency message and EOM code that also complies with the visual message requirements of 47 C.F.R. § 79.2(a)(2).

Authority: *(noun)* Describes the source of responsibility and the right to activate or request activation of an emergency alert on the relay network, utilizing the traditional or legacy EAS dissemination or the Common Alerting Protocol. The source of authority for EAS and WEA resides with federal, state, county and local emergency management and public safety officials as outlined in EAS plans and WEA rules.

Alert: (*verb*) A communication on something that has a known potential to happen and poses a public safety risk; an encompassing term that includes advisories, watches and warnings. The following definitions for Statement, Advisory, Watch, and Warning are intended to be generic. For example, NOAA's National Weather Service (NWS) has specific definitions for weather and hydrologic alerts which use these terms[1].

- **Statement:** A message containing follow up information to a warning, watch, or emergency.
- **Advisory:** A communication on something that is previously unexpected or unknown.

[1] See the NWS glossary at http://weather.gov/glossary and http://weather.gov/directives/010/010.php for details and policy on NWS use of these terms.

- **Watch:** A communication on an imminent but not current emergency hazard or threat.
- **Warning:** A communication that encourages recipients to take immediate protective actions appropriate to some emergency hazard or threat.
- For Wireless Emergency Alerts (WEA), FCC rules define the following classes of alerts:
  - **Presidential**: Alerts issued by the President
  - **Imminent Threat**: Alerts involving imminent threats to safety or life
  - **Amber Alert**: Urgent bulletin in the most serious child-abduction cases
  - **Public Safety Message**: An essential public safety advisory that prescribes one or more actions likely to save lives and/or safeguard property

Capability: *(noun)* An attribute describing the technical ability of an entity, possessing the equipment to activate code and analog or CAP message, upon the request of an authorized entity, on the relay network. This ability may reside with a government agency, a CAP vendor who provides this service or a broadcast entity. This relationship structure is outlined in the EAS plan.

Closed Circuit Test: *(noun)* Tests that do not reach the public, but do allow for reception by EAS participants for logging and evaluation.

Gatekeeper: *(noun)* The entity, as identified in the EAS plan, having ultimate authority to request activation (e.g. state/local emergency management, state police and local public safety) and the responsibility to ensure that the requested activations meet the standards of acceptability as to not saturate the system with unwarranted activations.

Notification/General Information: *(noun)* A communication relaying general information not related specifically to a public safety threat, such as general preparedness information

Originator: *(noun)* Refers to the authorized party who requests the activation of the legacy EAS, CAP message, or WEA. It specifically refers to the ORG code outlined in 47 C.F.R. § 11.31.

Relay Network: *(noun)* Describes the links and paths from warning origination points to EAS Participants for analog and CAP messages.

Response: *(verb)* A descriptive for the actions an emergency management asset brings to bear to manage an emergency to a quick and successful outcome.

Translation: *(verb)* The act of turning into a different language.

Wireless Emergency Alert: *(noun)* WEA is a public safety system that allows customers who own certain wireless phones and other enabled mobile devices to receive geographically-targeted, text-like messages alerting them of imminent threats to safety in their area.

3 Introduction

Table 1 shows a "big picture" view of public alerts, and its various facets and contexts. An alert is triggered by an event, which is then composed and disseminated using various dissemination technologies (see Section 6). Once the alert is received by its intended target, it will then be presented and potentially integrated with other relevant information.

Furthermore, there are several contexts to each facet of an alert. These facets include the policy and organizational aspect, the human factor, procedures, and technologies.

To understand and re-imagine emergency alerting, one must consider all the elements shown in the figure, and the important role each plays to ensure that an emergency alert is received by its intended target in a timely fashion.

The full analysis of all the elements in the table is a challenging task, which is beyond the scope of this group. Fortunately, a number of other organizations are actively analyzing parts of these facets and contexts. For the purpose of CSRIC VI WG2, we have focused our attention on the last three columns of the table. But, it is important to point out that collaboration between the various stake holders is critical to ensure that alerting system can fulfill its objectives end-to-end.

Table 1 - A "big picture" view of public alerts

Facets → Contexts:	Alert Triggering	Alert Composition	Alert Dissemination	Alert Presentation	Alert Integration
Policy and Organization	• Responsibilities • Appropriate use • Metrics of success	• Essential elements of information • Style and language	• Responsibilities at all levels • Access controls on delivery systems • Reciprocity on cross-jurisdictional warning	• Consistent presentation "style guides"	• Commitment to integrated warning • Education of officials • Planning at all levels
Human Factors	• Originator responsibility • Policy "top cover"	• Training and Exercise	• Training and Exercise	• Usability studies and standards	• Originator training • PIO and media training
Procedures	• Situational awareness • Inter-entity info sharing	• Forms and Templates	• Testing • Evaluation against metrics	• Consistent effectiveness studies	• Gap analysis • Comprehensive evacuation planning
Technologies	• Common operating picture • Sensors and monitors • Reporting and info sharing	• Usability • Consistency in tools • Interface standards	• Targetability • Reach and Coverage • Accessibility • Adaptability	• Individual media • Mass media • Public spaces • Languages, AFN, "mass personalization"	• Personalized contextualization of alerts against location, maps, plans, checklists, etc.

The recommendations in this report exemplify four trends related to public alerting:

1. **Technology advances are a catalyst for ongoing improvement to public alerting.** Electronic devices such as cell phones, cable boxes, and automotive infotainment systems are ubiquitous and continue to advance in technological capability.
    a. As alerting systems and alert-capable devices advance, they leverage alerting standards to ensure interoperability across alerting modes and consistency in the information delivered.
    b. Receiving devices leverage their location awareness to enhance the life and property saving potential of alerts. Processing of the alert on the device provides geographically relevant and actionable information that directs the recipient to

actionable behavior, e.g. to get out of harm's way, take cover and hold on, etc.
c. Advancements in technology and social science are revisited on a regular basis to assess the need for advancement in alerting capabilities. This work is performed by government chartered advisory groups as well as industry and academic bodies.

2. **The Internet of Things (IoT) is an emerging enabler that may enhance the life and property saving potential of alerts**. IoT includes physical devices, vehicles, appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which can enable these objects to connect and exchange data, which may be used to enhance the life and property saving potential of alerts. Enabling IoT for alerting, however, requires defining what capabilities of IoT can be leveraged for alerting, how such capabilities are managed & orchestrated, and how the data is communicated to an alerting authority/entity for validation and alert dissemination.

3. **Advancements in social science are a catalyst for ongoing improvement to public alerting.**
   a. Societal factors are a major driver of protective action-taking by the general public.
   b. Social media facilitates a dynamic exchange of information among and between the public and public safety officials, including crowd sourcing of emergency information.
   c. Advancements in social science are revisited on a regular basis to assess the need for advancement in alerting capabilities. This work is performed by government chartered advisory groups as well as industry and academic bodies.

4. **Accessibility is inclusive of all alert recipients to ensure the greatest possible understanding of alert information and to maximize any necessary protective action-taking by the public.** Traditional and emerging technologies should be leveraged to enhance multimedia presentation of alert information, convey equivalent information for people with disabilities, and provide alert information in multiple languages.

3.1 CSRIC Structure

Table 2 - CSRIC VI Structure

Communications Security, Reliability and Interoperability Council VI		
Working Group 1: Transition Path to NG911	**Working Group 2: Comprehensive Re-**	**Working Group 3: Network Reliability and Security Risk Reduction**

Chair: Mary Boyd, West Safety Services ***FCC Liaisons***: Tim May and John Healy	**imagining of Emergency Alerting** ***Chair:*** Farrokh Khatibi, Qualcomm Technologies, Inc. ***FCC Liaisons***: Steven Carpenter and Austin Randazzo	***Chair*****:** Travis Russell, Oracle ***FCC Liaisons*****:** Steven McKinnon and Vern Mosley

3.2 Working Group 2 Team Members

Working Group 2 consists of the members listed in Table 3.

Table 3 - List of Working Group Members

Name	Company
Farrokh Khatibi - Chair	Qualcomm Technologies, Inc.
Brian Daly	AT&T Access Architecture & Devices Wireless Network Architecture & Design
Charlotte Field	Charter Communications
Claude Stout	TDI -Telecommunications for the Deaf and Hard of Hearing
Dana Golub	Public Broadcasting Service Warning, Alert, Response Network project "WARN"
Denis Gusty	Department of Homeland Security
Edward Czarnecki*	Monroe Electronics Inc.
Francisco Sanchez*	Harris County Office of Homeland Security & Emergency Management
Gary Smith*	Cherry Creek Radio
Glenn Edwards	Bayou City Broadcasting
Harold Price	Sage Alerting Systems
Kelly Williams	National Association of Broadcasters
Kevin Gage*	One Media LLC.
Mark D. Annas	City of Riverside - Office of Emergency Management
Mark Paese	National Oceanic and Atmospheric Administration (NOAA) U.S. Department of Commerce National Environmental Satellite & Information Service
Robert Gessner*	American Cable Association
Roger Stone*	Federal Emergency Management Agency

	DHS-FEMA
Susan Miller*	Alliance for Telecom Industry Solutions (ATIS)
William A. Check	NCTA – The Internet & Television Association
Harold Price	Sage Alerting Systems
Kelly Williams	National Association of Broadcasters
Kevin Gage*	One Media LLC.
Mark D. Annas	City of Riverside - Office of Emergency Management
Mark Paese	National Oceanic and Atmospheric Administration (NOAA) U.S. Department of Commerce National Environmental Satellite & Information Service
Robert Gessner*	American Cable Association
Roger Stone*	Federal Emergency Management Agency DHS-FEMA
Susan Miller*	Alliance for Telecom Industry Solutions (ATIS)
William A. Check	NCTA – The Internet & Television Association
Steven Carpenter	FCC
Austin Randazzo	FCC

* CSRIC Members

The Working Group members had an option to nominate an alternate to participate in the discussions when they were unavailable. Although these alternates are not a member of the Working Group and may not vote, they provided valuable input towards the completion of this report that should be acknowledged. Working Group 2 alternate members are listed in Table 4.

Table 4 - List of Working Group Alternate Members

Name	Company
Andy Scott	NCTA – The Internet & Television Association
Craig Saari	Charter Communications
Mark Lucero	Federal Emergency Management Agency DHS-FEMA
Mary Lovejoy	American Cable Association
Mike Gerber	National Weather Service
Steve Barclay	Alliance for Telecom Industry Solutions (ATIS)

4 Objective, Scope, and Methodology

4.1 Objective

The objective of the CSRIC VI Working Group 2 is to conduct a comprehensive evaluation of emergency alerting and emerging technologies (such as the ATSC 3.0 broadcast standard and 5G) that may result in new alerting capabilities. As part of this evaluation, the Working Group developed recommendations for CSRIC's consideration on ways to streamline, simplify (by reducing burdens on licensees), and modernize existing systems, including the Emergency Alert System (EAS).
This report is not intended to make any recommendation to adopt or advocate for any particular technology.

4.2 Scope

The primary focus of this Report is to ensure the delivery of emergency alerts, and not on what may have triggered the alert or how it was composed. As mentioned in the Introduction section, the full analysis of all the end-to-end elements of the alerting system is beyond the scope of this Working Group due to limitations of the study period.

4.3 Methodology

The methodology used by the Working Group is to analyze the existing emergency alert dissemination techniques, as well as study various scenarios where emergency alert could save lives. The Working Group then developed recommendations that could improve public safety by ensuring that the relevant emergency information is made available in a timely fashion to the targeted individuals in an affected area.

5 Background

This section provides some background on public alerting systems.

5.1 Public Alerting Systems

There are a wide range of public alerting systems. Some are governed and/or funded by Federal, State, and Local governments as a public service. Others are fee for service, integrated with a product offering, offered as a public service by a commercial entity (e.g., broadcasters, newspapers, third party applications on smart devices, etc.), or otherwise provided as a free service and have little or no rules governing their design and use. Some alerting systems use traditional and "time tested" technologies, while others may leverage emerging technologies.

Alerting systems include, but are not limited to, the following.

- Emergency Alert System (EAS)
- Wireless Emergency Alerts (WEA)
- NOAA Weather Radio
- Television and radio broadcasts
- Electronic media including the web

- Text message and email
- Mobile applications
- In-vehicle infotainment systems
- Social media
- Reverse calling
- Smart home devices
- Highway signage
- Public address systems
- Sirens

These warning systems provide varying degrees of content, consistency, richness in media, delivery speed, geographic coverage, capability to geo-target, availability, system redundancy, security, and system resiliency. During a disaster, one or more alert systems may be degraded or unavailable making reliance on one or more of the other systems necessary. This report does not specifically discuss all of the above alerting systems. However, where applicable, each of the recommendations in this report should be applied.

As mentioned, some alerting systems are governed by FCC regulations and industry defined standards (i.e., EAS and WEA), while others are not bound to any regulatory governance or standards-based solutions (i.e., some third-party applications or fee for service applications, etc.). If not carefully managed, this can lead to interoperability challenges, non-standard or non-conforming public messaging, and the potential for the introduction (intentional or unintentional) of security risks.

5.2 Need for Relevant Alerts

Alerting authorities desire that people in a threatened area initiate protective action as prescribed by the alert. However, social science studies reveal that people do not often initiate protective action in response to an alert. “Milling” prolongs the time between threat detection and initiation of protective action. Alert recipients delay taking protective action and instead waste time searching for more information- trying to decide what, if anything, to do[2]. Thus, the alert recipient must be made to feel the alert is relevant and applies to them, and if the recipient seeks out or is pointed to other sources of information, those sources must have that additional information available when the alert recipient turns to that source.

5.3 Need to Reimagine Emergency Alerting

Emergency alerting in the United States dates back to the CONELRAD (Control of Electromagnetic Radiation) system, a former method of emergency broadcasting in the event of attack during the Cold War. It was intended to allow continuous broadcast of civil defense information to the public using radio or TV stations, while rapidly switching the transmitter stations to make the broadcasts unsuitable for Soviet bombers that might attempt to home in on the signals (as was done during World War II, when German radio stations, based in or near cities, were used as beacons by pilots of bombers). After the development of intercontinental ballistic missiles reduced the likelihood of a bomber attack, CONELRAD was replaced by the

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[2] Milling and Public Warnings by Wood, Mileti, Bean, Liu, Sutton, and Madden, http://journals.sagepub.com/doi/pdf/10.1177/0013916517709561

Emergency Broadcast System (EBS) on August 5, 1963, which was later replaced with the Emergency Alert System (EAS) on January 1, 1997.

On September 30, 2011 the FCC required all broadcasters to monitor the IPAWS EAS Feed for CAP-based delivery of EAS messages. This introduced several benefits over legacy EAS: CAP delivery direct to each broadcaster improves the likelihood that the message will be received versus the over-the-air daisy chain method. CAP delivery also supports pre-recorded audio files which dramatically improve alert audio quality compared to over-the-air daisy chain and text-to-speech audio. CAP delivery also gives local public safety agencies direct access to activate EAS through their alerting software tools versus relying on individual relationships with local broadcasters.

The overall value of EAS is waning and arguably provides a disservice to broadcasters and the general public when over-alerting occurs and alert fatigue results. The wide area coverage of EAS has been noted as a drawback for those seeking to geotarget a narrower or more specific area. EAS broadcasts are made to the entire footprint of a television or radio transmitter with no capability for the alert recipient to receive only those alerts relevant to them. Thus, EAS broadcasts geotarget on a scale of hundreds of square miles even though many alerts are intended for a county, sub-county, or even a block-level hazard. Additionally, the recent decline in public consumption of broadcast radio and television for entertainment has translated into a decrease in the reach and penetration of warning messages via EAS.

In 2007, the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) began defining the warning area for the most critical weather threats, such as tornadoes and flash floods, by polygon. These polygons are often at the sub-county level and sometimes even more localized to a specific community, streams and creeks, or coastal locations. Alerts for wildfires, active shooter incidents, evacuations, and other civil emergencies may also be highly localized.

The general public's expectation for precise geo-targeting of alerts continues to increase. The NWS often receives complaints from broadcasters about the frequency and length of interruption during their broadcasts. However, the NWS is merely providing life and property saving information intended for specific locations which are being rendered on televisions or broadcast on radio across hundreds of square miles. Furthermore, EAS provides limited text and audio information. EAS does not provide richer multimedia or other substantiating information which social science studies suggest would improve public response to alerts.

Another shortcoming of EAS is the reliance on specific alert types (i.e. event codes). In doing so, EAS places priority on the alert type rather than impact of the hazard. All hazards are not equal. Hazards vary in time, space, nature, and overall impact. Similarly, alerts for hazards vary in urgency, severity, certainty and the response needed to save lives and protect property.

In 2006, the U.S. Congress passed the Warning, Alert, and Response Network (WARN) Act, which created the Commercial Mobile Alert System (CMAS), now known as Wireless Emergency Alerts (WEA). WEA is a voluntary alerting network in the United States designed to disseminate emergency alerts to mobile devices supported by Commercial Mobile Service Providers (CMSPs), such as cell phones and pagers. The FCC's Commercial Mobile Service Alert Advisory Committee (CMSAAC) proposed the network structure, operational procedures, and technical requirements which ATIS and TIA developed into global industry standards, in order, in part, to facilitate international roaming. WEA went live in April 2012, and the NWS began delivering its Wireless Emergency Alerts on June 28, 2012.

WEA was designed to support the variety of networks and devices that could support WEA – including 2G & 3G wireless networks (GSM, CDMA, UMTS), 4G LTE, and paging networks. WEA was designed to support a wide variety of mobile devices including alphanumeric pagers, non-smartphones, and smartphones, without regard to the subscription level. Thus, in many cases the lowest common denominator was chosen, which appear to be a limiting factor for more advanced networks and devices. The goal was to provide WEA with a common look and feel across networks and devices, without disenfranchising any group of users. Any future re-imaging of emergency alerting must similarly account for legacy devices and networks.

The initial rules for WEA included an English language alert message that must not exceed 90 characters of alphanumeric text, with three classes of Alert Messages defined: Presidential Alert; Imminent Threat Alert; and Child Abduction Emergency/AMBER Alert. The Alert Message includes five mandatory elements—Event Type; Area Affected; Recommended Action; Expiration Time (with time zone); and Sending Agency, and cannot include a URL or telephone number (to minimize potential congestion impacts to the network). WEA alert geotargeting rules specified the transmission of a WEA 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 that geocode, circle, or polygon intersects.

Since the deployment of WEA in 2012, there has been extensive discussions on enhancements beyond the rules stated above. These enhancements are based on operational feedback from alert originators and emergency management on WEA effectiveness.

ATIS has also completed a feasibility study to evaluate techniques to distribute Early Earthquake Warning (EEW) notifications to the general public through cell phones via the cellular network. The purpose of this feasibility study was to evaluate the feasibility of the commercial LTE cellular networks in supporting public earthquake notifications. An EEW system has been conceptualized for the West Coast of the United States within existing operational environments of three regional seismic networks in southern California (Southern California Seismic Network, SCSN) and northern California (Northern California Seismic System, NCSS). The Pacific Northwest (Pacific Northwest Seismic Network, PNSN) and other Advanced National Seismic System (ANSS) areas in North America (e.g., the New Madrid, Seismic Zone, etc.) are beyond the scope of this study. The study took into consideration the basic EEW System service model consisting of components that are used, or planned to be used, in EEW systems around the world.

6 Alert Dissemination Techniques

Each of the technologies below have its own strength and weaknesses. Furthermore, they are in various points in their deployment and deployment cycle.

6.1 Advanced Television Systems Committee (ATSC 3.0)

The ATSC 3.0 (aka "Next Gen TV") standard holds the potential to not only vastly improve the broadcast television viewing experience and expand programming opportunities, but also enhance emergency communications capabilities and create new operational capabilities for broadcast stations. Advanced Emergency Alerting is one such capability that could be of relevance to broadcasters, their audiences, and emergency managers.

Enhanced emergency information distribution is one of the major enhanced capabilities and potential benefits of Next-Gen TV. ATSC 3.0 can support emergency information distribution in three distinct potential services:

- EAS support, through onscreen and aural transmission of emergency alerts
- Advanced emergency information services, via ATSC 3.0 "Advanced Emergency Alerting" (AEA)
- CAP relay, through ATSC 3.0's native IP transport capability

Transmission of conventional EAS messages can be supported under ATSC 3.0.

Advanced emergency information services in ATSC 3.0 AEA can support a broader range of information than the current EAS in place, beyond "emergency alerting"—providing a powerful tool to provide targeted emergency information of any type to TV audiences. This is an informational service capable of conveying a broad range of urgent information bulletins and updates to targeted audiences.

Support of IP-based CAP relay may provide a very robust and secure manner of transporting Federal, state and local CAP alerts from station to station.

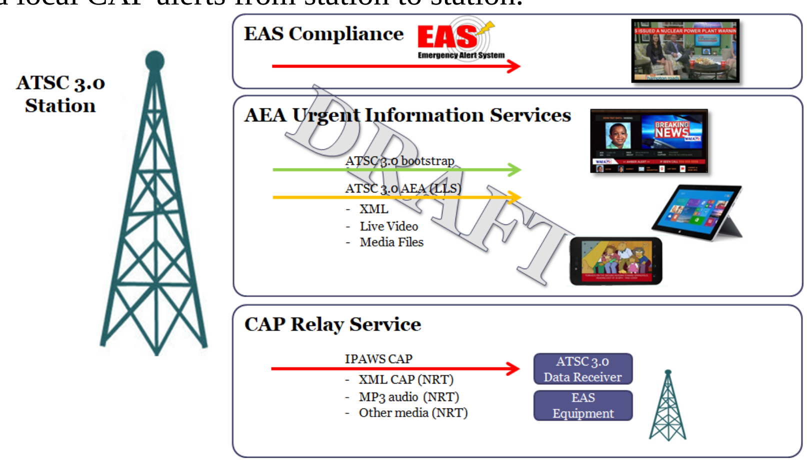

Figure 1 - Potential ATSC 3.0 Emergency Information Services

ATSC 3.0 Support for EAS

For conventional EAS, the EAS audio would likely remain as an embedded textual display in the video, and part of the main audio Track as defined in the ATSC A/342 standard. A/342 also provides for alternative audio Tracks (e.g., assistive audio services, other language dialog, special commentary, music and effects) with the main audio Track or other audio Tracks. In this sense, visual and aural display of EAS by ATSC 3.0 stations would remain substantially similar to current methods of receiving, processing and displaying EAS.

ATSC 3.0 Support for "Emergency Information"

For non-EAS emergency information displayed by the broadcaster, ATSC A/331 specifies the signaling of audio (speech) that provides an aural representation of emergency information provided by broadcasters in on-screen text display. Further, for “Accessible Emergency Information”, the ATSC 3.0 audio system supports the inclusion and signaling of audio (speech).

ATSC 3.0 Support for “Advanced Emergency Alerting” Services

ATSC 3.0 AEA is one of numerous services supported in this IP-based broadcast system. ATSC 3.0 AEA is an open, non-proprietary specification and incorporated in the ATSC A/331 standard, with support for other ATSC 3.0 standards. The ATSC 3.0 AEA service includes an XML-based messaging format intended for flexible communications of any manner of urgent information to the consumer receiver. In the most extreme circumstances, this service can also activate the bootstrap “wake-up” capability for enabled ATSC 3.0 receivers.

ATSC 3.0 AEA supports a broad range of urgent and emergency information. ATSC 3.0 AEA differs from the current emergency alert system in a number of key areas. ATSC 3.0 AEA can provide the ability to target audiences with emergency information about a school lockdown, school district closures, traffic emergencies or other local disturbances— exactly the type of local urgent information that audiences can use, but is also the kind of information that is NOT part of an EAS message.

ATSC 3.0 AEA can also serve to repurpose a less-critical EAS message to an ATSC 3.0 AEA bulletin, which in turn may serve to motivate the transmission of greater amounts of urgent information, via this alternative channel. An EAS event can be intrusive because it would interrupt audio programming and impose a crawl on screen. An ATSC 3.0 AEA message can be less intrusive to the viewer, because it does not interrupt programming, and allows the viewer to choose what information they want to see. Furthermore, ATSC 3.0 AEA messages can support much narrower geotargeting of emergency information, supplemented with graphics, video, and a station’s live stream of coverage of an event.

ATSC 3.0 AEA emergency information capability provides the potential for a range of capabilities offered by television broadcasters to fixed, mobile and portable consumer devices that support these features, including:

- Audience targeting, ranging from the general public to non-public restricted messaging to specific groups (such as first responders or other organizations).
- Flexible alert messaging capability, sufficient to handle virtually any form of emergency information, ranging from all hazards public alerting to narrowly targeted urgent messaging for a smaller defined audience, and even to specific messaging for first responder functions.
- Location targeting that will allow compatible receivers to monitor alerts that can be addressed to specific geocodes, polygons or circles, essentially meaning that an alert can be targeted as widely as the entire broadcast area, or as narrowly as receivers in a very specific set of coordinates.
- Multimedia capabilities, allowing ATSC 3.0-enabled receivers to receive and display graphics, photos, maps, video, and other assets as part of the emergency information.
- Alert update and cancellation features;
- Alert priority settings;
- Wake-up signaling, to awaken compatible receivers when in standby or sleep mode, and

- Multilingual support, providing the prospect for broadcast viewers to select their language of choice for receiving emergency information.

The alerting capability in Next-Gen TV is intended to provide enhanced next-gen emergency information capabilities for TV stations to reach the public.

The ATSC 3.0 Standards for AEA

ATSC 3.0 AEA is in fact drawn from features across the ATSC 3.0 suite of standards. Key components supporting ATSC 3.0 AEA are found within A/321 System Discovery and Signaling; A/324 Scheduler/Studio to Transmitter Link; A/331 Signaling, Delivery, Synchronization and Error Protection; A/336 Content Recovery in Redistribution Scenarios; A/338 Companion Devices; A/342 Audio; and A/344 Application Runtime Environment. Two of the key standards for ATSC 3.0 AEA are:

- **A/321 (System Discovery and Signaling)**, which describes the ATSC 3.0 bootstrap, which is the initial discovery and entry point in the ATSC 3.0 waveform. The bootstrap is the most robust part of the transmission signal, containing 3 symbols each with 8 bits. In the bootstrap is a "wakeup" field which—if enabled—would rouse the ATSC 3.0 television receiver from standby or sleep mode if an urgent emergency message is accompanied by a "wakeup" request.
- **A/331 (Signaling, Delivery, Synchronization and Error Protection)**, which defines the service signaling and IP delivery of a wide range of services and content, including electronic service guides, app-based services, linear audio-video services, and AEA. A specialized emergency messaging approach was needed for ATSC 3.0, tailored for this broadcast environment but also flexible enough to tackle a broad range of messaging requirements, including international, multilingual and multimedia capabilities.

The ATSC 3.0 AEA message format that is included in the ATSC A/331 standard is an XML-based format for ATSC 3.0 urgent message transmission. These XML-based messages are contained within an Advanced Emergency Alert Table (AEAT), which is one instance of low-level service info defined in A/331. The AEAT can contain one or more AEA messages.

The AEA capability in ATSC 3.0 will support a broad range of urgent information to the public — far beyond the scope and abilities of today's EAS—for emergency information to the public, as well as restricted messages to closed groups (which could conceivably include first responders). The AEA capability native to ATSC 3.0 supports a wide range of multimedia content, including cached or live media, multiple languages, and features useful for app developers on mobile, portable and fixed ATSC 3.0 receivers.

For TV broadcasters, the next-generation ATSC 3.0 standard will allow station-driven emergency information to be integrated into a broad range of services, offering viewers the potential for tailored emergency information over a portfolio of products (TV, web, mobile, etc.).

Contrasting EAS & ATSC 3.0 AEA

Our presumption is that conventional EAS (via FSK based audio relay) and CAP will remain a key element in the national alert and warning strategy. As such, ATSC 3.0 will support both EAS and ATSC 3.0 AEA capabilities. In the U.S., we presume that FCC regulations requiring stations to carry the Emergency Action Notification (EAN), National Periodic Test (NPT) and Required Monthly Test (RMT) alerts will require that TV stations continue to present an on-screen banner crawl for visual display of EAS messages, and that the EAS audio would likely remain part of the main audio track as defined in A/342.

However, ATSC 3.0 AEA may provide a means to encourage TV stations to provide more emergency alerts in a way that will be more attractive and usable for both the station and its audience. Some EAS messages, for example, that TV stations typically would not air could be provided as a less intrusive AEA message. A severe thunderstorm warning, for example, is something that is not typically aired by TV stations as EAS, but could be presented as an AEA message—and the user can decide whether or not they want to access the information.
EAS and AEA may evolve into a complementary relationship, where the conventional EAS alert could be accompanied by an AEA from the station, with more instructions, maps, graphics and information that the conventional EAS just cannot support.

ATSC 3.0 Support for CAP/EAS Relay

ATSC 3.0 transforms TV broadcasting to serve essentially as a wireless broadband data pipe. Broadcast TV stations may desire to voluntarily provide a data service to forward IPAWS CAP messages as a means of supplementing conventional Internet-based dissemination of CAP alerts. Today's ATSC 1.0 signal transmission can broadcast both digital television signals and other non-television digital data. As seen in a variety of projects fielded in the U.S. – including the FEMA IPAWS DEAS pilot (2004-2010) and the Ohio OEAS CAP datacast relay service (2017-present), this digital data can include CAP XML alerts, and multimedia files. These ATSC 1.0 initiatives highlighted the role of a secure, robust, redundant transport path for CAP alerts that can be voluntarily provided by interested TV broadcasters.

ATSC 3.0 expands upon this capability for interested broadcast stations, by potentially allowing them to create prioritized data services sent via ROUTE (Real-time Object delivery over Unidirectional Transport). A potential data service may be to relay CAP alerts and multimedia resources from TV station-to-TV station (essentially creating digital mesh), and TV station to other EAS Participant (extending the digital data broadcast network).

The Next Practical Steps

An ecosystem has already emerged to bring ATSC 3.0 AEA capabilities to reality. The ATSC Implementation Team provides a venue for industry discussions of issues related to implementation of AEA, including operational and technical requirements for the successful inclusion and implementation of emergency alerting as part of the rollout of ATSC 3.0.

Some broadcast manufacturers have moved forward in implementing and integrating ATSC 3.0 capabilities in their product sets for broadcast television stations. Over-the-air testing of ATSC 3.0 transmission with emergency alerting has been conducted since 2016. This next-generation emergency information capability is a voluntary initiative of broadcasters and equipment manufacturers that is separate from (although potentially complementary) to EAS. As complementary functions, we expect that EAS will continue to provide its essential functions for national and local public alert and warning, while ATSC 3.0 next-generation alerting and capabilities will provide a value-added function from television broadcasters.
Importantly, for the television broadcast community, the migration to ATSC 3.0 emergency

alerting capabilities can leverage many of the assets that most TV broadcasters already have in place in their facilities. Because this portion of the television broadcast industry already has certain specific EAS equipment in place that can be upgraded for ATSC 3.0 support, the migration path for these stations may become even easier.

6.2 Common Alerting Protocol (CAP)

The Common Alerting Protocol (CAP) is a digital data structure, commonly expressed in eXtensible Markup Language (XML), for exchanging public warnings and emergencies between alerting technologies. CAP allows a warning message to be consistently disseminated simultaneously over many warning systems to many applications. CAP increases warning effectiveness and simplifies the task of activating a warning for responsible officials.

Standardized alerts can be received from many sources and configure their applications to process and respond to the alerts as desired. Alerts from the Department of Homeland Security, the Department of the Interior's United States Geological Survey, and the United States Department of Commerce's National Oceanic and Atmospheric Administration(NOAA), and state and local government agencies can all be received in the same format by the same application. That application can, for example, sound different alarms, based on the information received.

By normalizing alert data across threats, jurisdictions, and warning systems, CAP also can be used to detect trends and patterns in warning activity, such as trends that might indicate an undetected hazard or hostile act. From a procedural perspective, CAP reinforces a research-based template for effective warning message content and structure.
The CAP data structure is backward-compatible with existing alert formats including the Specific Area Message Encoding (SAME) used in NOAA Weather Radio and the broadcast Emergency Alert System as well as new technology such as the Wireless Emergency Alerts (WEA), while adding capabilities such as the following:

- Flexible geographic targeting by using latitude/longitude “boxes” and other geospatial representations in three dimensions
- Multilingual and multi-audience messaging
- Phased and delayed effective times and expirations
- Enhanced message update and cancellation features
- Template support for framing complete and effective warning messages
- Digital encryption and signature capability
- Facility for digital images, audio, and video.

Background

The US National Science and Technology Council (NSTC) November 2000 report on "Effective Disaster Warnings" recommended that "standard method should be developed to collect and relay instantaneously and automatically all types of hazard warnings and reports locally, regionally and nationally for input into a wide variety of dissemination systems."

In 2001, an international independent group of over 120 emergency managers began specifying and prototyping the Common Alerting Protocol data structure based on the recommendations of the NSTC report. The project was embraced by the non-profit Partnership for Public Warning and a number of international warning system vendors. A series of field trials and long-term demonstration projects during 2002-03 led to the submission of a draft CAP specification to the OASIS standards process for formalization.

The CAP 1.0 specification was adopted by the Organization for the Advancement of Structured Information Standards (OASIS) in April 2004. Based on experience with CAP 1.0, the OASIS Emergency Management Technical Committee adopted an updated CAP 1.1 specification in October 2005. At a meeting in Geneva in October 2006 the CAP 1.1 specification was taken under consideration by the International Telecommunications Union for adoption as an ITU recommendation. CAP was subsequently adopted as Recommendation x.1303.

The current CAP specification version is 1.2. For particular environments and applications, the CAP standard is sometimes supplemented by various “CAP profiles,” which specify particular strictures on CAP usage within the scope of the general specification. Profiles are frequently adopted to ensure back-compatibility with previously existing “legacy” alerting systems. The Australian Government Standard for Common Alerting Protocol is an example of a CAP profile.

Global Adoption

In 2007, the International Telecommunication Union, Telecommunication Standardization Sector (ITU-T) adopted the Common Alerting Protocol as Recommendation X.1303. The recommendation annex contains an authoritative ASN.1 module translation of the CAP XML schema that may be useful for some implementations. Rec. X.1303 is within the remit of ITU T Study Group 17 (Security), Rapporteur Group on Cybersecurity (Q.4/17) for purposes of further evolution of the standard.

The Australian Government Standard for Common Alerting Protocol (CAP-AU-STD, 2012) was developed by a CAP-AU-STD stakeholder group comprising federal agencies Emergency Management Australia, the Bureau of Meteorology, GeoScience Australia, Department of Agriculture, Fisheries and Forestry and the Department of Health as well as a number of State Government authorities and emergency services agencies. The project was co-ordinated by the Australian Government Attorney-General's Department (Australian Emergency Management)
In Canada, a working group composed of public alerting practitioners and government agencies has developed a CAP Canadian Profile (CAP-CP) based on CAP but specialized to address the needs of Canadian public alerting stakeholders, such as bilingualism, geocoding for Canada, managed lists of locations and events, etc. The Canadian government has adopted CAP-CP for its National Public Alerting System (NPAS) project. The CAP CP working group, along with stakeholders and projects such as the Canadian Public Safety Operations Organization (CanOps) and Netalerts' Sarnia Lambton trial, are now working with and refining CAP CP for national application in Canada.

CAP has been implemented for a small-scale, grassroots hazard information system in Sri Lanka following the 2004 Indian Ocean Tsunami. This implementation was part of the "HazInfo Project", funded by Canada's International Development Research Centre.

The province of Alberta adopted CAP as part of its Alberta Emergency Alert system. In March 2015, Alert Ready, a national public warning system based upon CAP-CP, was officially launched. Participation in the system by all broadcasters and television providers is mandated by the Canadian Radio-television and Telecommunications Commission.

The Federal Office for Citizen Protection and Disaster Support (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe, BBK) is working on an implementation based on CAP 1.2, which will allow for Internet-based access to data provided by the nation's modular warning system MoWaS. The development of MoWaS is based on the satellite-based warning system SatWaS from 2001, which only provides information to less than 150 state and media entities. In case no broadcast receiver, like a radio or television, is running nearby, the resulting warning effect of SatWaS would be severely limited, because many state-run emergency sirens have been left unmaintained or were dismantled altogether. The use of CAP support in MoWaS should alleviate this problem.

The Department of Firefighters, Public Rescue and Civil Defence (Dipartimento dei Vigili del Fuoco, del Soccorso Pubblico e della Difesa Civile) of the Italian Ministry of the Interior adopted the CAP protocol with two Ministerial Decrees in 2008 and 2011. Since then, its 100 provincial control rooms, 18 regional control rooms and the national control centre exchange a daily average of 25,000 CAP private messages concerning rescue operations in real time. As per the decrees, any emergency stakeholder in Italy which wants to exchange or share data with the Fire Corps in the course of large scale emergency or rescue operations has to adopt the CAP protocol.

The first use of CAP protocol in a civil protection activity in Italy was recorded in 2009, in the aftermath of the Central Italy Earthquake, when the Fire Corps exchanged data with the Ministry for Cultural Heritage to coordinate their efforts in designing and implementing provisional measures for monuments and historical buildings.

In early 2005, the U.S. Department of Homeland Security (DHS), in partnership with the Association of Public Television Stations [*] demonstrated CAP-based "digital EAS" broadcasts over public television digital TV transmitters and satellite links in the Washington, D.C. area and nationwide.

CAP is the foundation technology for the national "Integrated Public Alert and Warning System", an all-hazard, all-media national warning architecture developed by the Federal Emergency Management Agency (FEMA) in consultation with DHS, the National Weather Service within NOAA, and the Federal Communications Commission.

6.3 Emergency Alert System (EAS)

EAS has two major use cases. The first derives from a requirement to provide for Presidential access to commercial communications during “a state of public peril or disaster or other national emergency”[3] reiterated most recently in the FCC report on the 2017 National Periodic Test “The EAS is designed primarily to provide the President with the capability to communicate via a live audio transmission to the public during a national emergency.”[4] To this end, FEMA maintains a

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[3] Section 706 of 47 U.S.C. 606, War Powers of President, June 19, 1934
[4] Report: September 27, 2017 Nationwide EAS Test April 2018, Public Safety and Homeland Security Bureau

Primary Entry Point (PEP) System using a primarily AM-radio-based backbone, which can feed broadcast Radio and TV, cable systems, and satellite services, The PEP system and EAS is designed to serve as a resilient backup to more sophisticated internet or other digital distribution systems, and to provide the possibility of communications when the more complex infrastructure of modern communication methods is not available.[5]

The typical day to day use of the EAS system, however, is by the NWS, and state, territorial, tribal, and local, governments; issuing thousands of alerts per year for such matters as severe weather, child abductions, and local emergencies. EAS alerts can also be initialed directly by EAS Participants such as radio, TV, and others. Testing also occurs, weekly, and monthly at the state, local, or individual EAS participant level, or less often at the national level by FEMA.

EAS is defined by Part 11 of the FCC rules. It was first deployed in 1997, based in large part on the NOAA Weather Radio Specific Area Message Encoding (WRSAME) protocol. EAS data is encoded in a format that can easily be sent over voice grade or better audio channels, using the same frequency-shift keying format used by the NOAA weather radio (NWR) network. The national Emergency Action Notification message can only be originated by the President using FEMA resources. The EAS system is also available for use by state and local authorities for other types of emergencies, using various distribution systems, and by NOAA using NWR.

The FCC mandated that its licensees add the capability to receive EAS alerts using the CAP in 2012. When directed at the EAS system, CAP is used to encapsulate an EAS message. Some of the CAP data elements are used to define an EAS message, which is then converts to the EAS protocol and transmitted by the EAS participant in the EAS format, using the traditional EAS data elements: originator type, event code, location list, start time, and duration. Text from the CAP message can be used to generate text data for video screens or crawls (though it is not transmitted as part of the EAS message), and audio can be sourced from data referenced by, or included in, the CAP message. Many EAS participates receive CAP messages through the internet.

While the CAP information is more “rich” than the original EAS provided for, much of the CAP message extended data is lost once the message is converted to EAS, including alternate languages, message text, pictures, video, maps, etc. EAS participants are required to receive EAS messages in both the CAP wrapper format, and in the original over-the-air analog audio relay format.

There are several problems that result from the “down sampling” of CAP to EAS, including de-duplication, loss of support for multiple languages and text.

Reimagining

One way to move into the future would be to remove the requirement relay messages received in the native EAS format. All EAS participants would then have access to all of the CAP data for any message they send, including:

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[5] An Emergency Alert System Best Practices Guide– Version 1.0, FEMA, https://www.fema.gov/media-library-data/20130726-1839-25045-9302/eas_best_practices_guide.pdf

- Rich media
- Improved audio quality
- Polygon-based locations
- Message authentications via digital certificates
- Message Cancellation
- Multiple Languages
- Better integration with NOAA, which has de-duplication issues when sending messages with more than a total of 31 locations, or messages with location lists that are subsetted by local transmitters.

The problem here is that this is counter to one of the main purposes of EAS, the "under all conditions" Presidential case, but also relevant to widespread communication outages as experienced in Puerto Rico as well as local internet outages. If we are to retain impaired communication capability along with an access to enhanced features, a hybrid approach can be used. We can retain the EAN capabilities for national emergencies, while relying on native CAP messages for day to day emergencies.

There have been several attempts to define extensions to the legacy EAS protocol so that we can have some of the advantages given by CAP:

- Adding extended location codes
- Add a language code
- Add a "storm identifier" code
- Add a URL link to more data
- Add a year to the date code
- Add a cancel capability

All of these have one or more areas of concern, such as:

- Breaks compatibility with WRSAME protocol as deployed in EAS.
- Implementation by NOAA potentially breaks compatibility with millions of consumer weather radios without engaging industry and government in significant research and testing.
- Trade-off between Increasing the length of the "non-human audio" portion of the alert or reducing the amount of enhanced data available
- Reduces message resiliency. In this context, message resiliency means the effect on the ability of the message to traverse the system; longer messages are at greater risk.
- Communication channel necessary to obtain the extended information may be unavailable.
- The ability to mark any analog EAS message as a test message.

The committee needs to look closely at the desirability of retaining EAS AFSK in its current state, trying to extend it to include some new features, relegating it to EAN/NPT/RMT/RWT only, changing the transmission format to increase data throughput, or dropping the analog system entirely and accepting an internet or the internet augmented with satellite or other suitable technology solution.

6.3.1 Technical Enhancements to EAS

The Working Group reviewed information from prior CSRIC reports, as well as information presented by its own subject matter experts, regarding possible improvements to the existing EAS system.

6.3.1.1 Clarification on how EANs are to be processed

This section clarifies how Emergency Action Notification (EAN) are to be processed.

6.3.1.2 Buffering of real-time alert audio

The issues raised the final report of CSRIC IV WG-3[6] section 3.1.2 (b) remain as described. This section discusses buffered audio, which allows the entire contents of the EAN audio to be relayed by each station in the chain, vs a switchover to real-time audio input, which requires the audio source to wait for several tens of seconds before meaningful information can begin.

6.3.1.3 Additional Received Headers During Processing an Alert

The issues raised in CSRIC IV WG-3[6] section 3.1.6 still remain, regarding a local insertion on an EAN, interrupting an alert being carried by a network audio feed. We recommend that a reference to this section be included in a future RM.

6.3.1.4 Streaming audio for EAN

Streaming audio for EAN, to meet the unlimited audio duration requirement for EANs, is still an open issue. See CSRIC III WG9 Final Report part 4, section 6.1.3 CAP EAN Streamed Audio Message for IPAWS OPEN[7].

6.3.1.5 Duplicate message detection

The duplicate message detection and disambiguation problem cited in section 6.3 on EAS duplicate message handling, also from CSRIC III WG9[7] still remains as described. In brief, a CAP message contains a set of locations but the SAME version of the message may contain only a subset of those locations relevant to the coverage area of a particular transmitter. This only arises from NWR messages. No method has been researched and tested to date for an EAS receiver to disambiguate the two versions of the message. This problem must be solved if the NWS is to deliver NWS messages via CAP and NWR.

6.3.1.6 Ensure that an EAS alert is only retransmitted during its valid period.

The FCC asked this working group to provide any recommendations necessary to ensure that an EAS alert is only retransmitted during its valid period (e.g., during its current year, day, and time). The issue here is that the non-CAP EAS protocol does not provide a year in its data code, only month, minute, and day of year. Adding a year to the EAS protocol could break compatibility with EAS receivers and millions of consumer weather radio receivers without significant research and testing, and cause issues where the year data is not relayed through the system. Defining a set of rules to define alert time validity and remove ambiguity in some of the EAS time definitions could reduce the size of the confusion window, but will not completely close it.

6 https://transition.fcc.gov/pshs/advisory/csric4/CSRIC_IV_WG-3_Final-Report_061814.pdf

7 https://transition.fcc.gov/bureaus/pshs/advisory/csric3/CSRIC_III_WG9_Report_March_%202013.pdf

6.3.2 Recommended Enhancements

The FCC has recently clarified its position on delaying the relay of EAS alerts in order to search for a matching CAP message. This will allow additional practical use of multi-language alerts, and might allow for better selection of messages for playback, such as using polygons. The National Periodic Test is specifically excluded, which will continue to cause issues for additional languages at the national level.

In summary, here is a list of open issues in EAS:

- Adding a year to the EAS protocol to reduce the window for replay attacks.
- Adding a cancel capability
- Removing the requirement in Part 11 to add the EAS originator, event code, location, and times to crawls and text to speech when CAP text is available. Removing the requirement will speed up the delivery of the localized information in the text, but does place the responsibility on the alert originator to provide all of the required information.
- Allowing EAS Participants to use CAP-derived polygons to make decisions about relaying an alert, rather than using the FIPS code.

6.3.3 Long Term Goals

The FCC has asked this working group to develop recommendations on any technical solutions to support authentication of alerts through digital signatures for both the Internet-based IPAWS and the broadcast-based legacy “daisy chain” to ensure that the alert retransmitted by an EAS Participant was generated by an authorized alert originator and has not been modified since its generation.

The committee needs to consider this. Issues include:

- Traditional digital signatures could more than double the length of the average EAS message.
- Using CAP message search for EAS messages could provide the necessary protections, but would not help in the case of a non-CAP origination or a communications outage.
- FEMA provides a system of authorizing an originator (by providing a signing key), and signed messages do ensure that the CAP message was not modified once signed. There is no comparable mechanism in place the validate non-CAP originators.

6.4 Public Broadcasting System (PBS)

PBS and local public television stations play a crucial role in protecting communities by using datacasting to deliver essential information to individuals and first responders. These benefits are all made possible by public broadcasting stations’ unique reach, reliability, and role across America, and are especially vital in rural and underserved areas.

PBS-WARN

The PBS-WARN system is the largest national public safety program currently undertaken by PBS, and its benefits to improving the overall resilience and cybersecurity of WEA were noted in the FCC 16-127 R&O. PBS-WARN enables Non-Commercial Educational (NCE) television stations to comply with the FCC 07-287, *Second Report and Order and Further Notice of Proposed Rulemaking* (2nd R&O) by leveraging the nationwide public television interconnection system to create a nationwide emergency alerting network. This robust, redundant backup path for the WEA C interface is, as noted in CSRIC V WG-2 technologically diverse from a CMSP's primary WEA gateway, and as noted in the CSRIC V WG2 report of March, 2016, it is "well positioned to provide an immediate alternate source of inbound WEA messages."

Key features of the PBS-WARN WEA Safeguard are:

1) PBS-WARN receives the WEA and associated CAP message from geographically redundant WEA gateway systems;
2) All messages go through all stations' terrestrial broadcast – CMSPs with data centers outside the physical boundaries of a given alert still receive that alert over the air and can distribute the alert to the appropriate geographic region;
3) Automatic distribution of all WEA-qualified CAP messages;
4) PBS-WARN acts as a "blind pipe" for the WEA and associated CAP transmission;
5) Opportunistic Data Insertion with a peak bandwidth < 100kbps/19.36Mbps broadcast stream. Stations have not reported any effects on video or audio quality of their primary broadcast stream.

Current Use by CMSPs

PBS and FEMA have sought to make the adoption of the C-1 backup by CMSPs as easy as possible. Accordingly, PBS does not track CMSP implementation of the C-1 interface and neither FEMA nor PBS require signatures or amendments to the existing CMSP MOU or ISA with IPAWS-OPEN in order to receive the C-1 signal over the air and incorporate it into their WEA workflow.

However, in the most recent WEA R&O, the FCC states "we amend our rules to make it clear that periodic C interface testing must include the testing of its public television broadcast-based backup… to 'ensure delivery of critical infrastructure services,' as recommended by the *CSRIC V WEA Security Report*"[8]. PBS intends to work with FEMA and CMS providers to implement this test requirement, which effectively requires implementation of the PBS WARN system by all CMS providers that have opted into delivering WEAs.

Additional use case

The California Office of Emergency Services (CalOES) uses the PBS-WARN signal received from KVIE to create a real-time map of all national WEA alerts. This map allows CalOES to improve their situational awareness of emergencies in their state, as WEA messages would otherwise only be received by cellular phones within a given polygon and not to the state's headquarters in Sacramento. This map has been made available to the public and to first responders by CalOES at warn.pbs.org. As the site only displays a live map, the table below illustrates the user experience of the map as it appeared at approximately 2pm EST on January 4, 2018.

Figure 2 shows National map showing polygons for multiple WEA messages (for SC alert here), zooms map to polygon boundaries (determined via CMAC Alert Polygon or via a lookup of FIPS codes when polygon is not present.

[8] FCC 16-127, Paragraph 71-72

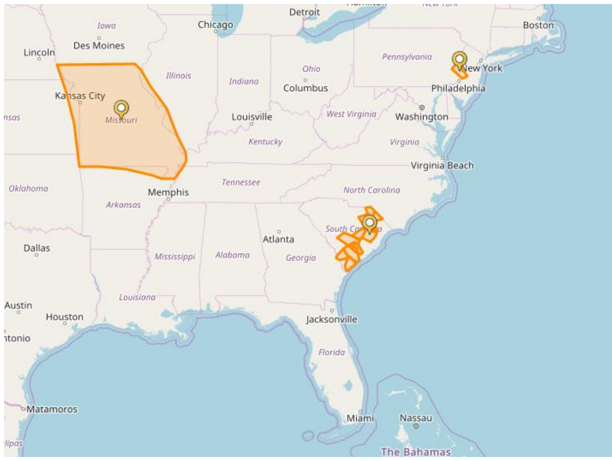

Figure 2 - National map showing polygons for multiple WEA messages

Figure 3 shows the screen once the marker is selected.

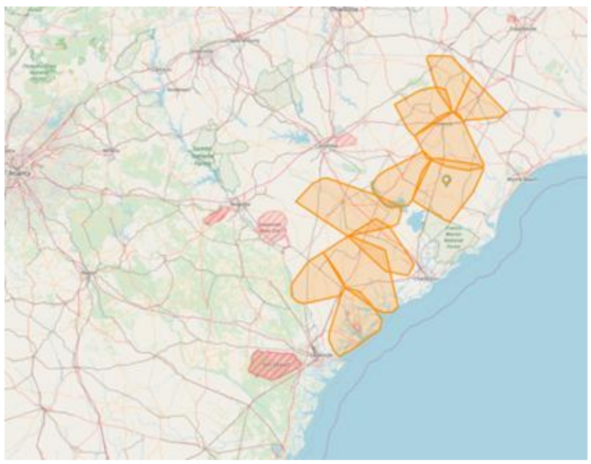

Figure 3 - Mouse click on marker

Figure 4 shows how mouseover of polygon reveals 90-character WEA (PORTIONS OF I-95 HAZARDOUS FROM MM77 TO GA STATE LINE – CALL 511 FOR TRAVEL UPDATES).

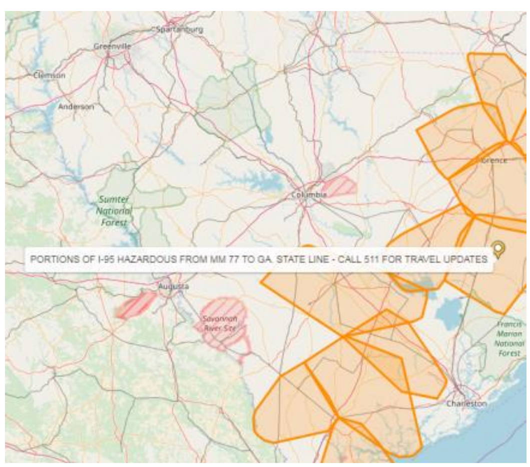

Figure 4 - Mouseover of polygon reveals 90-character WEA

Finally, Figure 5 shows how mouse-click on the polygon reveals full text of CAP message.

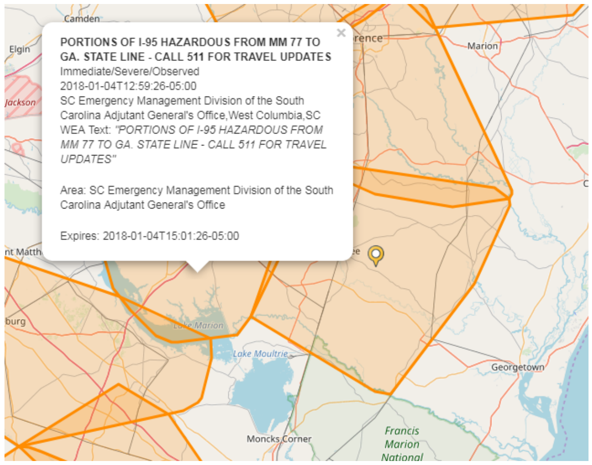

Figure 5 - Mouse-click on polygon reveals full text of CAP message.

Datacasting by Local PTV Stations

In addition to the nationwide PBS-WARN WEA safeguard, PBS member stations use their existing infrastructure to assist first responder communications and public alerts. Below we list a sample of the emergency alerting services currently offered by public television stations across the country.

State EAS Infrastructure:

OEAS Public Alertnet, covers the entire State of Ohio with a joint datacasting project to support emergency alerting bound for the public at large. Functioning as a backup to the existing EAS system, OEAS is a secure digital distribution path that does not rely on the public internet. OEAS Public Alertnet ties all eight Ohio public television licensees, their 12 PTV stations, and xx translators together into a common infrastructure that can be scaled up for video and other future public safety needs, including the ability to deliver encrypted messages to emergency responders.

Maine Public Broadcasting Network (MPBN), serves a similar function in the largely rural state of Maine. A dedicated digital channel allows the Maine Emergency Management Agency to send digital data to officials and broadcasters.

Alabama Public Television (APT), uses its statewide microwave transmission network as the backbone of Alabama's Emergency Alert System for all national, state, and local public alerting. APT also serves as the hub for the state's AMBER Alert system.

First Responder Datacasts:

Houston Public Media In 2015 and 2016, the Johns Hopkins University Applied Physics Laboratory (JHU/APL), under the direction of the Department of Homeland Security (DHS) Science and Technology Directorate (S&T), conducted a series of tests on a prototype datacasting system installed at Houston Public Media (Public Broadcasting Station KUHT). These tests showed the capacity of public television stations to create "a notional public safety communications architecture in which data could be collected in the field, transmitted to a command center using an available wireless network and then disseminated using datacasting." The After Action Report further notes that "the tests and subsequent operational use of the system to support critical public safety events provide validation of the potential utility of the system. Public safety representatives in Houston and Harris County… have been actively using the system during times of higher stress on their communications systems."[9]

These systems were first used in 2017 during Super Bowl 51 to aid in law enforcement communication. These systems remain in use by Houston and Harris County emergency services, and PBS has learned of its effective use for interagency video sharing during Hurricane Harvey in August 2017.

Nevada Public Safety Datacasting, KLVX has a Partnership with Clark County School District Police and Las Vegas Metropolitan Police for over-the-air and broadband datacasting, including live video, documents, maps, and related information. Terminals are located in Mobile Command Posts and supervisory vehicles.

Next Gen TV: Saving Lives One Alert at a Time, UNC-TV won first place in the National Association of Broadcasters (NAB) Pilot Innovation Challenge for a proposal that uses datacasting technology in broadcast television to update outdated first responder emergency pagers. Initial stages show potential to decrease a fire station's time to respond to a given alert by nearly one minute for each notification. The project currently uses ATSC 1.0 to reach fire stations across the state. Once ATSC 3.0 broadcasting is implemented, updated receivers connected to mobile devices will allow mobile paging for first responders, even in areas where LTE serviced does not reliably reach.

Multilingual Alert Messages, Twin Cities PBS undertook a pilot program to provide automated multilingual translations of the EAS feed on the secondary audio channel in the languages most relevant to their local viewership – Spanish, Somali, and Hmong. They currently broadcast English and multilingual emergency alerts and weather on a dedicated digital channel and were included in recent emergency exercises in November 2017.

6.4.1 Near Term Enhancements

The primary focus of PBS-WARN in the near term will be implementing updates to the PBS-WARN system so that it may receive and transmit enhanced WEA (eWEA) messages.

eWEA

PBS has received a three-year extension to the original WARN grant funded by the Department of Commerce through the NTIA. Thanks to this grant, PBS has sufficient funds to refresh the PBS-WARN system, which will allow the C-1 interface to continue to pass identical messages to those being sent over the C interface.

A December 2017 Government Accountability Office (GAO) report on telecommunications

[9] JHU/APL, "Datacasting: Houston Datacasting Pilot After Action Report," U.S. Department of Homeland Security Document HSHQPM-15-X-00122, July 2016. Prepared by JHU/APL for the Science and Technology Directorate First Responders Group Office for Interoperability and Compatibility. Available at https://www.dhs.gov/publication/datacasting-houston-integration-pilot-aar (accessed 11 January, 2018).

(GAO-18-198) recommended that the FCC monitor the wireless industry in order to improve network resilience. PBS offers PBS-WARN as an existing solution to wireless network resilience which can be incorporated into carriers' existing WEA workflows at an extremely low cost.

Service Interconnection

The public television interconnection system is currently satellite-based. A transition to a hybrid satellite/MPLS system (Service Interconnection) is underway and scheduled to be complete by the end of 2018. PBS intends to continue relying on satellite transmission for live content, including WEA, until 2020. The Service Interconnection will be used primarily for file delivery until at least that time.

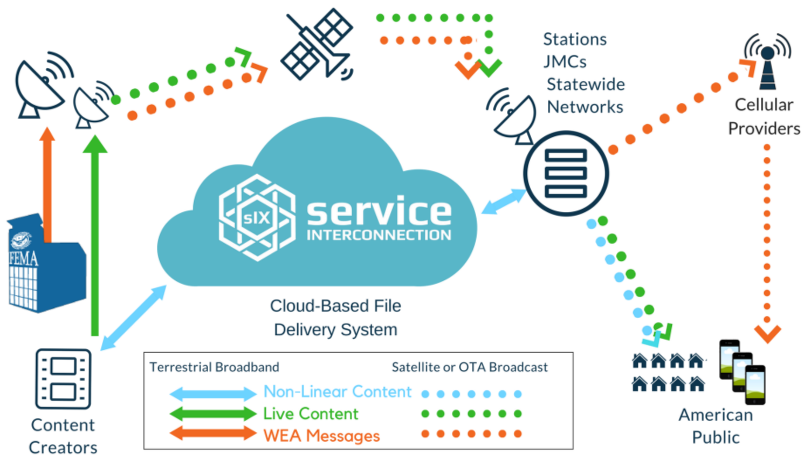

Figure 6 - MPLS File Delivery with Live Satellite Transmission

Additional uses of the PBS-WARN Data Pipeline

One of the weaknesses of the current EAS delivery method is the non-resilient reliance on local internet connectivity by broadcasters. In a letter to PBS dated November 2, 2017, Art Botterell of the California Office of Emergency Services expressed to us that California has "at least three significant areas where the loss of a single fiber connection, e.g., due to… fires, can knock out Internet connectivity for multiple days."

By simply adding the IPAWS EAS feed to the existing IPAWS-WEA feed in the PBS-WARN signal, PBS could add a technologically diverse backup to EAS for every station without additional drain on the FEMA server or a separate internet-linked EAS box.

Although this use of the PBS-WARN equipment would go beyond the scope of the current grant, PBS would like to investigate alternate sources of Federal funding to allow this proven delivery method to be expanded into a low-cost backup path for additional critical messages.

6.4.2 Long Term Goals

Service Interconnection

The anticipated transition of PBS from satellite distribution to MPLS interconnection offers the potential for much wider use of the PBS-WARN system.

A shortcoming of the WARN system as currently implemented is its reliance on the same type of IPSEC-VPN connection to IPAWS OPEN that every other CMSP gateway employs. While this version of PBS-WARN can guard against an internet failure at the CMSP, it cannot protect against the possibility of an internet failure at the DHS gateway. However, by incorporating IPAWS-OPEN as a content creation node of the Service Interconnection, IPAWS-OPEN WEA would be protected against such a failure through a distribution path that was completely independent from the Internet. At the same time, IPAWS-OPEN could take advantage of the decreased latency offered by MPLS' traffic prioritization capabilities in order to improve the capabilities of Earthquake Early Warning (EEW).

ATSC 3.0

The capabilities of ATSC 3.0 for improving EAS, CAP Relay, and AEA Urgent Information are thoroughly investigated elsewhere in this report. In this section, we will discuss the particular interest of PBS and public television stations in the capabilities offered by the new standards. Public television licensees that opt to broadcast in ATSC 3.0 will find opportunities to provide more robust emergency alert and communications services to first responders and to the public. Although most public television stations do not provide the reporting on local news and weather anticipated to populate the AEA Urgent Information, public television stations have missions driven by public service and deep connections within the emergency alerting and first responder personnel in their communities.

These types of connections among different communities drive innovation. The award-winning project undertaken by UNC-TV was built from existing connections between station representatives and emergency responders who were frustrated by the delays inherent in their existing paging system. Stations across the country have these types of connections and we believe that PBS stations and first responders can find even more ways to identify and utilize opportunities presented by ATSC 3.0.

ATSC 3.0 adoption will enable greater efficiency of television bandwidth, potentially allowing additional CAP feeds of national, regional and statewide data via custom PIDs. Stations would pass based on the needs of local agencies. The additional bandwidth utilized would be negligible to a station's transmission, and variable bitrate encoding could handle surges. For example, BLM could have a custom PID in the case of a wildfire, containing data not available in remote locations to areas which are not served well by LTE. This PID would be passed immediately, but only by stations in the affected area, thereby eliminating the delay caused by transporting a mobile FirstNet transmitter to the location.

Furthermore, while the Advanced Alerting capabilities of ATSC 3.0 are impressive, content for that system is reliant on the ability and desire of commercial broadcasters to create news and weather warnings to attract audiences. While broadcasters in major markets have an incentive to compete in this manner, rural markets often have public television stations as the only ones to be locally-owned and operated. And while public stations do not have the resources of national commercial broadcasters, the PBS-WARN system gives them an existing connection to the authoritative source of emergency alerts – IPAWS-OPEN.

Finally, in its 2017 publication, Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions, the National Academies of Sciences, Engineering, and Medicine describe one long-term goal of "augmenting IPAWS… as Integrating messages across communication channels, given the wide number of available technologies."

Because PBS has already implemented an intersection of traditional broadcast and cellular technologies through the nationwide PBS-WARN system, we believe that public media has shown itself be an ideal vehicle for projects which explore alerting at the intersection of the next generations of traditional broadcast (ATSC 3.0) and Cellular Mobile Service (5G).

6.5 Wireless Emergency Alert (WEA)

As mentioned earlier, initial rules for WEA included an English language alert message that must not exceed 90 characters of alphanumeric text, with three classes of Alert Messages defined: Presidential Alert; Imminent Threat Alert; and Child Abduction Emergency/AMBER Alert. The Alert Message includes five mandatory elements—Event Type; Area Affected; Recommended Action; Expiration Time (with time zone); and Sending Agency, and cannot include a URL or telephone number (to minimize potential congestion impacts to the network). WEA alert geotargeting rules specified the transmission of a WEA 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 that geocode, circle, or polygon intersects.

Since the deployment of WEA in 2012, there has been extensive discussions on enhancements beyond the rules state above. These enhancements are based on operational feedback from alert originators/emergency management on WEA effectiveness.

Enhancements that are currently being addressed in ATIS standards which go into effect May 2019 are:

- Message length increase from 90 characters to 360 characters (for LTE)
- Support for WEA alert messages in Spanish, both 90 and 360 characters
- Allowing clickable embedded references such as URLs and telephone numbers (in effect Nov 2017[10])
- Adding a new alert class for Public Safety alerts
- Ability for state and local agencies to initiate WEA tests

To address the issue of county-level geotargeting, many CMSPs have voluntarily been geotargeting a WEA message to the best approximation of a polygon (if provided by the alert originator) since the initial deployment of WEA. In 2017, the FCC revised the WEA geotargeting rules to codify the best practice which the industry was already adhering to – that is, CMSPs determine which of its network facilities, elements, and locations will be used to geographically target Alert Messages and must transmit to an area that best approximates the specified geocode, circle, or polygon.

To further tighten the geotargeting precision of WEA messages, in January 2018 the FCC further adopted rules requiring delivery of WEA alerts to the target area specified by the alert originator with no more than a one-tenth of a mile overshoot. This enhanced geo-targeting requirement will go into effect on November 30, 2019. ATIS is currently addressing the technology considerations and will be developing the standards for meeting this new

[10] https://apps.fcc.gov/edocs_public/attachmatch/FCC-17-143A1.docx

enhancement; standards are targeted for completion by early 2019.

The latest FCC rules also require alert messages to remain available in a consumer-accessible format on wireless devices for 24 hours after receipt, or until the consumer chooses to delete the message, which will enable the public to better review emergency information. This rule will go into effect on November 30, 2019, with ATIS standards in development to be complete early 2019.

Each of the above enhancements require changes throughout the WEA ecosystem, from the Alert Origination, to FEMA IPAWS, to the CMSP infrastructure, to mobile devices.

The industry is also addressing standards to support an Earthquake Early Warning System (EEWS), with initial standards targeted for completion in 2018. An interim EEWS using WEA would treat the EEWS Primary Notification as a WEA "imminent threat" alert. The Earthquake Warning Authority, authorized to originate WEA alerts and connected to FEMA IPAWS OPEN, would generate a WEA EEWS Primary Notification; this WEA EEWS Primary Notification follows the defined WEA protocols, and would contain the required WEA elements including the alert polygon and a "small" alert message defined by the Earthquake Warning Authority (e.g. "EARTHQUAKE DROP-COVER-HOLD ON") that is to be displayed on the mobile device.

The FCC continues to work with public safety officials and industry on additional enhancements such as rich media messages containing photos and videos, many-to-one messaging, and multilingual messaging other than Spanish. There have already been contributions on the record related to these topics.

One area of continued discussion is the desire to provide multimedia in WEA messages. WEA uses a standards-based broadcast technology that is text based. While there is a multimedia broadcast service defined in standards (eMBMS), it is not a technology that has been widely deployed commercially, and even if it were to be deployed it would likely be for limited coverage areas and not all devices (not ubiquitous like cell broadcast). In addition, any support for WEA on eMBMS would require further standards development, and deployment challenges and practices would need to be addressed (such as how to manage dynamic spectrum allocation). Thus, eMBMS is not viewed as a solution for multimedia WEA alerts.

The continued and expanded use of embedded references in WEA messages is the best solution for providing multimedia to WEA recipients. The use of embedded URLs in WEA messages allows an alert originator to point to a web site containing multimedia content.

6.6 5G

5G, also known as IMT-2020, is the 5th generation wireless systems. The system is based on a set of requirements developed by the International Telecommunication Union (ITU). Figure 7 shows enhancement of some key capabilities from IMT-Advanced (4G LTE) to IMT-2020 (5G).

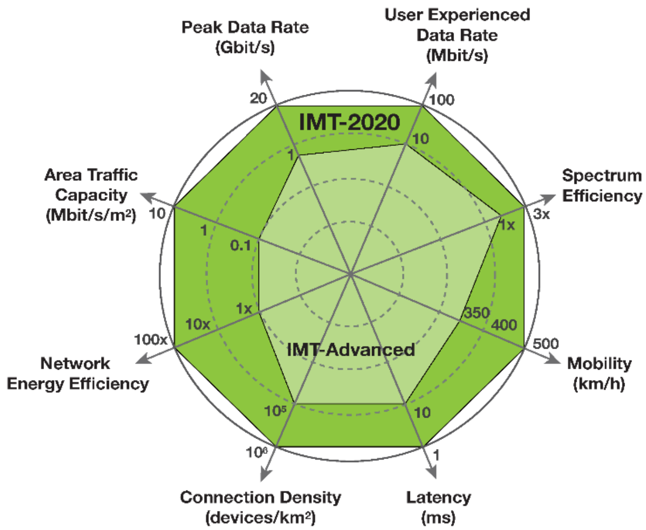

Figure 7 - Enhancement of key capabilities from IMT-Advanced to IMT-2020

As shown in the figure, the peak data rate will be 20x more, the user experienced data rate will be 10x more, while the latency, which could be critical for public safety applications, will go down to 1ms when moving from 4G LTE to 5G.

In addition to the enhancements to the air interface (RAN), the network architecture will also be enhanced to support concepts like Network Slicing and Service Based Architecture. 5G network slicing will allow operators to split a single physical network into multiple virtual networks. Service Based Architecture uses service-based interfaces between control-plane functions, while user-plane functions connect over point-to-point links. This will facilitate the demand for scalability, the ability to develop new functions easily, faster time-to-market, and use of off-the-shelf technology. The characteristics of 5G described above will provide benefit to enhanced mobile broadband, massive IoT, and ultra-reliable low latency communications.

With respect to WEA, the broadcast distribution of WEA messages over the air will have identical characteristics to how it is done in 4G LTE. Similarly, the limitations on the amount of data that can be broadcasted, the nature of the alert message (i.e., text only), etc. will not change.

As for the core network enhancement to WEA, it will be able to support Service based Architecture as shown in Figure 8.

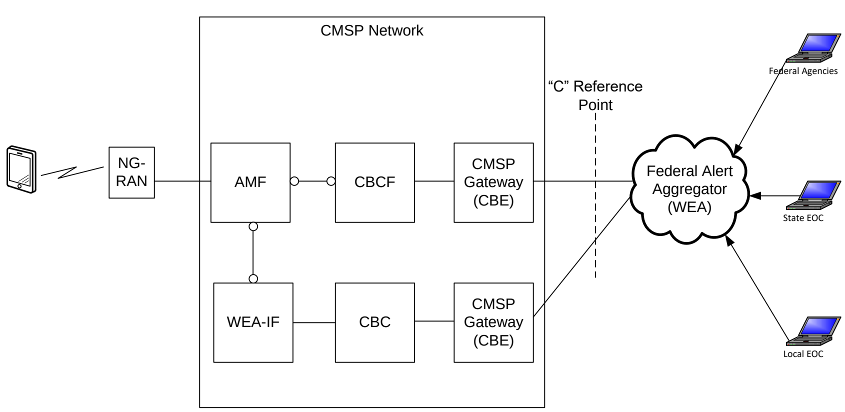

Figure 8 - 5G WEA Architecture

To address any potential concern of any service interruption as we transition from 4G LTE to 5G, there is a provision for the 5G System to support WEA elements of 4G network as shown in the lower portion of the figure.

6.7 FM Radio Networks Using Radio Data System Dissemination Techniques

FM radio networks using Radio Data System (RDS) is a proven alerting technology that uses existing transmitters (connected by satellite) to deliver life-saving messages within six seconds of activation.

Per a DHS grant legislated by Congress (2011), FEMA IPAWS delivered a study, independently produced by Northrop Grumman, stating the practicality of emergency alert system using RDS. Commercial systems are currently available to distribute emergency messages using RDS.

RDS utilizes existing infrastructure and requires no additional spectrum. It can be readily integration with FEMA IPAWS.

6.8 Spread Spectrum Satellite Dissemination Techniques

Use of a portable, low-cost digital media receiver that tunes into satellite channels transmitting from conventional geostationary transponders utilizing integrated and small form-factor antennas in both Ku and C-band.

The short-term goal is to develop a national multimedia weather receiver; a modernized version of the NOAA radio. The receiver could include a touch LCD display, as well as an integrated speaker which plays a live audio broadcast while digital media is downloaded to the device's local storage.

In the longer term, the goal is to provide a national, citizen-centric multimedia service that can be received by very low cost and low power modules. These modules will be embedded into all manner of emergency-related equipment, such as flashlights, power packs, and solar panels. Potentially including a low-power return channel network for the delivery of short messages in times of emergency.

7 Capabilities Needed to Improve Public Safety

Identifying capabilities associated with a comprehensive re-imagining of emergency alerting starts with a foundation of alert information and basic alerting capabilities which are then extended to improve public safety. These capabilities were mostly distilled from the user stories in Appendix A. The user stories were developed by public safety representatives of the working group and represent an ideal state of public alerting.

7.1 Foundation of Alert Information and Basic Capabilities

Device Wake-up

- Consumer electronics with the ability to receive public alerts should be capable of automatically waking up from a stand-by mode and notifying the user upon recipient of an alert.

Sources of Alert Information

- FEMA's Integrated Public Alert and Warning System (IPAWS) should continue to serve as an official source of all-hazard alert information.
- Alerting authorities should transmit alerts to FEMA's Integrated Public Alert and Warning System
- Alerting systems should only use alert information from authorized sources. FEMA IPAWS maintains a publicly available list of alerting authorities.

Rendering of Alerts by Default

- For alerting systems with Federal oversight, such as EAS and WEA, receiving devices should be set to receive and render alerts by default.

Interoperability, Consistency, and the Internet of Things

The following recommendations are to ensure consistency in information delivered by our nation's warning network and to foster interoperability between the Internet of Things.

- All alerting authorities should author alerts in the latest Common Alerting Protocol (CAP) version adopted by FEMA.
- All alerting systems should use alert information in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

7.2 Extended Capabilities

7.2.1 Geographic Targeting

- Alerting authorities should issue alert by polygon, rather than by geopolitical or other contrived boundaries, in order to convey the actual alert area.

- Alerting systems should use the polygon outline of the alert area for geographic targeting when a polygon is included in an alert.

- Alerting systems should leveraged location accuracy technology (e.g. GPS, IP-based, cellular triangulation, etc.) to target alerts to the recipient's current location. This ensures the alert is geographically relevant to the recipient and that people traveling into a threat area receive the alert. If location accuracy technology is not available, other methods for geographic targeting should be used, such as that associated with cell broadcast.

- Alerting systems should provide "precise geotargeting" defined as alerts to the actual alert area with no more than .10 mile error. This is in contrast with "best approximate geotargeting" defined as an area not larger than the propagation area of a single transmission site[11].

7.2.2 Speed of Delivery and Updates

- FEMA's Integrated Public Alert and Warning System (IPAWS) should provide a push of Common Alerting Protocol (CAP) messages, so that all redistributors of alert information can receive and redistribute emergency alert information in the timeliest fashion possible.

- Alerting systems should deliver earthquake alerts to the recipient and render them without delay. This implies that precise geotargeting of earthquake alerts must be avoided so that there are no delays associated with geotargeting earthquake alerts.

- Alerting systems should render rapid-update alert information in real-time, when available. For example, a CAP message may contain a reference to rapidly updating earthquake or severe weather information. Earthquake information may be revised every few seconds as the event proceeds and additional seismic data is collected. The initial CAP message may say that shaking is about to begin and include reference to a rapidly updating map which shows the expected earthquake intensity and a moving outline which shows where the onset of the quake is being experienced at that moment. WEA cell broadcast should be able to update the polygons where the earthquake warning is broadcast as the earthquake progresses. Similarly, NOAA's National Weather Service is experimenting with Forecasting a Continuum of Environmental Threats (FACETS). FACETS defines the alert area as probabilities of impact along the path of the threat, rather than as a discrete polygon, and updates the alert area every two minutes.

7.2.3 Impact Based Alerting

- Alerting systems should leverage the urgency, severity, and certainty information in CAP messages in conveying impact to alert recipients. Alerting systems, which use a native

[11] 47 CFR § 10.450(a).

schema, should carry the CAP urgency, severity, and certainty information into their schema and leverage it in conveying impact to alert recipients.

7.2.4 User Preference

- Alerting systems should provide users with alerts for locations defined by the user such as commuting routes, schools attended by the user's children, and other areas of concern.
- Alerting systems should leverage alert type information so that users can choose to receive alerts by the type of emergency.
- Alerting systems should leverage the urgency, severity, and certainty information in CAP messages so that users can choose to receive alerts which reach or exceed impact thresholds defined by the user.

7.2.5 Graphics and Rich Multimedia

- Alerting systems should carry or direct the recipient to text, graphics, audio, and other multimedia in or referenced by the alert.
- When an alerting system carries graphics, audio, or other multimedia, the alerting system should preserve the quality of the original content. For example, an image of a missing child, evacuation, or threat area should not be degraded.
- Alerting systems should display a graphical icon consistent with the type of hazard in the alert message. The icon should be from a standard set of icons as adopted by FEMA.
- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, safety checklists, and more.

7.2.6 Resiliency and Redundancy

Traditional and time-tested technologies should be leveraged to provide resiliency and redundancy for our nation's warning network in time of emergency.

- Consumer devices should consider including multiple and redundant alerting technologies to provide alert and emergency related information from authorized sources and that facilitated by news media.

- All Hazards NOAA Weather Radio should be enhanced with improvements to geotargeting, interoperability with CAP, and other capabilities which may facilitate protective action-taking by the general public.

7.2.7 Recipient feedback to Alerts

- When an alert requests feedback from alert recipients, alerting devices should prominently display the request for information.

- When an alert requests feedback from alert recipients, alerting devices should leverage any built-in capabilities which would facilitate response by the alert recipient to the alerting authority. For example, the recipient of an Amber Alert on a mobile device should be able to quickly and easily submit a lead containing photos (e.g. car, suspect, and/or child) and location coordinates captured by the device as well as contact information so that the alerting authority can follow up directly with further instruction, for example through the use of embedded references (e.g., URLs).

7.2.8 Accessibility

Accessible, comprehensible and actionable alert and warning information and instruction is important for everyone, and is required in compliance with Section 504 of the Rehabilitation Act of 1973, as amended. Individuals with intellectual, cognitive, and other disabilities are often left out of the emergency alerting process due to warnings in inaccessible formats, including via wireless handheld devices.

Access to actionable information for users with cognitive and intellectual disabilities can be a far greater challenge than for individuals with other types of disabilities. Some people with cognitive or intellectual disabilities experience limited comprehension and may not be able to understand, quickly process, or act on the complex information presented to them. Some people with cognitive, intellectual, mental health and other disabilities may become frustrated or upset when they sense difficult situations or when there is too much information happening at the same time. They may not be able to move from abstract to concrete thinking without effort, especially in time of crisis.

- Prominent audio, visual, vibration, and other techniques should be employed to notify the recipient of an incoming alert.

- Alert originators should insure that WEA, Local Self-Registry Notification Services, and other mass notification systems should provide recipients with direct access to a web page containing specific information about the emergency in accessible formats for easy viewing to avoid information overload. Other accessible messages should be posted alongside with information about shelters and other relevant protective action-taking.

7.2.9 Deaf and Hard of Hearing

Access to actionable emergency warning and information is especially important for people who are deaf, deaf-blind and hard of hearing, who are often left out of the emergency alerting process. Mass notification systems, such as WEA and subscription based services, must provide equally effective mass notification for people who are deaf and hard of hearing. It is crucial that everyone, including individuals who are deaf, deaf-blind, and hard of hearing, receive messages at the same time in a format that is accessible to them. They also must be alerted to the presence of such messages in a way that grabs their attention, even if they do not have the phone or communication device on them, or if they are not paying attention to the TV and when power and connectivity are interrupted.

Technological changes in the industry and expansion of telecommunications now provide people with many communication options. Individuals who are deaf and hard of hearing, and individuals with a speech disability are also following these trends and are rapidly migrating to more advanced telecommunications methods, both for peer-to-peer and third-party telecommunication relay service (TRS) communications. Internet-based equipment includes, but is not limited to, wireless devices, videophones/videocams, computers, and tablets.

Individuals who are deaf, hard of hearing, or have a speech disability, like the mainstream, have increasingly adopted Internet of Things and smart home-based technologies. These especially include smart lights and app-based notification systems, If-This-Then-That (IFTTT) actions, and local smart home hubs. Technologies like IFTTT already offer the option to program visual notifications in response to emergencies, but insufficient flexibility in what alerts are shown, latency, and reliability all are still significant problems. There are also limited solutions available for night time, when such individuals are asleep – due to a lack of compatible strobe lights and vibration equipment that would wake up someone from sleep.

A few government agencies, if they choose to “opt-in”, are offering mass notification services to residents who “sign up” to receive emergency warning and/or information. To receive notification, individuals must register or sign up with local self-registry notification service or emergency alert system through their local Emergency Management Agencies.

Here a just a few, among many, examples that individuals who are deaf, deaf-blind, and hard of hearing have encountered when facing disasters.

On July 13, 2103 at 2:31 pm, a fuel tanker crashed and exploded into flames near homes in Silver Lake, California. Several voice messages regarding the event were transmitted to smart phones. There was no equivalent text message. Thus, emergency information was not conveyed to people who were deaf or hard of hearing.

On October 9, 2017, two destructive fires consumed more than 52,000 acres in California’s Napa and Sonoma Counties. Approximately five hundred individuals who are deaf and hard of hearing were unable to receive notification until much later than their neighbors who have no hearing disability.

On October 17, 2017, an explosion rocked the Chevron Refinery in El Segundo, California.

Helicopters hovered over the area and announced instructions to residents by loudspeaker that they should evacuate the area. Naturally, people who are deaf and hard of hearing were not aware of the announcement.

For alerts that are pushed out over phone calls, people who are deaf, deaf-blind, and hard of hearing register their 10-digit numbers delegated to them from their preferred relay service providers. However, phone-based notification systems are problematic for individuals who rely on relay services, as several technical challenges may prevent the reception of the alert.

When the notification system automatically sends out computerized voice messages to subscribers in mass volume, these calls reach the designated relay service provider. Often, these calls are placed in a holding queue, waiting for the next available Video Interpreter or Communication Assistant to become available. During this delay, a recorded audio message is often played to alert hearing callers of the delay, announcing to the caller "Please hold for the next available agent".

Many automated notification systems do not recognize this automated voice announcement; causing it to disconnect and redial. The notification system may also misinterpret the recorded announcement as human voice, and then deliver the automated message. When this occurs, should the Video Interpreter or CA answer the call, it is most likely that he/she may not capture the full information before connecting with a relay user. Often, the notification system will then disconnect assuming the message has been delivered, when in fact it has not, and the individual who is deaf or hard of hearing misses the content of the alert.

Text-based notifications are not universally accessible to some people who use American Sign Language as their primary mode of communication. Reading skills and literacy vary widely across this group, with some studies citing an average reading level of 4th grade. Many of these people benefit from emergency messages in ASL – both for faster understanding of an alert, and for better understanding of complex emergency information.

- A notice should be posted on the online local self-registry notification service registration form advising individuals relying on Telecommunication Relay Services (TRS) to sign up to receive text message using a smartphone or mobile device by providing a mobile number. Telecommunication Relay Services (TRS) includes but is not limited to Text-to-Voice TTY-based TRS, Speech-to-Speech Relay Service, Shared Non-English Language Relay Services, Captioned Telephone Service; IP Captioned Telephone Service, Internet Protocol Relay Service, or Video Relay Service.

- Visual alert and warning information should be made available in American Sign Language (ASL) using "canned" videos, live certified deaf interpreter, or video remote interpreting services and closed captions for various situations to alert individuals who are deaf and hard of hearing[12].
- Emergency alert notifications, especially WEA, should be available to a wide range of devices (e.g., IoT-based and smart home technologies), so that individuals who are deaf,

[12] For example, see http://on.nyc.gov/1QCKYg5 message for an ASL video that was used as notice to stranded travelers at New York City LaGuardia Airport.

hard of hearing, or deaf-blind have the means to be warned even if they are not paying attention to their phone or if they are asleep.

- Information from emergency alerts should be available to assistive technologies, including but not limited to refreshable braille displays and hearing assistive technologies

7.2.10 Visually Impaired

Here a just a couple, among many, examples that individuals who are blind or otherwise visually impaired have encountered when facing disasters.

During Hurricane Matthew (October 2016), the Glenn County, Georgia emergency announcements that went out over radio directed individuals to the county government website for information on location and times for shuttles evacuating local residents. However, the .pdf document on the website listing evacuation routes and departure locations and times was not accessible, unable to be read by text-to-speech software. A visually resident reported how she was stranded as a result. She didn't know where the busses were departing from and missed the last bus out of town.

During Hurricane Irma (September 2017), much of Florida lost power. This meant that many residents relied on listening to local radio for emergency updates. However, local stations were passing through television news, which did a poor job of describing verbally what was taking place. This was not just a concern for blind and visually impaired residents, but local residents who turned to their battery powered radios to learn what was going on during the storm.

- When graphical images or video are used, there should be textual description of important information being conveyed, so that text to speech software can make the information accessible.
- Websites and other emergency management information should adhere to Section 508 accessibility standards if applicable to a federally funded activity, and accessible under title II of the Americans with Disabilities Act (ADA) for state and local government agencies. The World Wide Web Consortium (W3C) has established the Web Content Accessibility Guidelines (WCAG 2.0) that is the preferred standard upheld in the courts and by the Access Board in their 2017 final rule for Section 508 standards.
- Text messages should remain clear and concise, accessible to smart phone text-to-speech software like Apple's Voiceover or Android's Talkback.
- The FCC requires under rule 79.2(b)(2)(ii) that emergency information broadcast by television stations and passed through by multichannel video programming distributors

include an aural representation of the information on a secondary audio stream, accompanied by an aural tone.[13]

7.2.11 Multiple Languages

Multilingual alerting capabilities are still in a nascent stage, though there have been a number of initiatives to provide enhanced multilingual alert services in the U.S. There are two basic approaches to multilingual alerting: alert content is composed and relayed to dissemination channels by the alert originator; and/or alert content is converted in some fashion to multiple languages via a service or an application in a particular dissemination path. The following discussion updates certain findings in the September 2016 CSRIC [14]

The FCC's goals for multilingual alerting were identified in two areas:

- EAS rules presently allow (but do not require) an EAS Participant providing foreign language programming to transmit its alerts in the "primary language of the EAS Participant." (§§11.55(a)(4) and 11.55(d)(2))
- WEA rules will require mobile carriers to support Spanish-language alert messages and messages of up to 360 characters in length by May 1, 2019.

Originated Multiple Language Content

Most observers appear to lean towards reliance on multiple language content provided by the alert originator. For EAS and other systems, this capability is facilitated by the delivery of multilingual messages through the use of multiple <info> block elements in a Common Alerting Protocol (CAP) message. Certain other systems may avail themselves of multiple language content via the conversion of the CAP message into a medium specific format, such as that utilized by WEA or ATSC 3.0 for AEA emergency information (although the CAP message would directly be utilized for EAS in ATSC 3.0).

Real-world functional capability of this multilingual message delivery capability has been demonstrated though regional EAS initiatives, such as the Minnesota EAS system (providing support for up to four languages), and the IPAWS NPT testing effort, which has been bilingual.

Multilingual Translation by Dissemination Channels

The working group does not feel that automated translation of text is sufficiently reliable or accurate to be utilized in public safety applications, such as EAS, WEA or other warning techniques. Due to the nature of WEA, the working group feels that any non-English content (currently limited to Spanish) should optimally be provided by the alert originator.

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[13] "As in the First Report and Order, we note that the emergency information covered by this proceeding does not include emergency alerts delivered through the Emergency Alert System (EAS), the accessibility requirements for which are contained in Part 11 of the Commission's rules."

[14] CSRIC V Report: WORKING GROUP 3 - EMERGENCY ALERT SYSTEM. Final Report – Multilingual Alerting Recommendations (September 2016)

EAS participants are - in general - unable provide human language translation services for EAS messages. Many EAS participants operate in an unattended environment, do not have on-staff translators, or would be unable to bear the cost of procuring translation services. The working group feels that EAS Participants should be encouraged, but not required, to relay alerts in the languages appropriate for their audience, when the desired languages are available.

On the other hand, the working group also noted the existence of technologies in at least one CAP/EAS device to provide a basic transcoding of conventional EAS header messages into multiple languages, with text and audio. This type of capability allows a basic EAS message to be created in multiple languages, much as basic EAS messages are created in English. Although this technique does not enable the automated translation of complex free-form text in alert messages, it does enable the conveyance of a simple alert message consistent with the FCC's EAS rules.

Absent such a technology at a particular EAS participant site, if a required alert in not available in their desired alternate language, the English version must be played. If the Participant is able to provide the emergency information in an alternate language or format, but is unable to do so within the context of EAS (for technological or infrastructure reasons) they should be encouraged to provide the information as part of their regular broadcast.

A multilingual EAS project in the state of Minnesota provides a recent example of how both alert originators and EAS Participants can voluntarily collaborate to serve non-English speaking populations in their area. The pilot project successfully demonstrated a CAP-based alert with four languages: English, Spanish, Hmong, and Somali. The Minnesota system demonstrated the feasibility of multiple language origination, supplemented by language selection and automated transcoding of alert content into standard EAS messages in these four languages. Important to its success was the accompanying community engagement campaign, designed to ensure that the targeted populations understand how to access emergency information and act upon it.[15] Customized content can also be distributed when linguist teams are called to support alert originations. This work continues today with annual exercises.

EAS Channel Constraints

For EAS, there are practical technological limits on the number of languages that can or should be displayed.

- For EAS, the ECIG Implementation Guidelines provide for a technique where one language is conveyed as an EAS message (i.e. the audio is transmitted between the EAS header and the EAS End-of-Message signal. Messages in additional languages (audio and text) may be voluntarily

[15] Additional project information can be found at Ellen Shelton and Thalia Hall, "Real-Time Warnings and Alerts for Non-English Speaking Communities: Evaluation of Best Practices in Community Outreach and Engagement in the Minnesota Multi-Language Messaging Initiative, July 2015. https://www.wilder.org/Wilder-Research/Publications/Studies/ECHO%20Minnesota%20-%20Minnesota%20Multi-Language%20Messaging%20Initiative/Real-Time%20Warnings%20and%20Alerts%20for%20Non-English%20Speaking%20Communities.pdf

transmitted after the "primary language" is transmitted as EAS. However, there is a practical limit on how many languages should be transmitted in a given message. Voluntary transmission of even a limited number additional languages after the EAS message would potentially yield a burdensome message length for both the EAS Participant (suffering a significant interruption in programming) and the audience/subscriber. For such reason, this technique should be adopted only on a voluntary basis by EAS Participants, as appropriate given their audience and their particularly technological capability. The working group also noted that some EAS Participants operate systems that are incompatible with the ECIG approach (i.e. while they are capable of handling the required EAS message, they are not designed to handle the "post-alert" text and audio in the ECIG method. Therefore, while the ECIG methodology is potentially viable for a large number of EAS Participants, it cannot be viewed as a universally applicable solution.

- Multilingual support, in particular the delivery of text and provided audio, is a capability of much of the CAP/EAS equipment in the field. When alternate language text and audio is provided, the CAP/EAS device selects the appropriate text and audio file (if present). The use of multiple-language Text to Speech (TTS) is supported by some devices, and with some languages. Users must typically load the alternate languages they intend to use into the device – not all languages/dialects are available on all devices, and some languages aren't available on any device.[16]
- The current IPAWS implementation of CAP supports the use of a limited set of UTF-8 characters in text elements, although the working group understands that IPAWS will be expanding the character sets it will be able to support. However, for video services providers, the display of particular languages is still limited to the character sets supported by their display devices. In some cases, these are limited to simple ASCII characters, which makes display of non-English languages problematic.

In sum, the EAS framework provides flexibility to support multiple-language alert messaging, subject to certain operational and technological constraints. The working group noted that conventional EAS is best suited to conveying a single language message, or an EAS message accompanied by one or two post-alert messages in additional languages at the voluntary discretion of the EAS Participant.

While EAS can provide certain support for multilingual messaging, the working group still finds that such a capability should rely on the alert originator for full text description and audio of the alert message in each language. The working group concurs that auto translation of short standard EAS messages provides a workable supplement when the full text is not available in a non-English language (no worse than the conventional EAS header-driven sentence).

The working group considered a targeted approach for selecting the languages transmitted by the facility, to be consistent with the primary language of the EAS Participant, and most appropriate for the overall audience.

WEA Channel Constraints

[16] Multilingual support using universal intermediary devices (CAP converters) is more problematic because the EAS device controls the output but receives only EAS data from the converter. There is no multilingual support in the legacy EAS protocol so a CAP converter/Legacy EAS pair does not have the ability to carry more than one language.

For WEA, the working group also noted various technological constraints to multiple languages.

- The ATIS standards[17] provide support for Spanish and other languages, however, importantly, there are character limitations. Currently, WEA supports only GSM 7-bit encoding as described in 3GPP TS 23.038. Some languages require UCS-2 encoding to support extended characters (e.g., characters with accent on them). This constraint will require great care that the meaning of key words in the alert message are not altered with the lack of support for certain extended characters.
- Deviating from the GSM 7-bit encoding (as with UCS-2) encoding for multilingual text support would like create number of issues in the WEA system. The working group took note of the likely need to update numerous standards and the requirement for extensive software changes. The working group also noted that using an encoding schema other than GSM 7-bit encoding could dramatically reduce the number of characters available in a WEA message (potentially unpredictably for alert originator). For example, UCS-2 encoding requires twice as many bits as GSM 7-bit encoding, potentially reducing the text length of a WEA message by half.
- The working group concurs that that automated translation programs are not yet sophisticated enough to be used in an emergency service like WEA. As with EAS, the automated translation of emergency messages by software applications poses significant risks of translation errors.

Alternative Mechanisms for Multilingual Messaging

The working group noted that other dissemination channels outside of EAS and WEA may be more suited for multiple language use cases, particularly for exotic languages or handling messages with a significant number of language elements.

For example, while WEA may be best suited to conveyance of alert messages in English and/or Spanish, ancillary applications could conceivably handle alert messages with additional languages. The working group stresses that such applications are outside of the scope of the wireless carrier or handset manufacturer, and would need to emerge as a voluntary or market-driven capability.

Similarly, EAS may be best suited to the conveyance of an EAS message in one language, potentially followed by a non-EAS message in a second language. However, certain technologies, such as ATSC 3.0, suggest the emergence of additional messaging capabilities that can support messages with a greater number of languages.

7.2.12 Research to Application

There should be a path for research in improvements to public alerting to be applied in consumer electronics and other alerting systems.

- An organization should be established to oversee continuing research on improvements

[17] ATIS Standard on Implementation Guidelines for Mobile Device Support of Multi-Language CMAS (ATIS-0700013) and ATIS Standard on Implementation Guidelines for CMAS Supplemental Information Retrieval (ATIS-0700012).

to public alerting such as colors and animations used to convey hazard information, accessibility, clear presentation of information, alerts in multiple languages, etc.

- One or more consumer electronics standards bodies should be leveraged or formed to develop standards for public safety information in the various classes of consumer electronics. These bodies should leverage emerging technologies and results of research in public alerting to better save lives.

7.2.13 Outreach

- Extensive outreach should be conducted to encourage the integration and display of public alert information across the spectrum of consumer electronics including, but not limited to, cell phones and other mobile devices, television and radio, smart home devices/systems, and in-vehicle navigation/infotainment systems.

- Extensive outreach should be conducted to encourage the integration and display of public alert information in electronic media, the web, and social media.

- Extensive outreach should be conducted to encourage the integration and display of public alert information in public areas including retail venues, highways, and other locations frequented by the general public.

8 Recommendations

The following recommendations should be applied to the extent feasible and where they improve the content and/or delivery of alert information for consumers.

8.1 Short Term Recommendations (less than 5 years)

Technical Enhancements to EAS

- It is recommended that enhancements described in the EAS Section should be studied by a technical committee, similar to the EAS-CAP Industry Group (ECIG) that developed the ECIG Implementation Guide referenced by 47 CFR Part 11, as well as participation by NOAA, FEMA, and the FCC. Many of the issues with EAS will require participation from origination, relay, and dissemination groups to resolve.

- Based on the complexity of EAS and collaboration of work scoped by CSRIC VI, it is recommended that further examination be conducted by CSRIC VI to ensure technical and policy aspects are adequately captured.

Improve Geographic Targeting on Mobile and Stationary Devices

- Alerting authorities should issue alert by polygon, rather than by geopolitical or other contrived boundaries, in order to convey the actual alert area.

- Alerting systems should use the polygon outline of the alert area for geographic targeting when a polygon is included in an alert.

- Alerting systems should leverage location finding technology (e.g. GPS, IP-based, cellular triangulation, etc.) to geotarget alerts to the recipient's current location. This ensures the alert is geographically relevant to the recipient and that people traveling into a threat area receive the alert. If location finding technology is not available, other methods for geographic targeting should be used, such as that associated with cell broadcast.

- Alerting systems should geotarget alerts to the actual alert area with no more than .10 mile error.

Alerting Devices Should Leverage Common Alerting Protocol to Convey Impact to the Alert Recipient

- Alerting systems should leverage the urgency, severity, and certainty information in CAP messages in conveying impact to alert recipients. Alerting systems, which use a native schema, should carry the CAP urgency, severity, and certainty information into their schema and leveraged it in conveying impact to alert recipients.

Increase the Delivery Speed of Alert Information to Alert Redistributors

- FEMA's Integrated Public Alert and Warning System (IPAWS) should provide a push of Common Alerting Protocol (CAP) messages, so that all redistributors of alert information can receive and redistribute emergency alert information in the timeliest fashion possible.

- Alerting systems should deliver earthquake alerts to the recipient and render them without delay.

Enhance Public Alerting Systems with Multimedia Which Facilitates Public Action-taking

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.

- When an alerting system carries graphics, audio, or other multimedia, the alerting system should preserve the quality of the original content. For example, an image of a missing child, evacuation, or threat area should not be degraded.

Make Public Alerting Systems Resilient and Redundant
Traditional and time-tested technologies should be leveraged to provide resiliency and redundancy for public warning networks in time of emergency.

- Smart phones should consider including multiple and redundant alerting technologies to provide alert and emergency related information from authorized sources and that facilitated by news media.

- All Hazards NOAA Weather Radio should be enhanced with improvements to geotargeting, interoperability with CAP, and other capabilities which may facilitate protective action-taking by the general public.

Improve the Accessibility of Alert Information for All People

- Prominent audio, visual, vibration, and other techniques should be employed to notify the recipient of an incoming alert.

- WEA, Local Self-Registry Notification Services, and other mass notification systems should provide recipients with direct access to a web page containing specific information about the emergency in accessible formats for easy viewing to avoid information overload. Other accessible messages should be posted alongside with information about shelters and other relevant protective action-taking.

Improve the Accessibility of Actionable Alert Information for Individuals Who Are the Deaf or Hard of Hearing

- A notice should be posted on the online local self-registry notification service registration form advising individuals relying on Telecommunication Relay Services (TRS) to sign up to receive text message using a smartphone or mobile device by providing a mobile number. Telecommunication Relay Services (TRS) includes but is not limited to Text-to-Voice TTY-based TRS, Speech-to-Speech Relay Service, Shared Non-English Language Relay Services, Captioned Telephone Service; IP Captioned Telephone Service, Internet Protocol Relay Service, or Video Relay Service.

- Visual alert and warning information should be made available in American Sign Language (ASL) using "canned" videos, live certified deaf interpreter, or video remote interpreting services and closed captions for various situations to alert individuals who are deaf and hard of hearing[18].

- Emergency alert notifications, especially WEA, should be available to a wide range of devices (e.g., IoT-based and smart home technologies), so that individuals who are deaf, hard of hearing, or deaf-blind have the means to be warned even if they are not paying attention to their phone or if they are asleep.

- Information from emergency alerts should be available to assistive technologies, including but not limited to refreshable braille displays and hearing assistive technologies

[18] For example, see http://on.nyc.gov/1QCKYg5 message for an ASL video that was used as notice to stranded travelers at New York City LaGuardia Airport.

Improve the Accessibility of Alert Information for the Blind and Visually Impaired

- When graphical images or video are used, there should be textual description of important information being conveyed, so that text to speech software can make the information accessible.

- Websites and other emergency management information should adhere to Section 508 accessibility standards if applicable to a federally funded activity, and accessible under title II of the Americans with Disabilities Act (ADA) for state and local government agencies. The World Wide Web Consortium (W3C) has established the Web Content Accessibility Guidelines (WCAG 2.0) that is the preferred standard upheld in the courts and by the Access Board in their 2017 final rule for Section 508 standards.

- Text messages should remain clear and concise, accessible to smart phone text-to-speech software like Apple's Voiceover or Android's Talkback.

- The FCC requires under rule 79.2(b)(2)(ii) that emergency information broadcast by television stations and passed through by multichannel video programming distributors include an aural representation of the information on a secondary audio stream, accompanied by an aural tone.[19]

Increase Outreach to Encourage the Integration of Public Alert Information Across Consumer Electronics, Electronic Media, and Public Displays

- Extensive outreach should be conducted to encourage the integration and display of public alert information across the spectrum of consumer electronics including, but not limited to, cell phones and other mobile devices, television and radio, smart home devices/systems, and in-vehicle navigation/infotainment systems.

- Extensive outreach should be conducted to encourage the integration and display of public alert information in electronic media, the web, and social media.

- Extensive outreach should be conducted to encourage the integration and display of public alert information in public areas including retail venues, highways, and other locations frequented by the general public.

Continue Research on Improvements to Public Alerting

- An organization should be established to oversee continuing research on improvements to public alerting such as colors, icons, and animations used to convey hazard information, accessibility, clear presentation of information, alerts in multiple languages, etc. and should incorporate improvements in accessible, actionable instructions when power or connectivity are interrupted, degraded or destroyed.

8.2 Long Term Recommendations (5-10 years)

The following recommendations should be applied to the extent feasible.

Make Alerting Systems Capable of Handling a Real-Time Stream of Alert Information

- Alerting systems should render rapid-update alert information in real-time, when available. A CAP message may contain a reference to rapidly updating earthquake or severe weather information.

- Earthquake information may be revised every few seconds as the event proceeds and additional seismic data is collected. The initial CAP message may say that shaking is about to begin and include reference to a rapidly updating map which shows the expected earthquake intensity and a moving outline which shows where the onset of the quake is being experienced at that moment.

- NOAA's National Weather Service is experimenting with Forecasting a Continuum of Environmental Threats (FACETS). FACETS defines the alert area as probabilities of impact along the path of the threat, rather than as a discrete polygon, and updates the alert area every two minutes.

8.3 Evolutionary Recommendations

These items are already possible, may already be incorporated in alerts, and should continue to evolve in coming years.

Improve Alerting By Leveraging Enhancements to the Common Alerting Protocol (CAP) Standard

- CAP should continue to evolve as the standard for the exchange of emergency alert information.

- CAP should incorporate new elements agreed upon by the international CAP community to enhance the life and property saving value of CAP messages.

Provide Alert Recipients With the Ability to Receive Alerts Which are Relevant to Them

- Alerting systems should provide users with alerts for locations defined by the user such as commuting routes, schools attended by the user's children, and other areas of concern.

- Alerting systems should leverage alert type information so that users can choose to receive alerts by the type of emergency.

- Alerting systems should leverage the urgency, severity, and certainty information in CAP messages so that users can choose to receive alerts which reach or exceed impact thresholds defined by the user.

Enhance Alerts with Multimedia Which Facilitates Public Action Taking

- Alerting systems should display a graphical icon consistent with the type of hazard in the alert message. The icon should be from a standard set of icons as adopted by FEMA.

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, safety checklists, and more.

Facilitate the Alert Recipient in Providing Feedback to the Alerting Authority

- When an alert requests feedback from alert recipients, alerting devices should prominently display the request for information.

- When an alert requests feedback from alert recipients, alerting devices should leverage any built-in capabilities which would facilitate response by the alert recipient to the alerting authority. For example, the recipient of an Amber Alert on a mobile device should be able to quickly and easily submit a lead containing photos (e.g. car, suspect, and/or child) and location coordinates captured by the device as well as contact information so that the alerting authority can follow up directly with further instruction.

Develop Standards for Public Safety Information in Consumer Electronics

- One or more consumer electronics standards bodies should be leveraged or formed to develop standards for public safety information in the various classes of consumer electronics. These bodies should leverage emerging technologies and results of research in public alerting to better save lives.

9 Conclusions

There are a number of emergency alerting and emerging technologies available to ensure timely delivery of critical information to the relevant individuals or a targeted geographical area. While these techniques provide diversity, it is important for them to work complementary and harmoniously with each other. At the same time, we are gaining a better understanding of how to improve public safety.

The CSRIC VI Working Group 2 has made recommendations to streamline and modernize existing systems and to better address public safety.

Appendix A – Alert Originators Use Cases

User stories were developed by public safety representatives of the working group and represent an ideal state of public alerting. Each user story contains embedded bullet points describing one or more needed capabilities conveyed by the preceding portion of the story.

Rush Hour Tornado User Story

After a long day of work, Bob leaves the office and heads to his car. The tall city buildings obscure his view, but the clouds above look pretty dark. Bob remembers that the opt-out service on his cell phone displayed a special icon when he got up in the morning indicating there is a threat for severe weather.

- Alerting systems should display a graphical icon consistent with the type of hazard in the alert message. The icon should be from a standard set of icons as adopted by FEMA.

Concerned, Bob taps the icon and is presented with textual and graphical information about the timing, location, and severity of the threat. According to the map showing Bob's current location and projected path of storms, Bob realizes his commute is likely to be impacted by bad weather.

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, and more.
- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.
- Alerting systems should leverage the urgency, severity, and certainty information in CAP messages in conveying impact to alert recipients.

As Bob navigates the city traffic, his cell phone suddenly buzzes, vibrates, and flashes. The phone alerts him with a stern voice and brief, but prominent text message saying that his commuting route is in the path of a tornado.

- Prominent audio, visual, vibration, and other techniques should be employed to notify the recipient of an incoming alert.
- For nationally mandated alerting systems, such as EAS and WEA, receiving devices should be set to receive and render alerts by default.
- Consumer electronics with the ability to receive public alerts should be capable of automatically waking up from a stand-by mode and notifying the user upon recipient of an alert.

Bob previously selected areas for which he wishes to receive alerts on his phone. At the time, he drew an outline around his commuting path and selected his home as well as his daughter's school as specific points of interest.

- Alerting systems should provide users with alerts for locations defined by the user such as commuting routes, schools attended by the user's children, and other areas of concern.

Bob could pick up his cell phone to see where he is relative to the alerts, but instead taps goes to his dashboard infotainment system to verify what his phone is telling him. Bob taps the Map button on his infotainment system. The navigation application pops up clearly showing the outline of a tornado warning that starts along the highway Bob will be taking home and extends eastward. The colors inside the outline are quite vibrant, going from bright red along the most likely path of the tornado to yellows and greens which are also at risk.

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, and more.

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.

However, it's clear to Bob that the tornado threat will have cleared his route by the time he gets to the portion of highway which is currently under threat. If traffic backs up due to impacts from the tornado, Bob is prepared to take an alternate route suggested by the navigation application on his infotainment system or on his cell phone.

Bob remains concerned about the severe weather threat along his commute, so he keeps the navigation screen on and tunes to his favorite local radio news station. He even passes a highway sign warning of the threat ahead and advising him to seek additional information.

- Alerting systems should only use alert information from official sources.
- All alerting systems should use alert information in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

Bob watches as the tornado warning threat area updates every two minutes on his screen and listens to the reports of considerable damage coming in across the news.

- Alerting systems should render rapid-update alert information in real-time, when available. For example, a CAP message may contain a reference to rapidly updating earthquake or severe weather information. Earthquake information may be revised every few seconds as the event proceeds and additional seismic data is collected. The initial CAP message may say that shaking is about to begin and include reference to a rapidly updating map which shows the expected earthquake intensity and a moving outline which shows where the onset of the quake is being experienced at that moment.

Similarly, NOAA's National Weather Service is experimenting with Forecasting a Continuum of Environmental Threats (FACETS). FACETS defines the alert area as probabilities of impact along the path of the threat, rather than as a discrete polygon, and updates the alert area every two minutes.

Running a little low on gas, Bob stops for gas in the gas station on the way home. While the gas pumps, Bob steps into the convenience shop for a refreshing drink where he sees the attendant glued to the TV. Bob feels a sense of confidence as the rich multimedia information about the tornado on TV is remarkably is nearly identical to the information received on his cell phone and infotainment system.

- Alerting systems should only use alert information from official sources.

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.

The attendant says he is impressed by how accurately targeted the alerts are these days, that he was notified of the alert on his cell phone, TV, and inexpensive all hazards information device which all showed his location as just barely inside the actual alert area.

- Alerting authorities should issue alert by polygon, rather than by geopolitical or other contrived boundaries, in order to convey the actual emergency area.

- Alerting systems should leverage location finding technology (e.g. GPS, IP-based, cellular triangulation, etc.) to geotarget alerts to the recipient's current location. This ensures the alert is geographically relevant to the recipient and that people traveling into a threat area receive the alert.

- Alerting systems should geotarget alerts to the actual alert area with no more than .10 mile error.

- All Hazards NOAA Weather Radio should be enhanced with improvements to geotargeting, interoperability with CAP, and other capabilities which may facilitate protective action-taking by the general public.

Bob finally arrives home safely. He turns on the local news and learns all about the impacts from the tornado. Emergency authorities report that roads are dangerous from downed power lines and nearly impassable. While cell towers and phone lines are damaged or destroyed, people have been able to get emergency information over the radio on their cell phone, battery operated radios, and inexpensive all hazards information devices like the one at the gas station.

- Cell phones should include an activated FM radio chip which provides alert and emergency related information from authorized sources and that facilitated by news media.

Thanks to the abundance of warning, emergency responders report no fatalities and only minor injuries.

Earthquake User Story

Deep beneath the ground, a mass of granite shears under the accumulated pressure of the gradual movement of tectonic plates. The failure at one point transfers the pressure to an adjacent one, which also tears apart. In a sequence that continues over many seconds and several kilometers, the rocks fail, "unzipping" along a subterranean path that has ruptured repeatedly over geologic time.

Some of the pent-up energy is transformed into heat in the crumbling underground rock, but much of it radiates as a complex pattern of vibrations. A few seconds later the vibrations reach the Earth's surface, and an earthquake begins.

People unlucky enough to live directly atop the rupture feel the earth jump and then shudder beneath them. Within a few more moments electronic instruments detect the ground shaking and report it to a regional seismic laboratory. Computers quickly calculate the location and intensity of the ongoing earthquake, and apply carefully-calculated digital models to create a forecast of the timing and intensity of shaking as it will be experienced in the surrounding area. That forecast is broadcast at once, received almost immediately by a variety of alerting applications, and it is revised every few seconds as the event proceeds and additional seismic data is collected.

- FEMA's Integrated Public Alert and Warning System (IPAWS) should provide a push of Common Alerting Protocol (CAP) messages, so that all redistributors of alert information can receive and redistribute emergency alert information in the timeliest fashion possible.

- Alerting systems should deliver earthquake alerts to the recipient and render them without delay.

- Alerting systems should render rapid-update alert information in real-time, when available. For example, a CAP message may contain a reference to rapidly updating earthquake or severe weather information. Earthquake information may be revised every few seconds as the event proceeds and additional seismic data is collected. The initial CAP message may say that shaking is about to begin and include reference to a rapidly updating map which shows the expected earthquake intensity and a moving outline which shows where the onset of the quake is being experienced at that moment. Similarly, NOAA's National Weather Service is experimenting with Forecasting a Continuum of Environmental Threats (FACETS). FACETS defines the alert area as probabilities of impact along the path of the threat, rather than as a discrete polygon, and updates the alert area every two minutes.

As a teacher in a town not far from the "epicenter"… the point on the Earth's surface directly above the initial rupture… Julie receives a few second's warning that shaking is about to begin. The alert reaches her in multiple ways… on her cellphone, on an alerting device on her classroom bookshelf, and over the classroom's TV set, which switches on unexpectedly.

- Alerting systems should leverage location finding technology (e.g. GPS, IP-based, cellular triangulation, etc.) to geotarget alerts to the recipient's current location. This ensures the alert is geographically relevant to the recipient and that people traveling into a threat area receive the alert.

- Alerting systems should geotarget alerts to the actual alert area with no more than .10 mile error.

- Prominent audio, visual, vibration, and other techniques should be employed to notify the recipient of an incoming alert.

- For nationally mandated alerting systems, such as EAS and WEA, receiving devices should be set to receive and render alerts by default.

- Consumer electronics with the ability to receive public alerts should be capable of automatically waking up from a stand-by mode and notifying the user upon recipient of an alert.

- Alerting systems should only use alert information from official sources.

- All alerting systems should use alert information in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

Julie's cellphone and the alerting appliance on her shelf simply indicate that shaking is about to begin and remind her and her class to "drop, cover and hold on" as her best protection from injury. The TV shows a map of the region, tinted according to the expected earthquake intensity, and with a moving outline showing where the onset of the quake is being experienced at that moment.

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.

No sooner does the alert sound than Julie's students start feeling vibration… already knowing it's an earthquake and a significant one, they're quick to take shelter beneath their desks and tables, safe from any falling ceiling tiles or lights.

As the shift supervisor at a natural gas pipeline control center some distance from the quake, Roger hears the alert and sees the forecast shaking map via displays built into his control console. Based on the map of predicted shaking, Roger orders a series of valves to close, reducing the pressure on segments of the pipeline that are about to experience strong shaking.

As a passenger on the regional commuter rail system, Mark notices that his train is slowing at a place it doesn't usually do so. A few seconds later he feels what seems like a rough bit of track beneath the trains wheels. Shortly thereafter, his train resumes its normal speed. When he arrives as his destination, he'll notice electronic signs announcing that there was a quake, but that all rail operations are proceeding safely.

Wildland/Urban Interface Fire User Story

As the Incident Commander on a grass fire, Martha is becoming concerned about the speed with which the gusty winds are pushing the blaze toward a developed area about a mile away. Even in the middle of the night, the wind seems to be increasing. After a few minutes Martha decides she can't guarantee stopping the fire's run before it reaches the houses.

Making her decision, Martha pulls out her smartphone and opens the alerting app, which shows her a map centered on her current location. Martha pulls off a glove and uses her fingers to draw a rough outline of the neighborhood at immediate risk on the map. If she had more time Martha could ask Dispatch to connect her with a warning specialist who'd work out the details, but in the interest of speed she selects a generic Immediate Evacuation message for the targeted area and sends it out.

- All alerting authorities should author alerts in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

- FEMA's Integrated Public Alert and Warning System (IPAWS) should continue to serve as an official source of all-hazard alert information.

- Alerting authorities should transmit alerts to FEMA's Integrated Public Alert and Warning System

If they can't halt the fire there'll be time for more detailed, and extensive alerts in the hours to come.

As the on-duty Emergency Coordinator, Jeff receives an automatic copy of any alert sent out in the county. Seeing that this one is an evacuation, he rolls out of bed and starts organizing. The Sheriff's watch commander is expecting his call, but it takes a few minutes to mobilize the Red Cross for shelter support. Forming an ad-hoc team that will expand into a full EOC activation, Jeff and his law and care-and-shelter counterparts sketch out their plan for the evacuation.

The Sheriff's department calls on the Highway Patrol and together they set up traffic checkpoints where traffic inbound to the evacuation area can be redirected, and where evacuees will be given directions to initial shelter locations. Meanwhile the Sheriff's Search and Rescue reserve are called out; they'll move into the evacuation area, directing traffic as best they can while making sure the neighborhood is clear of residents. They'll enter the development as far as they can, then sweep the population outward ahead of them as the fire advances through the development.

As a resident of the Smokey Oaks community, Lisa is awakened by the vibration of her cellphone.

- Prominent audio, visual, vibration, and other techniques should be employed to notify the recipient of an incoming alert.
- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.
- Alerting authorities should issue alert by polygon, rather than by geopolitical or other contrived boundaries, in order to convey the actual emergency area.
- Alerting systems should leverage location finding technology (e.g. GPS, IP-based, cellular triangulation, etc.) to geotarget alerts to the recipient's current location. This ensures the alert is geographically relevant to the recipient and that people traveling into a threat area receive the alert.
- Alerting systems should geotarget alerts to the actual alert area with no more than .10 mile error.

At the same time her TV set and her smoke detector also start making noise. Her bedroom and living room lights flash on twice, then remain lit.

- All alerting authorities should author alerts in the latest Common Alerting Protocol (CAP) version adopted by FEMA.
- Alerting systems should only use alert information from official sources.

Her TV screen shows the words "WILDFIRE… EVACUATE NOW!" along with a map of her neighborhood with a recommended evacuation path drawn in flashing red arrows.

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.
- When an alerting systems carries graphics, audio, or other multimedia, the alerting system should preserve the quality of the original content. For example, an image of a missing child, evacuation, or threat area should not be degraded.

Lisa dismisses the alert on her cellphone, which is replaced with an evacuation checklist:

> "Medications
> Important Papers
> Pets and Pet Food
> Everyone in House evacuate by car NOW.
> If the situation permits, check on your neighbors…"

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, safety checklists and more.

Lisa loads her children and her Golden Retriever into her car and starts down the road. Her cellphone provides turn-by-turn directions per the evacuation plan. The evacuation app also reports her location, which appears on a map visible on Martha's and Jeff's cellphones as well as to the evacuation planners.

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, safety checklists and more.

- When an alert requests feedback from alert recipients, alerting devices should leverage any built-in capabilities which would facilitate response by the alert recipient to the alerting authority. For example, the recipient of an Amber Alert on a mobile device should be able to quickly and easily submit a lead containing photos (e.g. car, suspect, and/or child) and location coordinates captured by the device as well as contact information so that the alerting authority can follow up directly with further instruction.

Sheriff's deputies use that information to detect traffic jams and points of congestion in the evacuation area, and move quickly to clear them up. Meanwhile, the evacuation traffic plan is adjusted and Lisa automatically receives revised instructions from her phone that route her around the chokepoints.

HAZMAT User Story

The Mesozoic and Paleozoic Petroleum Refinery, known locally as "the M&P" or just "the Plant," sits in the center of a complex chemical and industrial ecology that sprawls over dozens of square miles. Interconnected by a tangle of business arrangements and physical infrastructure, the Plant supports, and is supported by, a variety of petrochemical facilities that convert the plant's various products and effluents into feed materials for still others, where they are transformed into a vast variety of chemical products, some of which go back to the refinery itself for re-use, along with firms that provide tooling, services and supplies for them all.

This spaghetti plate of industrial activity also forms a major rail, road and pipeline transportation hub, through which daily pass enormous volumes of commodities as prosaic as sand and as exotic as deadly acids used elsewhere in the manufacture of modern integrated circuits. Not surprisingly, the production, handling, and shipping of this chemical potpourri entails the occasional accidental release into the surrounding neighborhoods and countryside.

As an environmental health officer, Jorge receives an automatic page from the security control center at the M&P reporting a traffic accident involving a fully-loaded gasoline tank truck, which is now leaking fuel into a creek that runs along the plant's fence line before passing under a roadway and into the adjacent county. The accident is reportable to a long list of regulatory agencies, but Jorge is the one with immediate responsibility for the public safety implications.

Jorge activates the county's Community Warning System, an industry-funded integrated public warning network that triggers sirens, cellphones, telephone notifications and emergency broadcasts targeted on the affected areas of the county.

- FEMA's Integrated Public Alert and Warning System (IPAWS) should continue to serve as an official source of all-hazard alert information.

- Alerting authorities should transmit alerts to FEMA's Integrated Public Alert and Warning System

- Alerting systems should only use alert information from official sources.

- Alerting systems should only use alert information from official sources.
- All alerting systems should use alert information in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

Concerned that the flowing gasoline poses an immediate explosion hazard in the residential community just across the county line, Jorge takes advantage of a statewide "reciprocity" policy and also activates warning systems in the neighboring county, while simultaneously alerting that county's authorities.

Later, Jorge receives a letter of appreciation from the neighboring county's Board of Supervisors, for his quick action to protect everyone at risk from the gasoline spill regardless of political boundaries that could have delayed such action. Jorge is also treated to multiple adult beverages by his public safety counterparts in the other county, who are eager to learn more about the technology of integrated public warning.

AMBER Alert User Story

Marie is shopping at a local big box store on a Saturday afternoon with her 3-year-old son Jonathan, who is walking alongside her and playing with toys from the shelves. Marie notices a man in a hoodie nearby, but thinks nothing of it. As she asks for assistance from a store clerk around 1:00 PM, she looks away from her son for a moment as she walks down the aisle to retrieve an item. When she looks back a minute later, her son cannot be found. Immediately, she begins calling his name and checking a surrounding aisle. After searching for about 3 minutes, the store clerk notifies their management and Code Adam protocols are put into play.

After locking down the store, an employee broadcasts the child's description and sends a notice to customers in the store who had the store app. After 10 minutes of searching with no success, employees call 911.

The responding officer, Officer Martin, realizes this is a rare potential non-family abduction as she arrives at the scene 5 minutes later. She requests additional officers to respond, begins working to secure the scene and obtain information from witnesses, including Marie. Within 5 minutes, she has requested another investigator, Officer Jones, contact the AMBER Alert Coordinator for their state to request an AMBER Alert.

As she is being questioned by law enforcement, Marie only remembers the man in the hoodie, but there were many other customers in the store. The clerk says she remembers a man and a woman nearby before the incident occurred, but isn't sure of their height. Another customer, who had been outside shortly after the child went missing said she saw a child matching Jonathan's description being put into a sedan with Tennessee plates by a man in dark clothing. Law enforcement immediately reviews security from the store and can place an unknown male and female in the vehicle with license plates reading 123-ABC. They obtain better clothing descriptions from the videos. By this time, Jonathan has been missing for 45 minutes.

Thankfully, the wheels are already turning to activate an AMBER Alert. Officer Jones electronically begins the AMBER Alert request on a mobile data device and securely provide case details to the AMBER Alert Coordinator in real time. His device is updated as other officers on the scene fill out details on their secure tablets and submit witness statements. Speech to text technology enables law enforcement to record statements quickly. Officer Jones selects relevant portions of the reports to send to the AMBER Alert Coordinator as supporting evidence this case fits the criteria for an AMBER Alert. He quickly obtains a photo of the child from Marie's phone, and has no difficulty sending it through the AMBER Alert request application, even though it is a high-resolution image. Officer Jones begins sending information to the AMBER Alert Coordinator within 25 minutes of the child going missing.

Special Investigator Meade is the State AMBER Alert Coordinator and works out of a state law enforcement agency. Around 1:30 PM, Investigator Meade receives an alert on her phone that overrides her silent setting, letting her know that an AMBER Alert request is being submitted. Investigator Meade is at a barbeque, but can view the case information on a tablet she carries with her as well as on her phone. She dictates the case information and the A.I. enabled entry process fills out data fields and constructs a standard narrative for the AMBER Alert as she speaks. She also creates a shortened message to be used on digital signage and checks individual fields and descriptions. Investigator Meade completes much of the alert within minutes and can quickly view the information to confirm accuracy. The highly mobile software suite uses state of the art security features, allowing her to efficiently access information without making it susceptible to unwanted viewing.

- All alerting authorities should author alerts in the latest Common Alerting Protocol (CAP) version adopted by FEMA.

As she finds a place to work, her communications team at a 24/7 call center are already turning on the dedicated line for AMBER Alert leads. When the alert is ready, she clicks send.

- Alerting authorities should transmit alerts to FEMA's Integrated Public Alert and Warning System

Upon sending out the information, the alert is sent to a variety of state resources. Local media outlets can automatically broadcast the text and audio of the alert and include photos.

- FEMA's Integrated Public Alert and Warning System (IPAWS) should continue to serve as an official source of all-hazard alert information.

A WEA message is sent to the public in the whole state, as law enforcement does not know where the abductors are going. Law enforcement and AMBER Alert Coordinators in surrounding states also receive the alert information. Across the state, signs on highways, lottery machines, and digital signs broadcast the alert details.

- Alerting systems should carry text, graphics, audio, and other multimedia in or referenced by the alert.

- When an alerting systems carries graphics, audio, or other multimedia, the alerting system should preserve the quality of the original content. For example, an image of a missing child, evacuation, or threat area should not be degraded.

The information is sent to IPAWS and the National Center for Missing and Exploited Children, who automatically funnel the information to their networks of distributors with the click of a button. Major national companies alert their employees and customers in the state that a child has been abducted and the alert begins to spread like wildfire across social media outlets. Federal agencies, airports, borders, toll plazas, bus stations, and many other agencies receive the AMBER Alert information as part of these distributions. The work put into automation allows this information to spread rapidly with little delay due to human input. The child has been missing for about 45 minutes, and it's nearly impossible to not know about the AMBER Alert.

At 1:47 PM, Jerry is feeding his cat before heading out to meet friends. He heard the alert on his smart phone and his smart TV turned on automatically. The news broadcaster talked about the alert, and Jerry touches the screen to pull up additional alert information.

- Alerting systems should provide an easy to use interface which allows the alert recipient to quickly and easily pull up more information about the emergency. Additional information may include timing, location, and severity of the threat relevant to the recipient's location as well as maps, evacuation areas, safe zones, safety checklists, and more.

The map on the television screen shows the child went missing about 60 miles away, but since he lives near a major highway, Jerry commits the license plate to memory. He also sees the sedan is a 2006 Honda Civic which was gray in color, but it had a distinctive pineapple bumper sticker. Around 3:15 PM, Jerry spots a vehicle with a pineapple bumper sticker parked on the side of the road. He remembers that the update he heard on the radio indicated the suspects may be armed, so he keeps his distance. He pulls up the WEA message on his phone and checks the plates, which are a match. Jerry clicks an option to report a tip.

- When an alert requests feedback from alert recipients, alerting devices should prominently display the request for information.

He does not choose to report anonymously, and he snaps a picture of the car to send with the lead. His number, GPS coordinates, and the picture are sent to the investigating agency, the AMBER Alert Coordinator, and the local agency for his area. He receives a confirmation and law enforcement responds via a video call through the WEA app. They ask him to remain at the location.

- When an alert requests feedback from alert recipients, alerting devices should leverage any built-in capabilities which would facilitate response by the alert recipient to the alerting authority. For example, the recipient of an Amber Alert on a mobile device should be able to quickly and easily submit a lead containing photos (e.g. car, suspect, and/or child) and location coordinates captured by the device as well as contact information so that the alerting authority can follow up directly with further instruction.

When law enforcement responds, they also receive a stolen vehicle call from a half mile down the road, and witnesses provide descriptions which match the abductors. The second vehicle is sent to the AMBER Alert coordinator, who quickly subs in the new information and her software package enables all the composed messages to be updated accordingly, before being sent on the same distribution path as the initial message.

Law enforcement continues the investigation, and the male suspect's ex-girlfriend, Kelly, sees the AMBER Alert on her phone and recognizes him from the surveillance photo that was included in an update, she remembers he said he liked to camp in the mountains one state over. A toll plaza near the state line confirms the direction of travel with an automatic license plate reader, which has two-way communication with law enforcement and AMBER Alert systems. Kelly doesn't remember much else or specifically where he liked to go. The investigation reveals the suspect has purchased weapons recently, so the alert is updated to tell the public the abductors may be armed and they should not approach.

The child has been missing for almost 4 hours at this point. Throughout the investigation, law enforcement receives many leads, but the connectivity of the various applications on phones, cars, computers, televisions, and other sources allow the public to submit sightings which provide a heat map to the investigating agency.

This has helped to identify directions of travel and by seeing concentrations of sightings, law enforcement is more confident in certain leads.

Investigator Meade receives the information about the possible camping location and immediately notifies the coordinator in that state. Polly, who is a civilian AMBER Alert Coordinator for the neighboring state, agrees the alert meets criteria. With the push of a button, she activates the alert in her state. Most of the information is automatically duplicated, but she and Investigator Meade decide to add a line to the WEA message that the abductors may seek camping or park areas. Law enforcement finds the second vehicle abandoned, but they are unable to determine how the abductors continue to travel.

Pat and Kenneth are hiking in a national park, where they have had little to no cellular reception. Because of this, they did not receive the AMBER Alert right away. As they are hiking out of the park, they encounter a couple of adults with a little boy. They observe it’s a bit late in the day to begin hiking into the park, but the man has a backpack with some supplies so they assume it’s a little weird but nothing to worry about. When they get to their car, which has a satellite data connection and wi-fi, they immediately see the alert in multiple formats. On the car console, they see an alert notification and by clicking it they pull up the local broadcast about the alert.

Pat checks his social media while Kenneth watches the short broadcast. They both see images of the child and abductors, and realize the people they saw not 20 minutes earlier could be the same as those in the alert. Pat and Kenneth are aware of the potential danger of approaching the abductors, so they hit an option to “Call 911” on the car console screen. They are connected to the local 911 dispatch and the investigating agency and AMBER Alert coordinator receive a notice that a call has been placed and who is handling the call. Because the call was placed through a connected resource, the AMBER Alert, case information, and the location of the call are provided electronically to the dispatch center staff. The 911 dispatch center takes the report from Pat and Kenneth, dispatch officers to the location, and electronically sends the report to the other agencies involved.

Law enforcement responds to the location and by tracking the suspects along the hiking trail, safely take the abductors into custody and rescue the child. Further investigation finds the suspect had stockpiled weapons in a small cabin, and the response from alert citizens prevented a dangerous situation from becoming worse.

Appendix B – ATSC 3.0 Primer

ATSC 3.0 has been developed under the supervision of the Technology Standards Group known as TG3. TG3 has several Specialist Groups that have been created to manage the standards development work including:

- TG3/S31 – Specialist Group on System Requirements and Program Management
- TG3/S32 – Specialist Group on Physical Layer for ATSC 3.0
- TG3/S33 – Specialist Group on Management and Protocols
- TG3/S34 – Specialist Group on Applications and Presentations for ATSC 3.0
- TG3/S35 – Specialist Group on ATSC 3.0 Ecosystem
- TG3/S36 – Specialist Group on ATSC 3.0 Security

Each Specialist Group has one or more Ad-Hoc Groups that have been assigned specific parts of the standard development.
ATSC 3.0 consists of a suite of approximately 20 standards. Key components supporting Advanced Emergency Alerting are found within the following ATSC 3.0 Standards:

- A/321 System Discovery and Signaling
- A/324 Scheduler/Studio to Transmitter Link
- A/331 Signaling, Delivery, Synchronization and Error Protection
- A/336 Content Recovery in Redistribution Scenarios
- A/338 Companion Devices
- A/342 Audio
- A/344 Application Runtime Environment

ATSC 3.0 has been designed to be flexible; allowing broadcasters to deliver small screen content up to UHDTV to mobile and/or fixed receivers. It will allow broadcasters to utilize high tower / high transmitter architectures as well as cellular line SFN architectures. ATSC 3.0 integrates linear and non-linear, broadcast and IP as well as interactivity. The only draw-back of ATSC 3.0 is that it is not backwards compatible with ATSC 1.0.

ATSC 3.0 has been designed to utilize the most efficient technologies including error correction coding, compression algorithms, and modulation and coding schemes. The system has been designed to support:

- UHD (4K) ~ 3840 x 2160 {or 8K @ 7680 x 4320} at 60 frames per second (fps)
- HDR (High Dynamic Range) 1080 x 1920 Progressive at 60 (fps)
- Robust Services delivered to mobile devices (tablets and smart phones)
- High efficiency video compression (HEVC/H.265)
- Companion screens (a/k/a 2nd screen experiences)
- Broadband connectivity
- Seamless convergence of both OTA and online content delivery
- OFDM waveform with 1Mbps up to 57Mbps in a 6MHz channel (28Mbps typical)

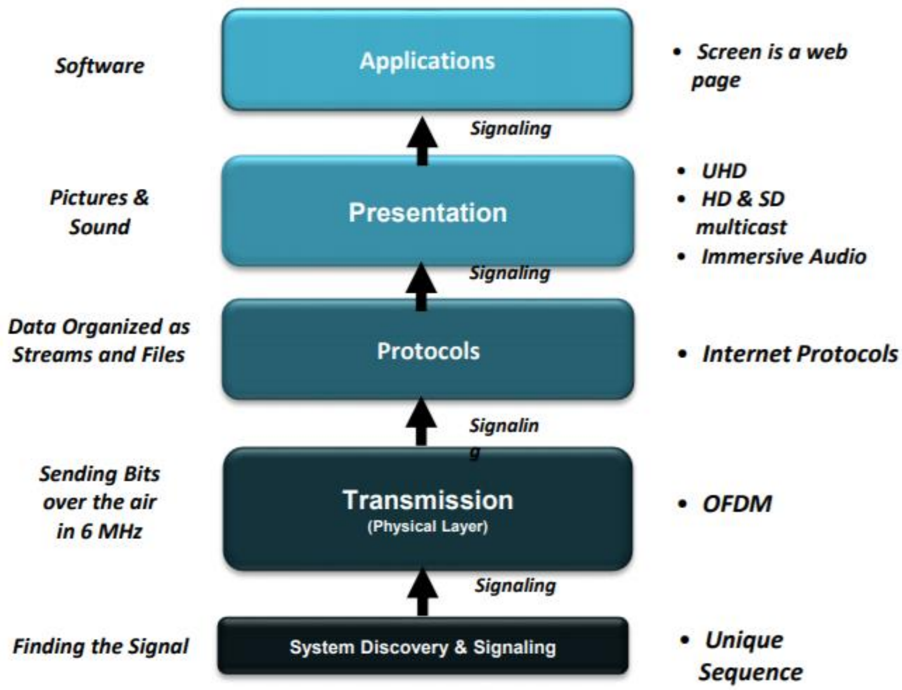


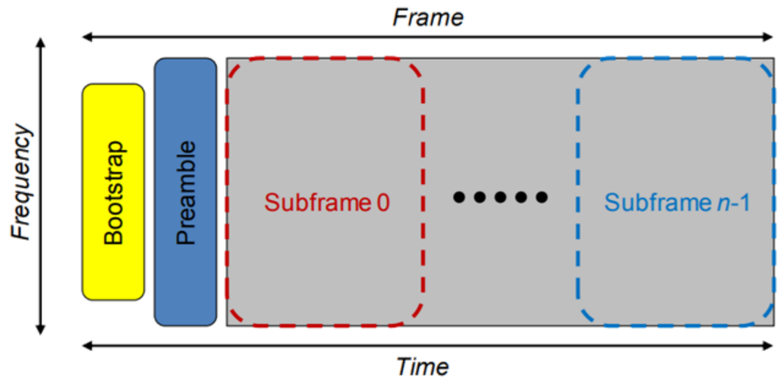
Figure 9 - ATSC 3.0 System Layers

ATSC 3.0 System Layers

ATSC 3.0 uses a frame structure that includes three primary components. These components include the bootstrap, preamble, and one or more subframes with data. The frame duration can be variable length with 50ms being the smallest and up to 5s the longest permitted frame length (with likely frame lengths between 250mS to 1s in the field). A frame can be setup to carry a variety of modulation types, FFT sizes, FEC strategies to allow multiple Services each with their own Quality of Service (QoS) in a single RF transmission.

The ATSC A/321 Standard describes the Bootstrap which is the initial discovery and entry point in the ATSC 3.0 waveform. The bootstrap has been designed to allow receivers to quickly and easily detect the RF signal. The bootstrap is extremely robust for reception in the most difficult RF channel circumstances. It contains the necessary data to demodulate the preamble. The bootstrap has a fixed modulation configuration including 4.5MHz bandwidth and a short 500 microsecond duration. The ATSC 3.0 Bootstrap includes a wakeup signal. Bootstrap contains 3 symbols each with 8 bits, with two bits reserved as a receiver “wake-up” indicator. The ATSC 3.0 signal can use this facility to notify enabled receivers to awaken from a stand-by or low power mode.

The Preamble immediately follows the bootstrap. It is responsible for defining the parameters required by the receiver to demodulate and decode the rest of the frame.



Physical Layer Pipes

ATSC 3.0 adds Physical Layer Pipes (PLP) which are similarly used in DVB-S2 and DVB-T2. A PLP allows a Service to be assigned to a specific reception robustness requirement. For instance, a mobile Service requires more robust (lower C/N) delivery than a fixed Service (higher C/N). Multiple PLP's can be combined (up to 64 for ATSC 3.0) into a single RF transmission allowing delivery of multiple Services (mobile, SD, HD, HDR, etc.) or even use multiple PLPs for delivery of a single Service. ATSC 3.0 also allows significant flexibility to modify the level of robustness / throughput that can deliver the desired Services to the targeted receivers.