Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Public Safety and Homeland Security Bureau	)	
Seeks Comment on Ways to Facilitate	)	
Earthquake-Related Emergency Alerts	)	PS Docket No. 16-32
	)	
Frank W. Bell	)	

Re: NOTICE OF PROPOSED RULEMAKING

This is an early implementation of such technology, so there are lessons yet to be learned in the seismology, system integration, public alerting and consumer electronics aspects. So some aspects may be proposed and tested but not necessarily implemented in the U.S. However some other countries may prefer such aspects, so in order to develop a standard for worldwide implementation that consumer electronics manufacturers would find attractive, these SHOULD not be rejected until such time as it is determined that they are not a requirement for e.g. an ITU standard. Also there are relevant other standards definitions in the progress of development e.g. the U.K. CAP profile, and perhaps others following.

The most comprehensive experience of earthquake alerting is that of the Japanese Earthquake and Tsunami Warning System (ETWS), which proved its worth (and perhaps paid for itself) in the 2011 Tohoku earthquake and tsunami. A comparison with the 2004 Indian Ocean tsunami fatalities show that the ETWS and other measures in Japan proved to be very effective, though some improvements are expected to be made. However, unlike IPAWS, the ETWS is not an all-alerts system. There are other systems that can be also learned from and can be incorporated into an IPAWS in those countries. Also, technology for an EEWS can be applied to the ETWS where better results are expected. Literature in English regarding ETWS does not readily note the processing durations of the system, though the total has been previously noted as being greater than 8 seconds. ETWS and WEA are similar implementations on LTE, so implementing EEWS should be made in such a manner as to improve the user experience. One anticipated problem is that with smartphones implementing ATSC 3.0 reception of alerts, there is a great likelihood of there being too many alerts.

Lessons from Japan may include how to manage and educate drivers so that ETWS doesn’t significantly add to the road toll for example.

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Seismology Considerations

Seismology has normally been concerned with analyzing all the data collected from seismometers and analyzing that to determine things like hypercenter location (depth under the epicenter), magnitude, and other details. However for alerting, the message(s) need to be sent as soon as possible to give more time for people and equipment to respond. So when only one seismometer has detected a shock wave (preferably a P-wave), there is no confirmation that this was not some small disturbance very close and not very significant. So this is unsuitable for a wide area alert at this point.

So it is proposed that Earthquake Early Warning System alerting be implemented in phases for EAS. Phase 1 would ignore such single triggers, and await satisfactory confirmation before transmitting an alert. This would be an EQW alert over a whole broadcast coverage area. This Phase 1 would be deployed sooner as there are large areas of population at risk, and it is preferable not to delay until all the technology is developed.

After some digital alerting receivers are deployed, a single detection alert could be used as a message trigger if a suitable threshold level is reached. This would be to a polygon that is does not include any other seismometers. This would be Phase 2 and the added alert would be an EQE eventCode. It is subject to the policy to implement this phase as legacy receivers would not receive such alerts. An EQW alert would follow if the conditions are met, otherwise an FAE would be digitally transmitted by manual supervision.

Phase 3 can be a method of successively transmitting alerts to larger polygons in a series of steps. EQ1, EQ2 and EQ3 would likely replace EQE, and be digital only. If no further alerts are generated, an FAE would be digitally transmitted by manual supervision. EQ4, EQ5, EQ6, EQ7, EQ8 and EQ9 would be overriding the audio and display on the video. If a false alarm has been detected for the EQ4-9 alerts, then an FAW can be manually transmitted. As digital receivers

processing EEWS are deployed, the first EQ alert received and presented can serve to suppress subsequent alerts being presented. However as the audio and video is delayed, the alert is not being delivered as soon as possible. Digital EEWS receivers would receive the alert and start playing out the memory recording of the tones (SEWS tone suggested) and the word "EARTHQUAKE". This playout is expected to have a duration of one second. Subsequent audio arriving would then be presented. How the interim audio is handled is not defined as the duration is not obvious, so switching to program after perhaps some repetitions is to be decided.

Phase 4 could subsequently be implemented when the seismology experience with EEWS is considered satisfactory. This provides for a countdown to be played out from the receiver, and it is digital only. Once a receiver has been triggered to countdown, subsequent alerts of a higher number do not restart the countdown. This means the successive concentric octagonal areas can start counting down. An E00 or EQ0 would reset the countdown to be stopped in preparation of another possible earthquake alert. FAE and FAW messages can also be manually sent. In order to provide for legacy receivers, EQW messages can also be transmitted, but these would not interrupt a countdown which has started. A countdown would replace the tens with "EARTHQUAKE" instead. Test implementations of these methods would need to be made to assess what technical, operational and educational modifications and details need to be addressed. The Japanese Meteorological Office has been asked what the details are about their system. However since the request did not come from a recognized authority, they did not provide information. Hopefully that can be addressed in the near future as there is likely valuable experience they have to add to this development. The incorporation of EEWS into an improved EAS and how that is also incorporated into WEA is a complex problem.

Over-Alerting Problem

Currently cellphones can receive alerts via WEA. However the situation is changing. It is also becoming possible to receive alerts via;

1) Broadband EAS. This is a technology that delivers alerts via LAN or possibly internet. However an internet implementation is liable to have security problems. It was developed by Hisham Kassab of mobilaps (dot) com (website may be under construction). These alerts may be received by smartphones via Wi-Fi. I am not aware of any implementations currently. It may be a desirable technology for corporate LAN alerts.
2) MEAS is currently broadcast on some TV stations. With the development of ATSC 3.0, this is proposed to be upgraded to an improved EAS/AWARN system. These would also be received by smartphones.
3) EAS is also broadcast on radio and TV. However the data transmitted is only in the form of modem tones which can carry a quite limited amount of data, as anything beyond the header is making the duration excessive for the public. A smartphone may receive digital TV, and also HD Radio or other digital radio broadcast (though none appear to provide for the latter at present).
4) Alerts from alerting vendors may be received as SMS texts. These may be of a longer duration that WEA. While these may be customized for the particular customer, some discussion as to how to take advantage of capabilities to avoid over-alerting is desirable. Responses from such vendors to this NPRM would, in my opinion, be welcome. Such

vendors receiving feeds from IPAWS may be contractually required to carry the CAP message ID or at least the eventCode. This SHOULD include the Federation of Internet Alerts (FIA).

5) Alerts from social media providers may also be sent. These are not regulated, but may be requested to carry the CAP messageID or at least the eventCode so as to permit devices to minimize over-alerting with suitable software.

So in summary, there are six modes of alert reception including FIA, and avoidance of repetitive messages between them is desirable. Using the eventCode to distinguish the same message within a time frame (30 minutes suggested as this is an EAS time limit) is an option that appears desirable. This is not as thorough as using the CAP message identifier, but that may not be practical in a WEA format.

AN ALGORITHM FOR IMPROVED POLYGON TRANSMISSION

Only one polygon is acceptable for the output, however this may be derived by combining adjacent jurisdiction polygons, circles and CAP polygons. Non-adjacent shapes SHALL require a separate message.
This algorithm is compatible with NWS SAME, NMEA 0183 and CAP formats.
<u>The U.S. NWS latitude and longitude format is illustrated by</u>;

LAT…LON 3165 8940 3179 8939 3180 8904
3176 8904 3175 8902 3173 8904 3173
8907 3170 8912 3163 8938

$$

The numbers are two decimal places of degrees at the end with the degrees before them. This example has no hundreds of degrees. Minutes are not used, as the example has more than 59. They are in pairs, with the latitude preceding the longitude. This example is a 9 point polygon. It is always North latitude and West longitude. Latitude precedes longitude because in navigation, latitude was a known factor before the longitude was. The blank line before the $$ is optional. The tab on the second and third lines is optional. The $$ denotes the end of the message and the latitude and longitude is always the last item.

<u>The proposed improved EAS format is illustrated by;</u>

<pHash3=##><pHash1=##>LAT.LON N52. (AB) E172.2 (ABC) N52.0 (ABC) W177.45 (ABCD) N51.02536 (ABCDEF) W177.451 (ABCD) N50.0096 (ABCDE) E172.176 (ABCD) A00593.2m (ABCD) C04000m (ABCD)<pHash2=##>

$$

The decimal points can be followed up to 5 places resolution, except for altitude and ceiling. The N, W, E, or S will be in the first character position because they are equivalent to a sign in arithmetic. They are in pairs, but the order within the pair SHOULD NOT be of concern to any software developed. Rather, all the pairs SHOULD have the same order for human convenience.

The following blank line is [CR][LF] and is not necessary if $$ is there. For processing efficiency, the LAT.LON string SHOULD be the first thing in the body after the header so the microprocessor can be processing that while receiving the rest of the message. Then determination as to whether the receiver is in the area specified can proceed. The (AB…) sections are the forward error detection and correction characters used as part of the algorithm described elsewhere. The example crosses 180 degrees. This algorithm is rather contorted. That is deliberate so as to greatly increase the difficulty of reverse-engineering it. So this algorithm also aids the security by making it difficult to generate unauthorized messages. End of line is [CR][LF].

The algorithm is not made public, but would be on the next pages if included. The brackets, (), <>, {}, [] and their contents SHALL NOT be displayed to the public on consumer receiver displays or data outputs. If there are more than 8 points, the whole polygon SHALL not be displayed other than on a map. The whole header and polygon SHALL NOT be displayed as a default setting. As this algorithm needs to be executed in devices like car radios, it cannot be too complex, also there is no possibility of the algorithm being upgraded as it has to be in firmware. The polygons are defined as enclosing areas for alert messages. Rumb lines are the connections between the vertices, these are simpler for small microprocessors to process. So the security is provided by inaccessibility from the public, which is one level. System security needs provision by other means, some of which are outlined elsewhere. Currently some exercising of the algorithm needs to be done to debug it but that SHOULD be completed soon. It provides for near or crossing of the equator or the 0° or 180° longitudes. If the bit error(s) in a character cannot be determined and corrected, but are too numerous, the character SHALL be followed by a "?". Then the polygon drawing algorithm can construct the largest polygon with the value that is unknown, this errs on the side of safety. Also the display of the “?” alerts the public to a signal quality issue. The limit SHOULD be 32 points. The A and C are the altitude and ceiling in meters from the CAP-EDXL message. The NMEA units are in meters, which SHALL be used here. The A MAY be followed by a - for below sea level altitudes. The algorithm also accepts the NWS SAME format.

The EEWS and improved EAS/AWARN (or whatever the developing system is branded as) SHALL be implemented in all TVs, cellphones, TV tuner cards, TV tuner modules and Set Top Boxes hardware and software IF they receive ATSC 3.0 or subsequent versions, EXCEPT FOR broadcast professional receivers that have a data output that is USB, RS-232 or LAN, where it SHOULD be an option that is disabled from operation by default.

This is an unusual FEC method in that it is human-readable. This is to be compatible with existing EAS equipment and for viewing by operators. It is advantageous that the security switches are passed through forward error correction. However they SHOULD be repeated also for reliability. This FEC algorithm is good against random noise, however it can be susceptible to burst noise. The pHash provides for detection of errors of consumer receivers. For improved reliability, the LAT.LON string can be repeated on a new line and the characters followed by a “?” SHOULD be replaced with acceptable data from the second copy if available in time. If there are discrepancies between accepted characters, the output of them SHALL be followed by a “?”, but that SHOULD be infrequent. Consumer radios may be incapable of performing the hash calculations in a timely manner, and a checksum may be appropriate.

If a second instance of the message is received and no “?” characters are in the message latitude and longitude section where there are any in the first message, the non-“?” character SHALL be substituted and the message transmitted. Consumer devices SHALL NOT reject a second instance of the message but SHALL amend their response so as to be applicable to the resulting corrected message. As small microcontroller consumer devices could be unable to process a 150 point polygon in a timely manner, such models may apply for an exemption to normal improved EAS compatibility requirements if they process the polygon using every odd number point.

The operator entry method of polygon closing SHALL be either by;

1) Finish polygon selection. The extra close polygon location point SHALL be generated as the origin point.
2) The origin SHALL be a snap point and selection within the snap box SHALL either finish the polygon or an Esc SHALL be required. CAD users are familiar with snap usage.

The <pHash1=##> and <pHash2=##> are the hash value for the polygon string excluding the <, > and contents calculated by the same algorithm as for CAP messages hash value and placed in the ## characters. If the received message hash value is the same as either ##, the number of bits in error including the <pHash12=> characters SHALL be added to the bit error count in improved EAS compliant decoders. The Forward Error Correction SHALL be applied and if the recalculated hash agrees with either hash value the message SHALL be forwarded with the incorrect hash value corrected. If there is no agreement between the three values, a “?” SHALL be added before the <pHash2=##> in the forwarded message. Then also for selection of the broadcast mode of private or public, the selection mode SHALL be based on inside polygon selection. In improved EAS compatible receivers, intended for consumer use, if the calculated hash value agrees with either pHash1 or pHash2, the polygon SHALL be used for selectivity selection. If not, then the selectivity SHALL be considered as inside polygon.

The <pHash3=##> is derived by the same algorithm as for CAP messages hash value and placed in the ## characters. The data it is derived from is the preceding header data. As the header is repeated three times, the <pHash3=##> value is added all three times for digital transmission only. If one header is received and the calculated hash matches the transmitted hash, the processing may continue based on that data unless the two subsequent copies differ and are the same. In such case, the processing shall restart and use the derived value obtained by checking all the bits in every copy of the header and checking that the result also agrees with the majority checksum. The purpose of this is to expedite processing, but at the same time provide immunity to errors resulting from such causes as lightning strikes. The following polygon string shall be transmitted after the first and third copy of the header. Transmission after the second copy of the header may be made if there is time available. The text of a standard should clarify this point. Consumer radios may be incapable of performing the hash calculations in a timely manner, and a checksum may be appropriate.

The rounding SHALL be to the lowest resolution digits. E.g. if the location latitude is N33.45675 and the alert polygon area is north of N33.4568, the location would be included in the area.

Fine Area Resolution Application. In a cellphone system, some handsets have GPS capability for a finer resolution of location than the cell sector. However most that are advertised as having GPS are likely to be using the E911 Phase 2 resolution of location which uses triangulation to more than one tower. While this uses extra processing at the tower, this is not a problem for 911 or revenue generating purposes. However EAS messages requiring the use of this can create a demand surge that MAY NOT be adequately served in a timely manner. Therefore such application requires appropriate engineering.

Emergency Telephone Notification (ETN or Reverse-911) can also apply finer resolution in two resolutions. First there is the local switch (exchange) area of cabling which is normally within major geographic or political boundaries. This defines the last four digits area when Local Number Portability (LNP) is not applied. Second the telephone database also has the address of each customer within the previous area and this database could be used to determine precise location. In this case the processing demand surge for EAS MAY NOT be adequately served in a timely manner. Therefore such application requires appropriate engineering.

The NMEA-0183 format MAY be used for data from a GPS or other navigation device. Its' format is illustrated by;

$$GPGGA,hhmmss.sss,ddmm.mmmm,N,dddmm.mmmm,E,F,SU,HD.P,AL.T,M,G,M,DGPSA,DGPS,CHK[CR]LF]

Where GP means that a GPS is the talker identifier. GGA means that it is a global positioning system fix data sentence.
hhmmss.ss is the fix time (UTC).
ddd or dd are the degrees. mm.mmmm are the minutes
N MAY be S, E MAY be W,
F is position fix (0 = Invalid, 1 = Valid SPS, 2 = Valid DGPS, 3 = Valid PPS)
SU Satellites Used (2 digits, presently 12 max.)
HD.P Horizontal Dilution of Position (same units as altitude)
AL.T Altitude (was based on WGS-84 ellipsoid, but EGM2008 is the most current geoid in 2014)
M meters, units of HD.P and AL.T
G Geoid separation
M meters, units of geoid separation
DGPSA Age of DGPS data in seconds
DGPS DGPS Station ID, 4 characters
CHK Checksum, 3 characters. This is inadequate for Forward Error Correction
[CR][LF] carriage return, line feed
The NMEA (www nmea.org) first published this in January 1983. The use of minutes is because navigators used paper charts that had degrees and minutes on. A format to transmit polygons from a receiver to a videoplotter is being researched. There are some proprietary formats existing. The U.S. Census Department and U.S. Geological Survey use and prefer an ArcView Shapefile format. NMEA could be engaged to formulate a polygon standard sentence. However this format does not provide for error correction and the associated bit error and quality assurance, so a translation application would have to be developed between this format and EAS.

Compatibility with improved EAS Format above and SAME Format;
The SAME format has a limit of 10 points for a polygon. While this one has a limit of 32, the resolution is up to 1000 times finer. So when the resolution is reduced, this is like blurring and an algorithm converting to SAME format would require fewer points for a polygon. The five decimal place resolution is to less than a meter, though such fine resolution MAY only be needed when digging for avalanche victims for example. The example in the standard on **polygon** is 4 decimal places, but in the Appendix B. 1 lines 40 to 42 are to 14 decimal places. Improved EAS SHALL round such resolution to 5 decimal places.

Application of Polygons Across Jurisdictions;
When the polygon is in one county, the P usage defines that polygon selection is to be applied. When the polygon is larger than one county or region, then the whole state (or region if applicable) code SHALL be selected and the P usage is applied to this larger area. If the polygon is across state borders, then the whole state code SHALL be selected and the P usage is applied inside the state. A similarly applied second message SHALL be generated for other states affected. The polygon MAY be the same in each case or MAY be segmented along state borders, but all equipment SHALL be able to process the message either way. If the polygon covers seas or oceans, then the message SHALL be communicated to the appropriate GMDSS authorities e.g. U.S. Coast Guard. If the polygon crosses national boundaries, the message SHALL be communicated to the appropriate national emergency management office for them to generate their national alerts. If these are automated transmissions, then the use of improved EAS will limit the content, but also assist the security of the CAP and DEAS core messages.

The CAP standard supports circles for area definitions. This is flexible for Emergency Management. Purposes, however to process this using latitude and longitude, requires trigonometric calculations with considerable accuracy. This is beyond the capabilities of small consumer microcontrollers because they are usually 8 bit devices and at least 32 bit processing is required. However proportional calculations on Rumb lines are possible. So circles to 8 or more sided polygons can be translated in the ENCODER/DECODER. The logging of this is noted in section 8 on Quality.

CAP uses + instead of N, and E and – instead of S and W. However this is not as humanly understood, so the letters are RECOMMENDED, but the sign SHALL also be acceptable and then the latitude precedes the longitude in pairs, with a comma after the latitude. The equator is then N0. (followed by zeros indicating resolution if needed) or 0. The 180 longitude is W180. not E180. The + sign SHALL always be used in improved EAS in order for the FEC algorithm to be simpler. A configuration of the ENCODER/DECODER SHALL be to convert CAP to NSEW usage or always use sign. The default SHALL be NSEW. In CAP, the last point coordinates SHALL always be the first point. In improved EAS, if there is a difference, the last point to the first point SHALL always close the polygon. Any CAP polygons with more than 150 sides SHALL be simplified to the best fit in the ENCODER/DECODER. A limit needs specifying so that the consumer electronics processor limits are not exceeded, which would likely result in a crash of the processor and the message not being effectively received.

Inside Polygon?

When a line is drawn from the location to the limit, if it crosses an odd number of polygon lines, it is inside the polygon. 0 is an even number. This can be checked by going in all 4 directions north, south, east and west. While all four SHOULD agree, an error in calculation MAY occur, so a majority will count. A disagreement SHOULD produce a “Polygon Inside Error Check” message. Equal vote SHOULD produce a “Polygon Inside Undetermined Error”. The exceptions are when a polygon crosses the 180 longitude. A polygon SHALL NOT circle a pole, location selection SHALL be applied for both poles. The longitude for the poles SHALL be E0.0 so that no unexpected processor behavior results. If the receiver has known accurate altitude data, e.g. from a GPS, then the altitude and ceiling SHALL also be considered, otherwise it is not a selection criteria.
.
This check also works when a polygon is inside a polygon, or lines cross inwards. While the inner area MAY be considered “inside”, topologically it is more “outside”. Consider an isolated hill. When the water level rises it is still dry land, even though it is isolated. The correct mathematics is the correct answer. This can be compared to “I ain’t not going” to which a correct response could be “OK, when?” and the answer cannot be “Never.” To determine which part of the globe is inside, a polygon latitude and longitude SHALL NOT exceed 30 degrees, unless more than 60 degrees latitude, when 50 degrees longitude is permitted. The inside polygon test SHALL NOT apply to single or two point polygons. These are also permitted for RRE and RRS activation codes.

A vehicle radio that is connected to a navigation system SHALL be improved EAS compatible when the navigation system is capable of providing suitable directions to exit the polygon. The location of the problem inside the polygon is not an appropriate reference point as this draws the attention of and movement toward this point by some people.

Vehicle radios that incorporate a navigation system SHALL provide dual data tuning and demodulating. The secondary station SHOULD be one with the best reception with data. This is because
a) The station that is user selected may not provide digital data.
b) If both stations provide digital data, the timing may be somewhat separated. So the processor then SHALL assemble the packets from both stations, and this can be of assistance in error correction and reducing the time taken to transmit the message. This is of particular importance to large messages which could be flood/inundation area maps for example.

When a radio is receiving the flood/inundation data, as this may take some time, the display SHALL display “FLOOD MAP Downloading” or the equivalent in the user selected language. As the data may not be the complete file, the blocks of data correctly received SHALL be displayed. In this circumstance it would be up to the judgement of the user to decide which side of the line is the downhill side. Also, as there may be more than one color line, there will be regular annotation of the depth in the same color in metric or feet units, the default being metric.

Emergency Alerting is but one function of an improved EAS compatible consumer electronics device. So as a design goal, the resources and cost of the addition of this feature SHOULD NOT be in excess of the value of the added feature. This is a reason for tightly defining and limiting the requirements in consumer electronics devices. For example, assuming that alerts consist of

about 0.2% of program time, the added cost of improved EAS SHOULD be about 0.2% of the product price. In reality, if the value can be demonstrated to be higher with market research, then that can justify a fraction of that value added. If it is more than a fraction, it is unprofitable to society, and MAY be politically unacceptable.

If a polygon has only one or two points, then this is for First Responders category receivers only for their information, e.g. for rescue purposes. It is not for selectivity in these cases.

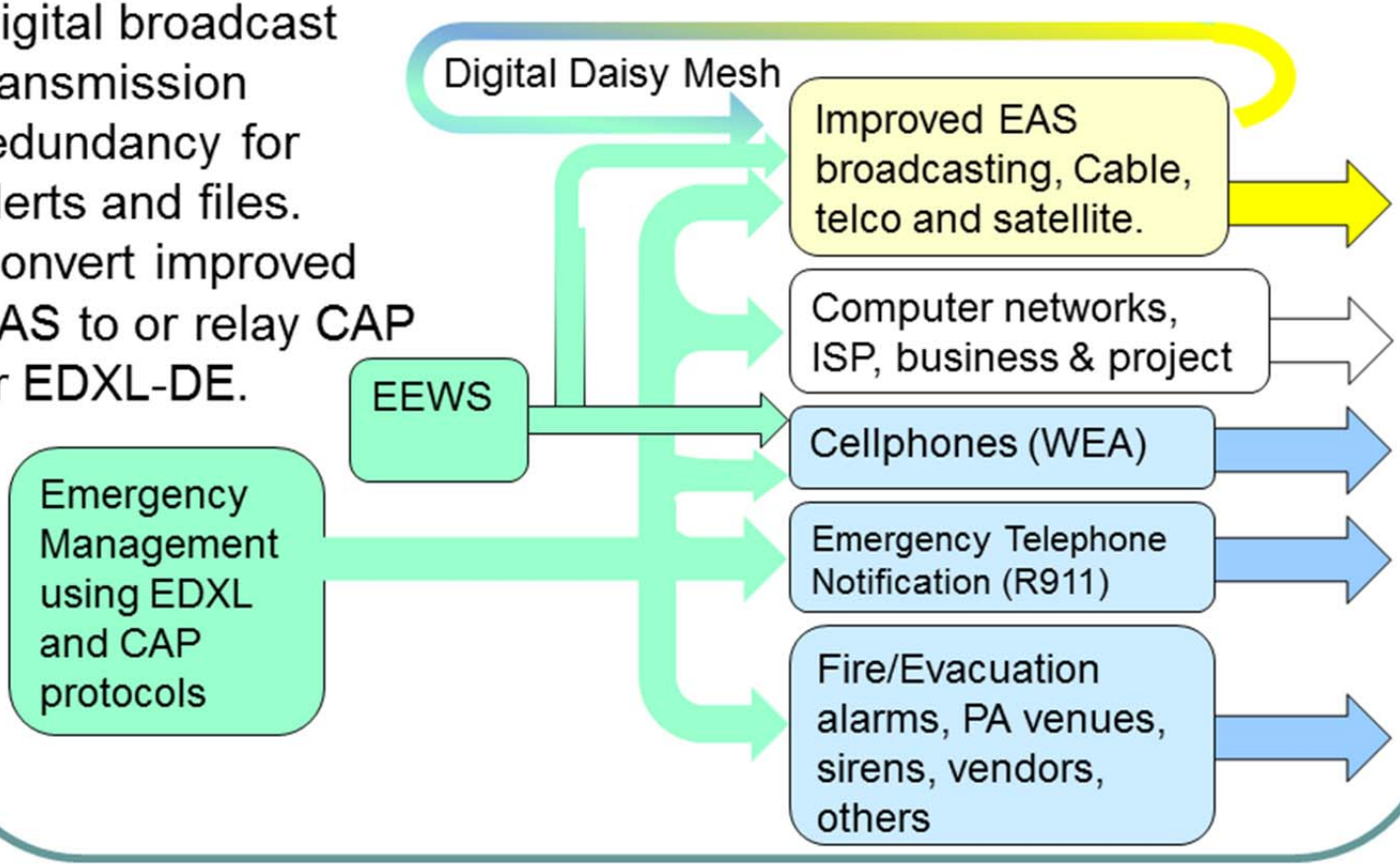
If a rescue is the event code, additional "LAND", "SEA", "LAKE", "RIVER" or "SHORE" details SHOULD be included if the position is accurately known or if this information is communicated.
The direction of rotation of the output SHALL be following the left hand rule, i.e. your left hand is to the inside of the polygon, regardless of the direction of rotation of the user entry.

Diagram Including EEWS

This diagram does not show the feed of EEWS messages to IPAWS. This is only omitted for simplification. In actuality IPAWS would be fed messages from the alerting authority. However, the EEWS messages, arriving sooner, would be duplicates and ignored by the encoder/decoders unless there was some failure of the EEWS network for the area that was targeted.

IPAWS Introduction - 3

- Digital broadcast transmission redundancy for alerts and files. Convert improved EAS to or relay CAP or EDXL-DE.



Earthquake Event Codes for Various Types of Alerting

There are various modes of earthquake alerting that appear appropriate. Some may not be able to be implemented at present because of limitations of data and analysis that is currently available. However that situation may change, and the implementation of capabilities in consumer electronics software is difficult to change after manufacture. An example is the provision of a countdown capability. Another is the provision for other languages. The numbered alerts can be sent in a sequence so as to provide octagonal rings of delayed alerts. Earthquakes do not necessarily propagate in all directions with the same velocity. So an ellipse could be a better alert pattern. However CAP does not provide for an ellipse, only a circle. A plume model does not apply either. An octagonal shape could approximate an ellipse. An octagon is about 11% larger an area than a circle, so that is close enough for emergency alerting purposes as a bit of safety margin is not really a problem. Also, if the octagonal shape has latitude and longitude lines for four of the sides, this makes a rectangle that is simple to compute, even on an 8 bit processor. A circle on the surface of the earth is effectively processed with a 32 bit processor. Even adding the four corners calculations of an octagonal shape, the processing is simple for an 8 bit processor. Consumer radios may have processors, but not necessarily 32 bit ones. TVs are getting smarter, but for the purposes of reducing cost, power consumption, size, and the lower energy of electromagnetic radiation from the processor circuitry, a specification requiring more than an 8 bit processor is less desirable. The memory space for the code is also a consideration, but memory costs are low and decreasing.

As can be seen in the diagram above, EEWS is direct to the LP broadcasters and the Digital Daisy Mesh can rapidly forward the alert to other broadcasters and also be a redundant alert path to cell towers using a TV tuner card. Whether this is faster than the WEA alert distribution is unknown for their EEWS, but using the eventCode it is possible to deliver the first alert and not have a repetition. The EEWS would send an alert to IPAWS, but that is omitted on the diagram for simplicity.

US State and Local Codes	**EAS code**	**Use Notes**	**Decoder Priority, , Authorization, (notes)**	***Australia* Canada XML**	***Australia* Canada ORG**
Earthquake Countdown	E*nn*	Digital Only	1, , L(5,36,37,58)		
Earthquake Alerting Finished	EQ0	Digital Only	1, , L(5,36,47,53)		
Earthquake Alert #1	EQ1	Digital Only	1, , L(5,36,47)		
Earthquake Alert #2	EQ2	Digital Only	1, , L(5,36,47)		
Earthquake Alert #3	EQ3	Digital Only	1, , L(5,36,47)		
Earthquake Alert #4	EQ4		1, , L(5,36,47)		
Earthquake Alert #5	EQ5		1, , L(5,36,47)		
Earthquake Alert #6	EQ6		1, , L(5,36,47)		
Earthquake Alert #7	EQ7		1, , L(5,36,47)		
Earthquake Alert #8	EQ8		1, , L(5,36,47)		
Earthquake Alert #9	EQ9		1, , L(5,36,47)		
Earthquake Damage Statement	EQS		7, , L(5,34,47)		
Earthquake Emergency	EQE	Digital Policy	1, , L(5,36,39,40,45)		
Earthquake Warning	EQW		1, , R(36,39,46)	earthquake	Geo
False Alarm Emergency	FAE	Digital Only	2, , L(5,15,40)		
False Alarm Statement	FAS		5, , L(5,40,53)		
False Alarm Warning	FAW		1, , L(5,15,40)		

The codes ABA, ABS, ABW, ADV, ADX, AFS, AGA, AGE (e.g. locust swarm or quarantining), AGS, AIA, AIS, ALW, ANQ, ANS, APA, APS, AQA, AQP, AQW, APW, ASA, ASB, ASW, ATW, AVS, BCW, BHW, BSW, BWW, BUW, CAN, CAP, CBA, CDE, CHA, CHW, CMW, CRA, CSE, CUW, CVA, CVS, CWW, CYW, DAS, DAW, DBA, DBW, DCW, DEW, DRA, DRS, DRW, DXF, EDQ, EDV, EDX, E*nn*, EQ1,EQ2, EQ3, EQ4, EQ5, EQ6, EQ7, EQ8, EQ9, EQE, EQS, EVW, EXP, EXW, FAE, FAS, FAW, FBW, FCA, FCW, FHA, FIW, FMA, FOS, FOW, FRA, FRS, FRV, FSA, FSW, FVW, FXA, FZW, HAS, HAW, HEA, HEB, HEF, HEH, HES, HFW, HLS, HMA, HQW, HU1, HU2, HU3, HU4, HU4, HU5, HUH, HUX, HWC, HWS, HZW, IBW, ICS, ICW, IE1, IFW, IHS, ILA, IPA, IPW, ISA, JPG, LAA, (LAS), LEA, LEE, LEW, LSA, LSW, MAR, MAS, MDW, M*nn*, MP4, MPG, MPH, MPS, MPW, MSW, MTS, MTW, MVS, NAT, NFA, NIE, NST, NUS, ODP, ODT, OLS, OLW, OTH, OZA, PCR, PDA, PDE, PDF, PDW, PES, POS, PPA, PQA, PRA, PRS, PSA, PSB, PSF, PSS, PSV, PTR, PTS, PWW, RAA, RA1, RA2, RA3, RA4, RBA, RBW, RCA,

RDA, RDS, RFW, RHA, RHT, RIE, ROS, RRE, RRS, RTF, RUS, RWW, RWA, RWI, RWY, RYT, RZA, SAA, SAW, SBA, SBW, SDE, SDW, SFW, SGW, SHA, SHP, SIE, SIL, SLA, SLI, SLL, SMA, SMW, SNA, SNW, SPA, SPE, SSA, SSW, STA, STW, SUW, SWE, SWS, TEA, TEC, TEF, TEH, TEM, TEO, TEU, TEW, TFA, THE, TRA, TRE,TSH, TSO, TSX, TWW, TXB, TXF, TXO, TXP, TXT, TXW, URG, UTA, UTC, UTD, UTG, UTH, UTI, UTP, UTR, UTS, UTT, UTW, VAW, VG1, VG2, VG3, VG4, *Vnn*, VHW, VLW, VOS, VPW, WAV, WFA, WFW, WGW, WOW, WQA, WSQ, WTA, WTS, WSW,XML, YLW, ZDW, ??A, ??E, ??S, and ??W are not official U.S. codes. Codes may also be added for compatibility with other standards. MPS MAY be for prison escapees or Alzheimers patients for example, which are not covered by Amber Alert. SIL MAY be used for Alzheimers. If jurisdictions legislate codes that are not official U.S. codes, these codes SHOULD be listed here for compatibility with other jurisdictions. EVI and EVW only differ in their priorities and urgency.

15) The FAS and FAW First Responders codes are for a redundant notification method if the primary method is unavailable. The IHS MAY be similarly used, or as messages directed to highway motorists.

34) IEEE 1512 provision added. AMBER Alert is already included there. The <vehicle> item is adapted to the terms used there. The section below is from the Disasters list in IT IS-00-00-00. The 30?? Ids are used in the IEEE 1512 standard. The Event Codes ending in / are added because an equivalent was not found. This is after the TSO additions. While developing an application to translate between the two systems, or adding CAP ability to an IEEE 1512 based Computer Aided Dispatch (CAD) is adding complexity, the first step is to rationalize the terminology. While standards developers are likely not intending to develop “silos of complexity” that do no interoperate, there may need to be some acceptance of extensions of scope to enable reasonable interoperability by project sponsors.

```
<xs:enumeration value="flash flood" id="_3073"/>                    FFW
<xs:enumeration value="major flood" id="_3074"/>                    FLW
<xs:enumeration value="reservoir failure" id="_3075"/>              DBW
   “Dam Break” warning
<xs:enumeration value="levee failure" id="_3076"/>                  FVW/
<xs:enumeration value="tsunami" id="_3077"/>                        TSW
<xs:enumeration value="tidal wave" id="_3078"/>                     TSA
   “tsunami” advisory, over 1 hour”
<xs:enumeration value="volcanic eruption" id="_3079"/>              VOW
<xs:enumeration value="ash fall" id="_3080"/>                       VAW/
<xs:enumeration value="lava flow" id="_3081"/>                      VLW/
<xs:enumeration value="serious fire" id="_3082"/>                   FRW
<xs:enumeration value="forest fire" id="_3083"/>                    WOW/
<xs:enumeration value="wildfire" id="_3084"/>                       WFW
<xs:enumeration value="building fire" id="_3085"/>                  FBW/
<xs:enumeration value="brush fire" id="_3086"/>                     WBW/
<xs:enumeration value="grass fire" id="_3087"/>                     WGW/
<xs:enumeration value="fire danger extreme" id="_3088"/>            FXA/
<xs:enumeration value="fire danger very high" id="_3089"/>          FRA
```

```
<xs:enumeration value="fire danger high" id="_3090"/>            FHA/
<xs:enumeration value="fire danger medium" id="_3091"/>          FMA/
<xs:enumeration value="fire danger low" id="_3092"/>             FRS
<xs:enumeration value="earthquake damage" id="_3093"/>           EQS/
<xs:enumeration value="air crash" id="_3094"/>                   ABW
<xs:enumeration value="rail crash" id="_3095"/>                  RCA
<xs:enumeration value="toxic release" id="_3096"/>               CHW
<xs:enumeration value="toxic leak" id="_3097"/>                  HMA/
<xs:enumeration value="radioactive release" id="_3098"/>         RHA/
<xs:enumeration value="radiation hazard" id="_3099"/>            RHW
<xs:enumeration value="reactor leakage" id="_3100"/>             NUW
<xs:enumeration value="explosion" id="_3101"/>                   EXW/
<xs:enumeration value="major hazardous materials fire" id="_3102"/>
      SHW
<xs:enumeration value="major hazardous materials release" id="_3103"/>
      HMW
<xs:enumeration value="disaster cleared" id="_3199"/>            ROS
```

36) The EQE code is designed for automated earthquake alerts. This message may be transmitted without validation, e.g. only one seismometer with a threshold exceeded, and so be faster. However a policy decision as to whether this is going to be digital alert only or a local public broadcast is appropriate. The alert area would be smaller, but more rapidly alerted. The area would be an octagon centered on the seismometer. For the simplest processing by the receiver, the octagon should be with lines on the latitude and longitude that are the length of the radius, joined by rhumb lines. EQW by comparison would be for a higher threshold or for validated seismometer messages, and would be public, but as a result would take longer to reach the public. Multiple EQE messages may be sent within the same minute IF the seismometer is transmitting more data that justifies an alert to an increased number of jurisdictions than the previous message in the same minute. Additional PSSCCC are preceded by hard hyphens and only the last one has a "+" following.

37) Codes 000-999 and <*letter EXCEPT E,M and V*>00-99 are reserved for file and update codes. There shall be an encrypted code to description and file extension table and only the description shall be displayed for the user to approve the file or update installation. If there is no code with an entry, there shall be a message saying that the file or update is unrecognized or erroneous and that there is an error with an ID of <*character*><*Code*> where the character is a format character beginning with the use of "1". If the <*letter*> is w, x, y, z, W, X, Y, or Z, then these are reserved letters and the error message shall not display. If the <*letter*> is U, V, W, X, Y or Z, the message SHALL only be transmitted on digital TV, this is to avoid transmission of large files over HD Radio.

39) For EQE and EQW event codes, in order to provide for legacy HD Radio receivers and analog receivers, the best method appears to be to send the EQE and EQW alerts immediately on the analog audio and force tune all legacy HD Radio receivers to the analog channel. This does not add to the bandwidth required and has the lowest latency. The same method may also be applied to all other alerts. Improved EAS compatible HD Radio receivers would then, if not selected for an alert, would then have the HD Radio program continuing as normal. The disadvantage of this method is that there would not be any private mode possible on HD Radio unless a smaller bit depth and lower sample rate mono channel data could be included. This may be practical with FM. If the State Plan provides for two independent TV channels to be LP1 and LP2, and the digital daisy

mesh core network is TV based, then that is not necessarily a problem. Regional or local LP3 or LP4 stations could be included in the plan for more local insertion of EQE, EQW and MSW and also possibly other alerts. This would be to reduce latency and add some redundancy. If TV broadcasters are not available, an HD radio station could be considered for this role for EQE, EQW and MSW alerts. HD radio stations then would still be usable as the digital periphery of the mesh, and analog radio stations may monitor these HD stations. Radio stations that are LP SHOULD become a higher number (LP10 or more) if HD Radio. Alternative language radio stations SHOULD have at least one LP station.

40) The False Alarm Emergency (FAE) code is for example so that seismologists can monitor, and so that automated alarm system from seismometers to the public be implemented. Then it would be possible to send correcting information when the EQE code is generated which is only broadcast digitally. The FAW (False Alarm Warning) code is similarly applied when the EQW code is a false alarm. FAS (False Alarm Statement) is for when a priority 1 message is not justifiable. Having this option would enable the earthquake warnings to be faster by not requiring human approval, and enable human oversight to be effective. The actual use of this approach would depend on circumstances, experience, public acceptability, and how this is incorporated in the State Plan. The implementation in a user interface may select which of FAE, FAS or FAW depending on the event code of the message being corrected instead of adding complexity for the user. This is becoming an extremely complex system, and with staff turnover and the low frequency of disasters, it is desirable to avoid complexity.

44) The EQE event code may be transmitted to a small polygon centered on the location N33.0001^{o}, E120.0001^{o}, which is off the coast of Los Angeles. Coverage selection criteria for messages shall include this location. This location shall be the default location of consumer electronics products, thereby such a message would inform the owners that they need to enter the actual location of the product for effective use. Also system test messages may be transmitted to this location and so checked easily.

45) About 5 minutes after an EQW is issued, an RWT should be issued from the same input to EAS, to the same area, as digital only. This is to initiate a QC process so that the condition of the network is assessed after the earthquake and any steps appropriate may be initiated to ensure the network is available for the distribution of alerts which may be needed for secondary shocks or problems. This may be optionally triggered automatically by software, the default value being that it is turned on. The purpose of this being automatic is because it is anticipated that Emergency Managers are expected to be otherwise occupied at such times.

46) EQ0 is the finish of an earthquake alert sequence. EQ1 to EQ9 are the sequence of alerts and may be defined further by an octagon or polygon. EQ0 to EQ9 SHALL NOT to be presented by alarm clock HD Radios when in the standby mode unless a user setting permits that. The default is not to present. Cellphones that are charging and 9 or less hours prior to an alarm set time SHALL NOT present EQ0 to EQ7 alerts unless a user setting permits that. The default is not to present. IF the user is able to change the duration, nine hours SHALL be the default value. While the sequence is numerical, values may be skipped and results that depended on reaching a particular value SHALL be triggered by the first value larger arriving if the selected value is skipped or the EQW code. While it may be considered to be of value to delay earthquake alerts through a

cascade as provided for here, it should be remembered that consumer electronics is normally not on UPS power and that interruptions and outages of the electric power system caused at locations near the epicenter can propagate through the system at a speed approaching the speed of light. Therefore alerting SHOULD be prompt, otherwise the alert may not be delivered before the device microcontrollers crash or the devices lose power.

53) "All Clear" statements SHALL use a light green background. These are for event codes FFS, HUS, HLS, CIS, DAS, EQ0, FAS, FRS, NUS, OLS, ROS, RRS, SLS, UTA.
58) E*nn*, M*nn* are countdown triggers in the receiver. The value 00 is a timer reset. The values 01-09 are seconds of countdown start value. The value 10 SHALL NOT be used. Values 11-99 SHALL have the tens reduced by 1 and the resulting value multiplied by 10. This gives a maximum of 980 seconds. The timer SHALL reset at 985 seconds or receipt of an E00 or EQ0 message. Receipt of an E*nn* or M*nn* message for the selected receiver SHALL start the timer and output the countdown, beginning with the word "EARTHQUAKE" or "MISSILE" at the start and every 10 seconds UNLESS the timer is already running for a previously received E*nn* or M*nn* message. Polygon area selection SHOULD be as an octagon. I will be possible to have a series of alerts for a central octagon followed by wider octagonal rings with the delivery timed for the predicted arrival of the missile or earthquake. Other languages than English MAY also be provided An S-wave propagates at from 2 to 8 km/s. So in 980 seconds, an S-wave would travel from 1960 to 7780 km. An R-wave propagates at from 50 to 300 m/s. So in 980 seconds it would travel from 49 to 294 km. Assuming the alerting is based on S-wave arrival at the slowest velocity, an alert of this type would be limited to 1960 km maximum range. This is greater than the diagonal distance of California NW to SE (1375 km). It also is possible to cross state borders, so adjacent states may need to be alerted. If areas outside of the maximum range are to be alerted, subsequent alerts using polygons or FIPS codes or State Sectors may be appropriate. State Sectors are using the P sector method applied to the whole State code. These would need to be defined by the SEMO and SECC. As the waves propagate, subsequent seismometer detections can provide data to more correctly measure the velocity of propagation and the magnitude. That data could be applied to modify the subsequent alert transmissions. Extending a laboratory test system to process such data is possible after the basics are tested, and should be implemented before such software is applied in the field. These complexities should be explained in public educational material, but the alerting should be kept simple. Using a countdown is expected to be understood, but the possible arrival sometime after zero, or even a few seconds before, should be included.

The FCC Required text & Processing Time Budget for Earthquakes

The FCC required text sentence SHALL be constructed directly from the EAS ZCZC header string. This header string is specified by the FCC Rules Part 11 and is also defined above. The header string is generated from parsing the CAP message and applying the CAP/EAS Profile. The CAP/EAS Profile insures that the same ZCZC string will be produced across vendors and platforms. This regularity will thus also produce the most consistent text across platforms. The FCC Required Text will, at a minimum, include a translation of the following:

The ORG (EAS Originator) code;

The EEE (EAS Event) code;
A listing of all of the PSSCCC (Location) codes;
The valid time period of the alert event;
The FCC Required Text MAY be dropped as a requirement in the future. At that time the same kind of information would be presumably included within the other CAP fields.

The header is transmitted three times. As the burst errors from lightning are normally less than 100 ms, there SHALL be an interval of 250 ms minimum and 350 ms maximum between the starts for the headers when transmitted digitally EXCEPT for AM radio OR IF the transmission of the first polygon is too long to enable this to be met.. In the case of AM radio, whether HD Radio or not, the interval between the starts of the headers SHALL BE a minimum of 650 ms and a maximum of 750 ms UNLESS the transmission of the first polygon is too long to enable this to be met. This is because of the increased susceptibility of AM radio to lightning bursts, which sometimes are longer than 100 ms. The higher data rates make this specification necessary. If the first two headers are identical, the processing SHOULD then proceed. This means that there is likely to be a minimum pass through delay of about 300 ms. This adds to the timing from sensor to the public of a priority 1 message, e.g. earthquake, but only a small amount compared with the budget. The computer and operating system SHOULD be optimized for rapid CAP, EDXL-DE and improved EAS message processing so as not to delay significantly the alert transmission.

The budget for sensor to public time for the most rapid message e.g. earthquake is as follows;

Sensor to Emergency Management (MAY include a satellite hop)	1 s
Emergency Management processing time from 10 ms to	1 s
Emergency Management to broadcaster transmission time (if satellite)	1 s
Broadcaster improved EAS processing and compression (may be reduced below)	1 s
Broadcaster to public (if satellite is used)	1 s
Public receiver processing time (selectivity processing MAY be needed)	1 s (during 1s pause)
TOTAL	=6 s

The Broadcaster compression time of 1 sec is with normal compression systems, and that is not a precise amount. However by using the Baseball Mode for HD radio and the improved EAS Mode for digital TV, this time can be reduced to nearer 200 ms. HD Radio audio is normally delayed, this may be 5 seconds, so an audio override method introduces too much delay. Data transmission is not delayed for the first interleave stream. However if that is not received, then the copy is delayed. Details are in the section on Compression System Considerations. Eliminating all but one satellite hop leaves the shorter time budget as below;

Sensor processing and Emergency Management (SAFER concurs)	1 s
Broadcast processing	0.5 s
Public receiver processing time (0.7s alert tones, 0.3s “EARTHQUAKE”)	1s
TOTAL	=2.5 s

Note, the above 2.5s includes about 1s of tone and the word “EARTHQUAKE”. As the world has accepted the use of the word “tsunami”, so education about the word “earthquake” is expected to be needed for other languages. Consumer electronics manufacturers may include

language preference selection for their products. If so, the alternative names and their audio recording may be an option, but the default setting is for English.

The possibility of applying this technology to earthquake alerts SHALL NOT in any way be considered a substitute for established mitigation measures, e.g. appropriate building codes, vibration analysis of structures, quality of construction and other public preparation measures. Rather, this capability, along with appropriate other measures, is to more rapidly inform the public so that they may personally take some action that they may consider appropriate. The only organizational measure that may be advisable would be to slow down trains so that the kinetic energy available to create additional damage is reduced. Vehicle drivers SHOULD be particularly aware that an alert of this nature may lead to unpredictable behavior by other drivers, and Department of Transport authorities should consider what would be appropriate public education regarding such a situation. Such information may be included in the phone book along with such recommendations as to avoid using the phones or cellphones so as to not “overload the lines” which could prevent emergency messages from getting through.

As the emergency management may generate an initial CAP message without validating the seismometer data by waiting for the shock wave to reach another seismometer, this SHOULD be transmitted as a whole county selection code for the value of P. A subsequent CAP message would be uniquely identified, but may be in the same minute, which makes it possible to create a duplicate message in the EAS protocol. To avoid this, a second message SHOULD use P to indicate that a polygon area shall be selected. If no polygon or circle data is in the CAP message, a polygon then SHALL be generated as defined by the jurisdiction area.

The processing time of each step is important. The architecture of having nationwide CAP processing has advantages, but some states may prefer to bypass this step for selected message types such as tsunamis and earthquakes to reduce this processing time, especially if satellite hops can be avoided. Dolby Digital provides for an Emergency Audio channel. However this is for one language only, and expected to be subject to the normal Dolby processing time. While the Emergency Audio SHOULD carry the emergency alert in the default language of the broadcaster, the broadcast of all the languages with the minimum delay SHALL also be provided on other audio channels with other PIDs or equivalent UDP or TCP Port(s) as required and identified as such in the PMT or PAT or both.

A way to reduce the public receiver second would be to include the audio “EARTHQUAKE” and reproduce it when the header indicated during the 1s pause. Now can this feature addition sell? This time is lengthy when considering that seismic shock waves travel at about 7 km (5 miles) per second. However as the duration of an earthquake is considerably longer, it begins to be useful as an early warning system. Any time reduction in the budget items is an improvement. The use of the “Baseball mode” in HD radio is an example. In order to provide for legacy HD receivers and analog receivers, the best method appears to be to send the EQE and EQW alerts immediately on the analog audio and force tune all legacy HD receivers to the analog channel. This does not add to the bandwidth required and has the lowest latency. The same method may also be applied to all other alerts. Improved EAS compatible HD receivers would then, if not selected for an alert, would then have the HD program continuing as normal. The disadvantage of this method is that there would not be any private mode possible on HD radio. If the State

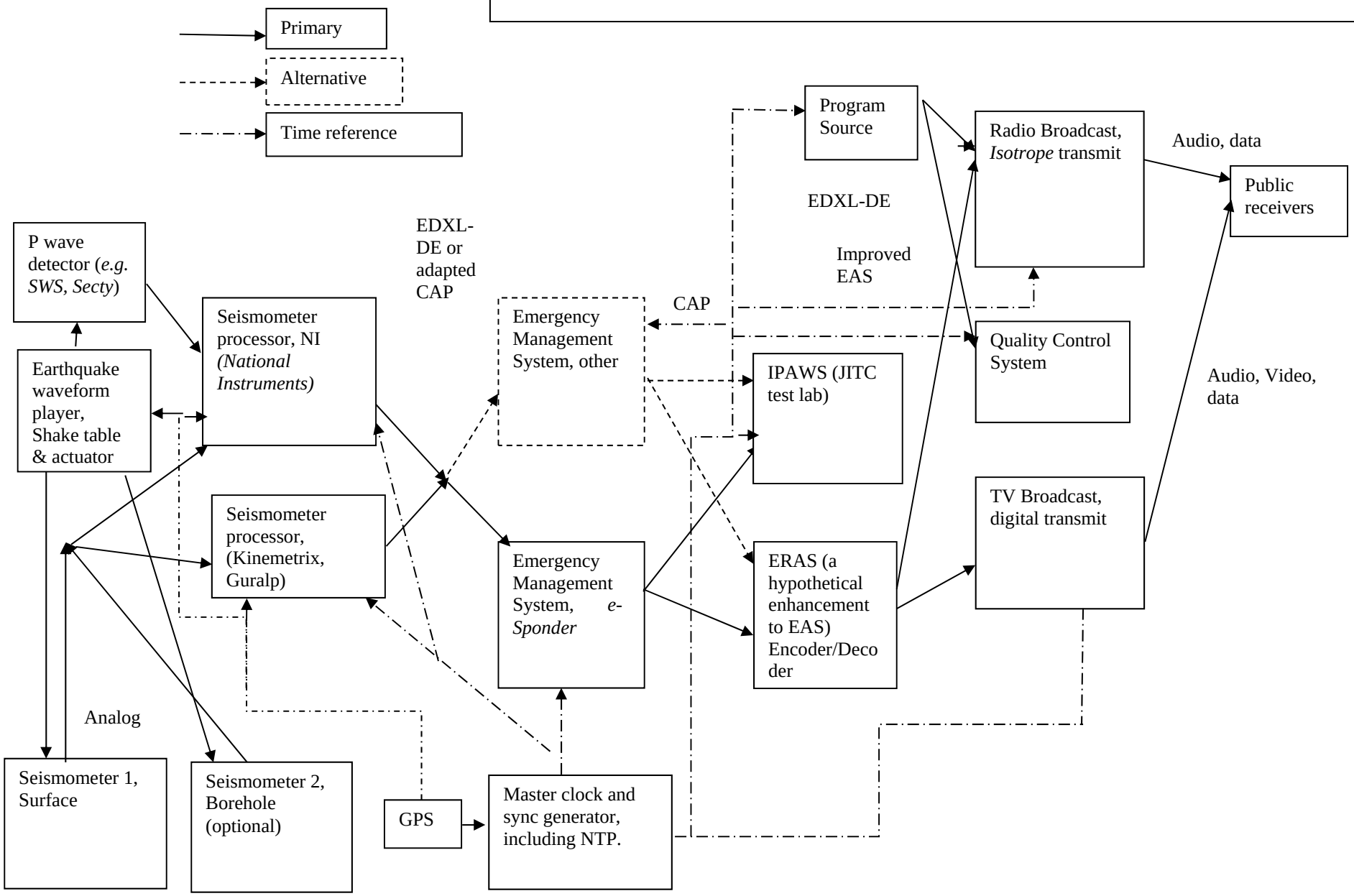
Plan provides for two independent TV channels to be LP1 and LP2, and the digital daisy mesh core network is TV based, then that is not necessarily a problem. Regional or local LP3 or LP4 stations could be included in the plan for more local insertion of EQE, EQW or MSW and possibly other alerts. This would be to reduce latency and add some redundancy. If TV broadcasters are not available, an HD radio station could be considered for this role for EQE, EQW or MSW alerts. HD radio stations then would still be usable as the digital periphery of the mesh, and analog radio stations may monitor these HD stations. Consumer receivers with improved EAS capability SHALL output from memory the SEWS tone for 0.7s followed by the word "EARTHQUAKE" in a masculine voice for an EQE or EQW message in the area selected in a feminine voice in the area selected. As this is driven by the data which should arrive before the audio, this reduces the alert delay. The transmitted audio then follows.

As there is consideration being given to install sensors deep underground e.g. for the San Andreas fault, this can aid detection before the shock wave reaches the surface at the epicenter. As errors in systems could lead to false alarms, there is an event code FAW for human oversight of this automated system to address any such false alarms. False alarms for fires are an accepted risk for the benefit of having the fire alarm systems. The matter of enabling automated message generation is not primarily technical, it is a policy matter of who is the responsible individual and does that person have the credentials and authorization to initiate a message. It may be only that earthquakes and perhaps tsunamis and lahars would be permitted message types which would be exceptions. Japan is reportedly developing a tsunami and earthquake warning system which is comparable to what is discussed here. So they are not considering that earthquakes are self-alerting events, and as the P wave travels faster than the S wave, use is made of this.
In order to expedite the process, if the message is for an earthquake, the first packet of the CAP message SHALL contain all the information for the improved EAS system to process and generate a header, perhaps with the optional polygon. Then the encoder/decoder SHALL proceed to process and retransmit this without waiting for the rest of the message to be received. The first few packets transmitted from the EMO SHALL be such packets to the LP1 and LP2 and any other LP encoder/decoder. The implementation of the internet between these devices SHOULD be so as to minimize the number of hops and transmission time and maximize the QOS.
The varied circumstances of organizations and individuals are quite varied. So addressing the appropriate details is the responsibility and legal liability of such organizations and individuals. For example, the default setting of earthquake alerting is set to OFF for a preset number of hours prior to alarm clock set time. This is because, with appropriate seismically resistant building construction, the probability of individuals injuring themselves by waking and panicking in the dark is quite significant. Therefore the individual or organization is responsible to decide which setting to apply, and also which structural and other precautions to make. Equipment manufacturers SHALL adequately explain this and other responsibility/liability points in documentation provided to the purchaser. The manufacturer MAY, with documentation notes, make the preset value to ON for equipment that is sold to regions that have significant seismic activity.

The following diagram illustrates that it is recommended that a complete system integration test lab be developed in order to test products of multiple manufacturers. While the Agile method of software development is shown to be most effective, there is also standards development being

implemented so testing intervals of a week may be impractical, but testing is likely to be around monthly cycles. This is complex testing. The timing of the P-wave for comparison shall be from the time of the peak. Various earthquake waveforms can be stored in memory and replayed to compare system behavior. An element here can be quite a complex system as other EAS functions are to be tested e.g. ATSC 3.0 immersive sound, which requires 128 channels of audio. Timing measurement may be in logs of devices, LAN analyzers, visual and audio recorded on UHD video or other. Different methods can be compared. An approach that is opposite to Agile is BDUF (Big Design Up Front). This has been shown to be an ineffective, costly and time consuming method that likely results in project failure. Those who are advocating additional time before starting may well be advocating a BDUF. An expression used in Agile is “Fail early, test often and fail often”. The resulting success is higher, and for less cost and time. An extreme application of this is one major software developer that compiles their code developed each day into finished applications overnight for their company to test and use very soon.

Figure 12; Earthquake Rapid Alert System Diagram



EAS= Emergency Alert System – ERAS= Earthquake Rapid Alert System – GPS= Global Positioning System – CAP= Common Alert Protocol – EDXL-DE= Emergency Data Exchange Language, Distribution Element – IPAWS= Integrated Public Alert & Warning System – NTP= Network Time Protocol – *Vendors and Technologies in italics*

The ERAS above is a lab model of an EEWS. The implementation of EEWS needs to be optimized for speed and reliability. So the IPAWS polling method is not appropriate as it introduces a delay compared with a push system. A push architecture to the regional LP stations can be implemented as well as sending the messages to the IPAWS server system. Then the CAP messageID remains the same and whichever message arrives first gets distributed. The above diagram does not mention testing of WEA or ETWS to cellphones. However this lab should be portable so it can be set up in coordination with such testing at whatever location is desired. Computer security at all locations is essential.

The definition of the specification for all broadcast modes is desirable for the purposes of standards development. The development of code in EAS Encoder/Decoders for these is also desirable as it is little extra. The development of transmission systems for non-US broadcast systems is not within the scope of a FEMA funding. However the possibility that NOAA Weather Radio may adopt an appropriate version of HD Radio is a matter to be discussed, and is an option that may be appropriate for consumer radios, especially newer emergency-style receivers. Current emergency-style receivers are often just poor quality receivers that have crank generators or solar cells. An improved EAS, being digital, deserves a receiver design that is for a good quality receiver, e.g. stereo as a minimum. Having a means to determine the receiver location is also important. This might be by Bluetooth from a smartphone GPS, when it can also provide service as a better speaker for cellphone audio. The ability for an alert to override the audio and display SHALL be a requirement for compatibility testing. Compliance is different, additional requirements for professional or broadcast equipment.

Comments on Specific FCC Items

Are there members of the public in earthquake-prone areas who receive neither EAS nor WEA alerts?

Such member of the public may receive alerts by various means, though these may have limitations. They include;

a) ETN (Emergency Telephone Notification). This is under the control of local emergency management authorities, who may choose to implement this. The delivery time is expected to be longer than 3 seconds.
b) SDARS (e.g. Sirius-XM). They have had an emergency message channel. However there does not appear to be a method to deliver alerts selectively (e.g. with polygons) as is proposed. Also the delivery time is expected to be longer, as already 0.7 seconds is added for the link delay.
c) DBS (Dish, Echostar, Sky Angel). This not only has an added 0.7 second link delay added, but discussion to effectively integrate alerting would need to be undertaken.
d) Staff in highly secure computer environments, who may not have their cell phones on. Using Broadband EAS, which is not currently being sold, a TV tuner card in the secure network could deliver messages and alert staff, trigger file saving and other activities as configured by the network administrator. The delay would be a minimal addition to that of EAS.

e) People on boats and ships are relatively immune to earthquakes unless quite close to shore and a tsunami results. There they may receive EAS or WEA alerts. In addition, there is a GMDSS system called Navtex operated by the Coast Guard. However such alerts may need to be entered manually and so be delayed.
f) Disabled and other people may not receive alerts directly. This may be because of one or more reasons e.g. they are incapacitated or imprisoned, so this is a matter for their caregivers. They may not have receivers that suitably deliver alerts, so this becomes a matter of educating the public about the availability of suitable receivers, which is part of the responsibility of the marketing and advertising of such receivers. Also this can be monitored by organizations of the disabled in coordination with FEMA.
g) An important cause of non-reception of alerts is that of vandalized equipment. For example, after the 2004 Indian Ocean tsunami, a number of buoys were installed to detect tsunamis. Earlier in 2016 there was a major earthquake in the ocean in that region. However none of the tsunami detection buoys reported anything because they had all been vandalized or damaged by people. This is a part of the world in which pirates operate, perhaps they don't care for tsunami alerts. So both public education and added security measures are relevant. The damage had not been repaired at the time of the earthquake because there was no budget provided for that. Perhaps photographs of the pirates could be released to the media next time to assist their apprehension under appropriate local law, and their assets confiscated. Fortunately for the people of the region, the tsunami was not repeated this time. In the U.S., pirate radio stations that are not implementing EAS are also depriving people of lifesaving alerts. One security technology that may assist is that of electric fencing. It even works on sheep with all that wool on, but it is non-lethal. Such electric fence controllers may include monitoring of shorts and disconnections on the fence with an ability to transmit alarms remotely.
h) The different languages being an obstacle to the understanding of alerts is a problem. This is addressed in the filing made for proceeding 15-94. Included there is even provision for braille. There have been some suggestions to incorporate American Sign Language. Firstly, this could only function on TV. Secondly, an ASL translator would constantly need to be available for every message. Thirdly, as the alerts are in text, which may be machine generated with details, and Text-To-Speech is being increasingly used, it is more sensible to apply the Closed Captioning based on EIA 708 which has capabilities in the TV receivers. The Chinese have used EIA 708 for Pinyin, and the Japanese have adapted it for their alphabets. The ASCII extensions also provide for other languages.

Non-USGS Earthquake Detection

The Seismic Society of America this year considered the subject of using seismic detection for earthquake alerting using devices other than seismometer networks. There are some vendors of seismometer devices that claim to detect P-waves to trigger alerts. These devices may not generate a message that can be sent to an Emergency Management processor. However a contact closure or voltage change can be used by a processor to trigger the generation of such a message. So such devices should be tested to assess the performance. The diagram above makes provision for this. The potential benefit is that of having a probability of reliably detecting an earthquake sooner, and also having multiple detections made sooner, thus being able to more rapidly generates an alert. This was reported in Homeland Security Newswire 2016-4-25.

Geographic Targeting, Message Length and Costs

Please see the sections above on Event Codes for Earthquake Alerting, and an Improved Protocol for Polygon Transmission. The ATIS use of a circle has some issues as discussed there, but the encoder/decoder can translate to an octagon.

The message length is quite short as only the header and polygon is required. Basically sending lengthy instruction is not effective when people have become stressed. “The Unthinkable” by Amanda Ripley illustrates this. In a disaster, normally people mill around and discuss it before acting. So authorities in earthquake prone areas need to conduct education and drills, i.e. “Drill or Mill”. There is also not time to distribute complex instructions. However by using the data transmission mode beforehand, documents in self-contained common formats can be push published. Examples of such formats are TXT, RTF, PNG and PDF (without links embedded). Also pull downloading of such documents should be possible on FEMA and other websites.

The costs of implementing EEWS are primarily those of the seismology and emergency management capability upgrade and maintenance. The improvement of EAS is already proposed to include EEWS as that is the technically most difficult task. Part of it is to use the header and polygon to trigger tones and the word ‘EARTHQUAKE” from receiver memory to bypass the delay of the audio and video content. The costs of improving WEA are not known by myself. However most smartphones and some cellphones can have their software upgraded, a minimal cost.

A standard definition for a protocol from seismometer processors to emergency management is not defined. While CAP could be used, the polygon would become one location (the seismometer) including an altitude and other data to assist making the system self-documenting (e.g. model, serial number, installation date and installer code.).

Error Detection and Correction in Computers, Equipment Reliability

Based on observations of large computer systems in mission critical use and a discussion with KK Ma, Manager of Advanced Microelectronics and Radiation Effects, Sandia National Laboratories, the following conclusions were reached. Also “Quantum Engines Must Break Down” Prof. Oppenheim ucl.ac.uk and Prof Michal Horodecki University of Gdansk.

1) Space qualified and high radiation resistant electronics is prohibitively expensive for use in an EAS application. Also the software development for such hardware is specialized and similarly expensive, e.g. there are no PC architecture machines for such an environment.
2) The occurrence of Single Event Upsets (radiation caused memory errors) is real in computers in normal use, but the effects are similar to but considerably less frequent than soft errors. Typically such errors in normal computers are corrected by rebooting.
3) Other causes of errors such as software bugs, power glitches and hardware failures can also introduce errors. Error detection and possible correction may be effective on these problems also.
4) The use of Scrubbing Software (SS) is an economical and usually effective measure against computer memory errors. Basically SS examines the content of all memory in use and compares at least two versions to determine if any errors are present. Detection of an

error should result in an alert being made to an operator to address the issue, with suitably detailed information as to how to do so.

5) The design and development of SS is highly dependent on the operating software. The frequency of operation of the SS is dependent of the application. One possibility is for this to be run on every day that the last digit of the date is a two, and to do so at 4 am. Also any software upgrades to the computer should not be scheduled for that day or the previous day.
6) Some hardware designs use FPGAs. These are gate arrays whose configuration is set by registers and the register settings are input at the device reset or power on. As such registers may be modified in Single Event Upsets or as soft errors, the hardware configuration is likely to be affected. While scrubbing software may be devised for checking this type of problem, it would be difficult or perhaps not realistic to do so. An alternative technology that may be applied would be to use boundary scan testing (IEEE 1149.1). This may be possible, but it would require the equipment to be out of service during testing. It is a technology that is good for diagnosis if it is designed into the hardware.
7) EAS is an unusual application in that while regular tests are made, the code for very many mission critical items may never be used in the lifetime of the Encoder/Decoder, and so the presence of errors may not be detected, but be a serious problem that does not manifest until an emergency.
8) Software development should be made using methods that are more safe and secure. For an example discussion of this subject see www.adacore.com for Ada_Safe_and_Secure_Booklet.pdf.
9) As CAP and EDXL are XML messages, it may be more cost-effective, and reliable, to provide the message routing and processing in hardware rather than software based. The only vendor currently known with this type of processor is Solace Systems.
10) Consumer electronics may not requires the same corrective measures as noted in this section, but are still likely to have the same problems, e.g. that register value changes unpredictably. For example, a consumer multistandard DVR player would unexpectedly switch from NTSC to PAL output. With an NTSC TV it is very difficult to operate the setup menu that is in PAL. The addition of a button on the remote that is “TV type” would be an option. In general, it is preferable to have monitoring of important register settings that can be disruptive to the consumer experience e.g. the Program Association Table values are not just set and left, but as this system switches the PID or equivalent UDP or TCP Port values, there SHOULD BE a check against the PAT values and to have a timeout period (3 minutes except for EAN and NIC event codes) and number of PAT derived PID or equivalent UDP or TCP Port values that become applied in case of such register errors. Consumers do not appreciate having to reboot or power cycle their radio or TV in order to restore correct operation.
11) Measures to improve equipment reliability include, but are not limited to;
    a) Use of electrolytic capacitors rated at 105°C or higher. While the equipment is quite unlikely to operate at such temperatures, this is a test of the seal of the capacitor which prevents moisture from leaking out over years and leading to failure. This is a relatively inexpensive measure, which shall be incorporated in professional equipment and is recommended also for consumer electronics as longer life leads to less discarded equipment and so is a more green approach.

b) Use of backup media, preferably automatically. Flash drives are becoming an alternative to RAID arrays.
c) The use of surge and lightning protection.
d) The use of UPSs.
e) The design of fans such that they can be replaced easily. Some equipment provides for their replacement without opening the box or turning off the power.
f) The use of air filters that are easily inspected and cleaned. Also larger filters to reduce the air flow velocity need less frequent cleaning.
g) The inspection of operating system installation and applications for security flaws so that the equipment is much less vulnerable. This may mean that developers use a more secure language and consult with computer security experts.
h) These and other such methods can result in equipment that may operate for perhaps 20 years non-stop without failing, excluding fan and disk drive replacement. Industrial or server grade PCs have been observed to operate for over 5 years without rebooting. These may not be running Windows or Mac however.
i) Microcontroller devices can incorporate watchdog timers for reliability. However PCs may require rebooting, which with remote control power outlets, can be done remotely. This method is a potential security vulnerability.
j) The ability to be monitored for temperature, hours since last reboot, received signal error rate and strength, supply voltage, error log, fan status, etc. remotely by standard protocol.
k) The login system SHOULD be defined in the State Plan, and use methods such as TACACS+, Kerberos. CHAP or other suitable protocol.

MONITOR MESSAGES

A QC monitoring system is desirable. This should be under the State Emergency Management Office (SEMO) and the State Emergency Communications Committee (SECC). All alerts transmitted can automatically have the state of their distribution checked. As this should include digital only test messages, this is providing frequent monitoring. A geographic display of successful distribution is desirable as a layer in the Emergency Management application. XchangeCore is an example of such a contributing application. This should be all automated to minimize the work required by valuable technical resources who currently are doing this manually. In addition, The FCC is seeking to implement logging of EAN and perhaps other selected alerts. This reporting system should also provide such reports prepared automatically as much as possible, with administrative monitoring. Since the FCC is a regulatory agency, the provision of reports has a legal aspect. The SEMO and SECC monitoring is primarily a Quality Control feedback loop. The funds for the SEMO and the SECC to implement this QC function need to be provided, which may involve FEMA.

The EAS monitor receivers SHALL send acknowledgement messages of all EAS and CAP Broadcast messages as emails in the following format;
ORG-EEE-PSSCCC-YYYYJJJHHMM-LLLLLLLL;WWW;BER=M.Ne-P;LEVEL=<+/-VV>dBr100mS;MMSS.S; and <identifier>*identifier* AND <sender>*sender* for CAP or <distributionID>*distributionID* and <senderID>*senderID* for EDXL-DE on separate lines if multiple messages are acknowledged.

Where WWW is the county or state ID of the monitor receiver, 000 being reserved for the county monitor email address. M.N are the units and tenths of the Bit Error Rate. P is the exponent, with a maximum of 9. If the BER is better than 0.1e-9 it SHALL be indicated as 0.0e-9 unless there are no errors in which case it SHALL be indicated as 0.0e-9. The LEVEL is the level of the peak audio that lasts for 100ms, as the simplest level measurement of voice audio. It is relative to the reference analog or digital level as appropriate, where VV is the dB. The reference level for digital is -24 dB of digital absolute peak, this is the dialnorm value adopted by ATSC. The time of receipt of the ZCZC or CZCZ start of the message is the MMSS.S. This is to measure distribution time. The subject line SHALL be PSSCCC-YYYYJJJHHMM-WWW. The FSK modem tones of analog-only broadcasts are used.

The email address is RECOMMENDED to be in the form PSSCCC-WWW@<mailserver>. If a message to this address with a subject line RUOK, the reply SHALL be with a subject line of PSSCCC-YYYYJJJHHMM-WWW-OK. The content SHALL be;
LLLLLLLL-RX=M.Ne-P, (repeated for multiple receivers)
<TEMP>=+/-VVVC
<AC>=VVV or < DC>=VV.V>
<PSU1>=OK/Fail
<PSU2>=OK/Fail/NA
<UPTIME>=VVVVVHRS
<VER>=software version
<FAN>=1 or 0 or a value in between if one of many fans failed or NNNNNRPM
<ERROR_MSGS>=NONE or a list of error messages since the list was last cleared. The condition of configuration check failure or software validation failure, which are periodic system self checks, SHALL be included with any details here. The occurrence of these or other selected errors SHALL promptly generate the above message even when no polling message was received.

Where RX=M.Ne-P is the receive signal strength in dBm with an accuracy of +/- 20%, and the – could be a + if appropriate. The TEMP is Celsius, and the + could be a -. The AC or DC are the input supply voltages. The UPTIME is the time since last boot. Together these email messages can not only monitor the EAS messages but also the EAS monitoring system automatically with software, for cost-effectiveness.

CAP messages have some details that MAY NOT be able to be carried in the improved EAS protocol, but are not needed by consumers. So the CAP message and the corresponding improved EAS message(s) generated will be made into log entries in the ENCODER/DECODER, probably a selected directory. Also that this entry or entries SHALL be emailed to the QC email receiving in the same format. Also that the QC email sending an enquiry to the ENCODER/DECODER SHALL result in a response email formatted as above. See the specification on translating CAP and EDXL-DE messages to improved EAS as it incorporates some <XML> expressions in the improved EAS text.