FEASIBILITY STUDY

ATIS-0700023

FEASIBILITY STUDY FOR LTE WEA MESSAGE LENGTH

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ATIS Standard on

Feasibility Study for LTE WEA Message Length

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Abstract

This feasibility study performs a technical analysis of the proposed maximum length of displayable characters in a Long Term Evolution (LTE) Wireless Emergency Alert (WEA) message in response to Recommendation 2.1 of the December 2014 Federal Communications Commission (FCC) Communications Security, Reliability & Interoperability Council (CSRIC) Working Group 2 Wireless Emergency Alerts final report of December 3, 2014.

Foreword

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

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

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

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

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

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1 Scope, Purpose, & Application

1.1 Scope

The scope of this document is a feasibility study into the optimal message length for WEA messages in LTE networks based on recommendations from the FCC Communications Security, Reliability & Interoperability Council (CSRIC).

1.2 Purpose

At the December 3, 2014 meeting, the Federal Communications Commission (FCC) Communications Security, Reliability & Interoperability Council (CSRIC) approved the final report from the CSRIC Working Group 2, Wireless Emergency Alerts [Ref 1].

While the FCC has received the recommendations from the CSRIC working group, the FCC has not acted on those recommendations, i.e., no notice of proposed rulemaking has been issued. However, the CSRIC working group report does contain recommendations which require action by ATIS prior to any FCC Notice of Proposed Rulemaking (NPRM). Specifically, Recommendation 2.1 [Ref 1] (as quoted below) tasks industry to perform a technology confirmation of the proposed maximum length of displayable characters in an LTE WEA message:

> *"**Recommendation 2.1:** It is recommended, following technology confirmation by ATIS standards, that 47 CFR § 10.430 Character Limit be modified to such that a WEA Alert Message processed by a Participating CMS Provider has a maximum length of 280 displayable characters of displayable text on capable 4G LTE based CMS Provider Infrastructure and devices. The existing 90 Character Limit rule will remain for 2G, 3G and legacy 4G networks and devices based on the limitations of these networks and the expectation that the overwhelming majority of CMSP infrastructure and mobile devices will churn[1] to capable 4G LTE."*

1.3 Application

This feasibility study is applicable to cellular network operators, the FCC, the FCC CSRIC, and the members of the regular WEA partner meetings which include the FCC, the Cellular Telecommunications Industry Association (CTIA), the Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), the National Weather Service (NWS), and cellular network operators.

2 Normative References

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

[1] '*In the context of this Recommendation, the term "churn" refers to the wireless subscribers replacing their older technology mobile devices with new technology mobile devices.*'

[Ref 1] FCC CSRIC IV Working Group 4, *Geographic Targeting, Message Content and Character Limitation Subgroup Report*, October 2014.[2]

[Ref 2] 3GPP TS 23.041, *3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Technical realization of Cell Broadcast Service (CBS)*.[3]

[Ref 3] 3GPP TS 36.331, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification*.[3]

[Ref 4] 3GPP TS 36.413, *3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)*.[3]

[Ref 5] FCC 07-214; *Federal Communications Commission Notice of Proposed Rulemaking in the Matter of the Commercial Mobile Alert System*; December 14th, 2007.[4]

3 Definitions, Acronyms, & Abbreviations

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

3.1 Acronyms & Abbreviations

3GPP	3rd Generation Partnership Project
ATIS	Alliance for Telecommunications Industry Solutions
CB	Cell Broadcast
CBC	Cell Broadcast Center
CMAS	Commercial Mobile Alert System
CMSP	Commercial Mobile Service Provider
CSRIC	Communications Security, Reliability & Interoperability Council
CTIA	Cellular Telecommunications Industry Association
DCI	Downlink Control Information
DHS	Department of Homeland Security
eNB	Evolved Node B
FCC	Federal Communications Commission
FEMA	Federal Emergency Management Agency
GSM	Global System for Mobile Communications
LTE	Long Term Evolution

[2] This document is available from the FCC at < http://transition.fcc.gov/pshs/advisory/csric4/CSRIC_CMAS_Geo-Target_Msg_Content_Msg_Len_Rpt_Final.pdf >.

[3] This document is available from the 3rd Generation Partnership Project (3GPP) < http://www.3gpp.org/ >.

[4] This document is available from the Federal Communication Commission at: < http://fcc.gov/ >.

MME	Mobility Management Entity
NPRM	Notice of Proposed Rulemaking
NWS	National Weather Service
SIB	System Information Block
TS	Technical Specification
UCS	Universal Character Set
WEA	Wireless Emergency Alerts

4 Analysis of LTE WEA Maximum Length

This clause analyzes the factors that contribute in determining the number of display characters that can be sent over the air to the mobile devices in an LTE network for WEA messages.

The factors that contribute to the length are: format used to carry the display characters, the character set used for display characters, broadcasting technique used to transmit the data over the air, the bandwidth and the coding rate available for the transmission, mobile device screen aspects of display, and the time required by the mobile devices to collect all the display characters before a presentation. Some of these factors may have to be viewed as a negative consequence of the increased length rather than as a limiting factor.

Here, the term “Message Length” refers to the number of displayable characters transmitted over the air to the mobile devices. The total number of octets transmitted over the air (which is more than the octets required to transmit the displayable characters) will also include a few additional overhead data that carry information such as Message Identifier, Serial Number, Data Coding Scheme, and a few transmission-specific attributes.

For the purpose of this analysis, this clause considers two types of display characters:

- GSM 7-bit
- UCS-2

With GSM 7-bit, each display character takes 7 bits of data, whereas with UCS-2, each display character takes 16 bits (or 2 octets) of data. The display characters in a WEA message are always encoded using the GSM 7-bit format; however, the similar emergency alerts broadcast in Canada may use UCS-2 format. For that reason, both types of character sets are considered in the analysis.

4.1 Data Format

This clause illustrates the role of the data format used to carry the display characters in determining the LTE WEA message length.

The 3GPP specifications TS 23.041 [Ref 2], TS 36.331 [Ref 3], and TS 36.413 [Ref 4] describe the data format used to transmit the WEA message octets within the CMSP infrastructure and then to the mobile devices over the air. For the purpose of this analysis, the focus is on the format used to transmit the data over the air, even though, at times, the other aspects may be referenced (as needed) as well.

4.1.1 Background

Within the LTE, the display characters (also known as warning message contents) are sent over the air using the Cell Broadcast Data (CB Data) format. The encoding of the display characters into this format is done at the Cell Broadcast Center (CBC) and as such the format and the contents are transparent to other network nodes (i.e., MME and eNB) within the CMSP infrastructure. The Figure 4.1 illustrates this point.

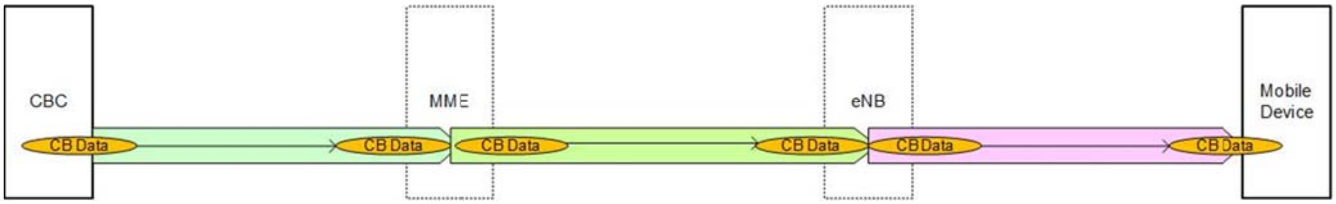

Figure 4.1 – CB Data Format is Transparent to MME and eNB

The method used to transmit the display characters from one node to another node may be different (e.g., WRITE-REPLACE-WARNING-REQUEST between CBC and MME, and between MME and eNB and System Information Block (SIB) between the eNB and the mobile devices), but the format used to carry the display characters (i.e., CB Data format) remains the same end-to-end from CBC to the mobile devices. The eNB transmits all the octets of CB Data over the air to the mobile devices as a part of warning message contents, irrespective of whether those octets carry the actual display characters or some filler bits (also known as padding bits). The eNB does not look at the contents of CB Data. With this approach, the format used for the display characters is a business between the CBC and the mobile devices.

3GPP TS 23.041 [Ref 2] defines the CB Data format as shown below:

Table 4.1 – CB Data Format

Octets	Description
1	Number of Pages
82	Page Information 1
1	Page Length 1
82	Page Information 2
1	Page Length 2
• • •	• • •
82	Page Information 15
1	Page Length 15

As shown in the Table 4.1, the display characters are included in Page Information n (where n = 1 to 15) element of CB Data. As shown, there can be a maximum of 15 instances of Page Information with 82 octets per each instance. Each instance is referred to as a CB Data Page. So, the maximum number display characters that can be sent using the CB Data format shall be accommodated within 15 CB Data Pages or within the 1230 (= 82 * 15) octets. For each CB Data Page, there is 1 octet used to carry the Page Length, and overall, another octet is required to identify the total number of CB Data Pages present within the CB Data. Thus, the maximum number of octets that can be present within the CB Data is 1246 (= 1 + 15*82 + 15).

As quoted below, 3GPP TS 23.041 [Ref 2] clause 5 further specifies that for a given CB Data Page when present, the CBC shall always include all 82 octets in the Page Information part of the CB data irrespective of the number of display characters.

> "***5 CBC Functionality:***
>
> *…*
>
> - *Initiating broadcast by sending fixed length CBS messages to a BSC/RNC/eNodeB for each language provided by the cell, and where necessary padding the pages to a length of 82 octets (3GPP TS 23.038).*
>
> *…*"

In other words, if the number of octets required to carry the display characters in a CB Data Page is fewer than 82, the CBC would pad remaining bits of a partial octet and the remaining octets of that CB Data Page, thus resulting in always 82 octets of Page Information per CB Data Page. The Page Length would tell the mobile devices how many of those 82 octets carry the display characters.

This rule of always including 82 octets of Page Information in a CB Data Page is also logical based on the format of the CB Data because the Page Length comes after the Page Information within the CB Data for each CB Data Page. A mobile device can handle the received CB Data if and only if it knows which octet carries the Page Length, accurately.

4.1.2 Analysis

The clause 4.1.1 explains that the display characters of WEA message are encoded using CB Data format. A CB Data contains a certain number of CB Data Pages with 82 octets of Page Information per CB Data Page. The Page Information carries the display characters. The CBC pads the unused bits of an octet and unused octets of a CB Data Page.

The number of display characters that can be sent using the octets of CB Data depends on the character set used. For example, with GSM 7-bit character set, a CB Data Page can include a maximum of 93 display characters with 5 unused bits (and CBC pads those 5 unused bits). With UCS-2, a CBS Page can include a maximum of 41 display characters with no unused bits.

Table 4.2 below illustrates the number of octets in the CB Data required to carry various number of display characters:

Table 4.2 – Comparison – Number of CB Data Octets Vs Number of Display Characters

CB Data Length			Range of Display Characters (that can be sent)			
Number of CB Data Pages	Number of Octets		GSM 7-bit		USC-2	
	CB Data	For Display	Minimum	Maximum	Minimum	Maximum
1	84	82	1	93	1	41
2	167	164	94	186	42	82
3	250	246	187	279	83	123
4	333	328	280	372	124	164
5	416	410	373	465	165	205
6	499	492	466	558	206	246
7	582	574	559	651	247	287
8	665	656	652	744	288	328
9	748	738	745	837	329	369
10	831	820	838	930	370	410
11	914	902	931	1023	411	451
12	997	984	1024	1116	452	492
13	1080	1066	1117	1209	493	533
14	1163	1148	1210	1302	534	574
15	1246	1230	1303	1395	575	615

Table 4.2 above shows the number of display characters that can be sent over the air with each CB Data Page. Table 4.2 can also be used to determine the number of CB Data Pages required to transmit a certain number of display characters, thus allowing to determine the number of CB Data octets required to transmit a certain number of display characters.

For example, to transmit 280 display characters with GSM 7-bit character set, 4 CB Data Pages will be required and hence, 333 octets of CB Data will be transmitted over the air. On the other hand, to transmit 280 display characters with UCS-2 character set (i.e., 16 bits per character), 7 CB Data Pages will be required and hence, 582 octets of CB Data will be transmitted over the air.

Table 4.3 and Table 4.4 illustrate how a 280 character WEA message is encoded in the CB Data format using GSM 7-bit and UCS-2 character set.

Table 4.3 – Number of CB Data Octets for 280 Character GSM-7 bit Display

Octet Number	Usage	Value	Padded Bits/Octets	
			Partial Octets	Complete Octets
1	Number of pages	4	0	0
2 to 83	Page Information 1	Display characters (1 to 93)	5 bits (octet 83)	0
84	Page Length 1	82	0	0
85 to 166	Page Information 2	Display characters (94 to 186)	5 bits (octet 166)	0
167	Page Length 2	82	0	0
168 to 249	Page Information 3	Display characters (187 to 279)	5 bits (octet 249)	0
250	Page Length 3	82	0	0
251 to 332	Page Information 4	Display characters (280)	1 bit (octet 251)	81 octets (252 to 332)
333	Page Length 4	1	0	0

As shown in Table 4.3, the Page Length would be 82 for the first 3 CB Data Pages and 1 for the last CB Data Page. As shown in Table 4.2, the same octets of CB Data (i.e., 333 octets) will be able to transmit 372 number of GSM 7-bit display characters.

Table 4.4 – Number of CB Data Octets for 280 Character UCS-2 Display

Octet Number	Usage	Value	Padded Bits/Octets	
			Partial Octets	Complete Octets
1	Number of pages	4	0	0
2 to 83	Page Information 1	Display characters (1 to 41)	0	0
84	Page Length 1	82	0	0
85 to 166	Page Information 2	Display characters (42 to 82)	0	0
167	Page Length 2	82	0	0
168 to 249	Page Information 3	Display characters (83 to 123)	0	0
250	Page Length 3	82	0	0
251 to 332	Page Information 4	Display characters (124 to 164)	0	0
333	Page Length 4	82	0	0
334 to 415	Page Information 5	Display characters (165 to 205)	0	0
416	Page Length 5	82	0	0
417 to 498	Page Information 6	Display characters (206 to 246)	0	0
499	Page Information 6	82	0	0
500 to 581	Page Information 7	Display characters (247 to 280)	0	14 octets (567 to 581)
582	Page Length 7	68	0	0

As shown in Table 4.4, the Page Length would be 82 for the first 6 CB Data Pages and 68 for the last CB Data Page. As shown in Table 4.2, the same octets of CB Data (582 octets) will be able to transmit 287 number of UCS-2 display characters.

4.1.3 Summary of Analysis

The analysis shows that the number of CB Data Pages required to carry the display characters, and not the number of octets required to accommodate those display characters, has a role in determining the WEA message length in LTE. The number of CB Data octets transmitted over the air can be determined using the following formula:

GSM 7-bit:

1 + 83 * (ceiling (character-count/93)) Formula {1}

UCS-2:

1 + 83 (ceiling (character-count/41)) Formula {2}

For example, with GSM 7-bit character set an alert text with 280 display characters will require 333 octets of CB Data and the following illustrates how it can be derived from the Formula {1}.

Number of octets = (1 + 83 * (ceiling (280/93))) = (1 + (83 * (4))) = (1 + 332) = 333.

It has to be noted that same number of CB Data octets can carry 372 display characters with GSM 7-bit character set. That is because ceiling (372/93) also results in the value 4. On the other hand, an alert text with 279 display characters would require 3 CB Data Pages (because ceiling (279/93) results in the value 3) and hence, 250 octets of CB Data.

In the same way, Formula {2} can be used to determine CB Data octets required to carry the 280 display characters with UCS-2 format as shown below:

Number of octets = (1 + 83 * (ceiling (280/41))) = (1 + (83 * (7))) = (1 + 581) = 582.

It has to be noted that same number of CB Data octets can carry 287 display characters with UCS-2 format. That is because ceiling (287/41) also results in the value 7.

4.2 CB Data Transmission Over The Air

In LTE, the WEA messages are transmitted over the air using system information block (SIB) type 12.

4.2.1 Background

4.2.1.1 Bits per SIB12 Segment

The 3GPP TS 36.331 [Ref 3], clause 5.2 states the following on the number of bits that can be carried inside one segment of SIB12:

> *"The physical layer imposes a limit to the maximum size a SIB can take. When DCI format 1C is used the maximum allowed by the physical layer is 1736 bits (217 bytes) while for format 1A the limit is 2216 bits (277 bytes), see TS 36.212 [22] and TS 36.213 [23]."*

Note that the above are the maximum number of bits that a physical layer allows a SIB to have. In some situations, the physical layer may not have so-many bits available to share with SIB (for example, with the lower carrier bandwidth, the number of bits that are available for the physical layer may be smaller). In some situations, the physical layer may require more bits for its own processing and may thus be able to share only a smaller number of bits with the SIB (e.g., lower coding rate will result in a fewer number of bits available to SIB). In summary, the number of bits available for a SIB can be fewer than the above-quoted maximum value and the actual bits available vary based on the carrier bandwidth and coding rate.

This analysis does not go into further details of illustrating the mapping between the bandwidth/coding rate to number of SIB bits, but rather just points out that the number of bits available can be fewer than the maximum quoted. Therefore, one cannot really determine the number of display characters that can be sent over the air based using the above mentioned maximum value.

4.2.1.2 Segmentation

The 3GPP 36.331 clause 5.2.15 [Ref 3] also has the following:

> *"CMAS notification is contained in SystemInformationBlockType12. Segmentation can be applied for the delivery of a CMAS notification. The segmentation is fixed for transmission of a given CMAS notification within a cell (i.e. the same segment size for a given segment with the same messageIdentifier, serialNumber and warningMessageSegmentNumber). E-UTRAN does not interleave transmissions of CMAS notifications, i.e. all segments of a given CMAS notification transmission are transmitted prior to those of another CMAS notification. A CMAS notification corresponds to a single CB data IE as defined according to TS 23.041 [37]."*

The above paragraph is telling that in the event a CMAS notification has more bits than the number of bits the physical layer allows SIB to have, the bits will be transmitted using segmentation. For each notification, there can be up to 64 segments. The size of a SIB segment (for a given segment, for a given event notification) always remains the same. This means that, as an example, if a WEA message is transmitted using two segments, then when those segments are repeated, they will have the same size as when they are transmitted earlier. In other words, if segment #1 had 1500 bits and segment #2 had 1000 bits then all repeated segment #1 would always have 1500 bits and all repeated segment #2 would always have 1000 bits. These details are not important for this analysis, but they do clarify the above referenced text from 3GPP TS 36.331 [Ref 3].

The segmentation is an inherent capability associated with the system information broadcasting, and one cannot really design something based on the segment size. For example, if there are 200 octets (1600 bits) of data to be sent and if the physical layer allowed bits for SIB is 1500 bits, then the segmentation would apply with 1500 bits in the first segment and 100 bits in the second segment. On the other hand, if the physical layer allowed bits for SIB is just 500, then segmentation would apply with 500 bits in the first 3 segments and 100 bits in the last segment. This is inherent of transmission capability, and therefore should not really play a role in determining the length of WEA message, except to the points stated in clause 4.3.

4.2.1.3 Overhead Data

The 3GPP TS 36.331 [Ref 3] clause 6.2.2 provides the following definition for the SIB12 information element:

SystemInformationBlockType12 information element

```
-- ASN1START

SystemInformationBlockType12-r9 ::= SEQUENCE {
    messageIdentifier-r9                BIT STRING (SIZE (16)),
    serialNumber-r9                     BIT STRING (SIZE (16)),
    warningMessageSegmentType-r9        ENUMERATED {notLastSegment, lastSegment},
    warningMessageSegmentNumber-r9      INTEGER (0..63),
    warningMessageSegment-r9            OCTET STRING,
    dataCodingScheme-r9                 OCTET STRING (SIZE (1))         OPTIONAL,   -- Cond Segment1
    lateNonCriticalExtension            OCTET STRING                    OPTIONAL,
    ...
}

-- ASN1STOP
```

Figure 4.2 – SIB12 Information Element Definition

The *warningMessageSegment-r9* Information Element (IE), shown in Figure 4.2, carries the displayable characters coded by the CBC in the CB Data format described in clause 4.1.1. As far as SIB12 is concerned, those characters are just the bits contained within that IE. As can be seen in Figure 4.2, there are additional data sent as a part of SIB12. These are called overhead data, and the analysis performed in various wireless industry laboratories shows about 12 to 14 octets being taken by these overhead data. For the purpose of this analysis, it is assumed that about 14 octets are being taken as the overhead data for each SIB12 segment. At the end, the overhead data may not have that much significance in determining the WEA message length, but nevertheless, they do have some significance.

4.2.2 Analysis

Looking at the maximum allowed bits for SIB12 (see clause 4.2.1.1), and taking 14 octets out as overhead data (see clause 4.2.1.3), a SIB12 segment will have 263 octets available for the CB Data with DCI type 1A and 203 octets available for the CB data with DCI type 1C.

Table 4.5 below analyzes the number of segments used in the transmission of WEA message with various character size depicted in clause 4.1.2:

Table 4.5 – Number Segments for Various Display Character Size

CB Data			SIB12 (max possible; 14 octets of overhead per segment)			
Number of Display Characters		CB Data Octets	277 Octets per Segment (Type 1A)		217 Octets per Segment (Type 1C)	
GSM 7-bit	UCS-2		# of Segments	Last Segment Size	# of Segments	Last Segment Size
1 to 93	1 to 41	84	1	98	1	98
94 to 186	42 to 82	167	1	181	1	181
187 to 279	83 to 123	250	1	264	2	61
280 to 372	124 to 164	333	2	84	2	144
373 to 465	165 to 205	416	2	167	3	24
466 to 558	206 to 246	499	2	250	3	107
559 to 651	247 to 287	582	3	70	3	190
652 to 744	288 to 328	665	3	156	4	80
745 to 837	329 to 369	748	3	235	4	153
838 to 930	370 to 410	831	4	56	5	33
931 to 1023	411 to 451	914	4	139	5	116
1024 to 1116	452 to 492	997	4	222	5	199
1117 to 1209	493 to 533	1080	5	42	6	79
1210 to 1302	534 to 574	1163	5	125	6	162
1303 to 1395	575 to 615	1246	5	208	7	42

Table 4.5 shows the number of segments required to transmit various number of display characters. Table 4.5 should be read as shown below:

- When the number of display characters is in the range ***so-so***, ***so-many*** octets of CB Data will have to be sent and, with the maximum possible bits available for SIB 12 per segment, ***so-many*** segments will be required and the size of the last segment is ***so-many***.

For example, if the number displayable character is 280 (then the row that has 280 to 372 has to be chosen), then 333 octets of CB Data will have to be sent over the air, and with maximum possible bits available for SIB12 per segment, with DCI type 1A (277 octets per segment), a total of 2 segments will be required with 263 octets of CB Data going in the first segment (277 – 14 overhead octets) leaving 70 octets to the second segment and hence, 84 octets (70 + 14 overhead octets) as the size of segment 2. The same with DCI type 1C (217 octets per segment), a total of 2 segments will required with 203 octets of CB data in the first segment (217 – 14) leaving 130 octets to the second segment and hence, 144 octets (130 + 14) as the size of segment 2.

As explained in clause 4.2.1, a segment may not always have the maximum number of bits specified. Carrier bandwidth and coding rate determine the number of bits available in a segment for transmission. For example, the number of bits available with 10 MHz carrier may be half of the bits available with 20 MHz carrier.

To illustrate the consequence of this possibility, the Table 4.6 redraws the Table 4.5 with a fewer number of octets available for SIB12 per segment (an example of 40 octets, 160 octets, and 217 octets are considered here – the value 217 is repeated just for an easy comparison).

Table 4.6 – Number Segments for Various Display Character Size (smaller segments)

CB Data			SIB12 (14 octets of overhead assumed per segment)					
# of Display Characters		CB Data Octets	40 Octets per Segment		160 Octets per Segment		217 Octets per Segment	
GSM 7-bit	USC-2		# of Segments	Size of Last Segment	# of Segments	Size of Last Segment	# of Segments	Size of Last Segment
1 to 93	1 to 41	84	4	20	1	98	1	98
94 to 186	42 to 82	167	7	25	2	139	1	181
187 to 279	83 to 123	250	10	30	2	56	2	61
280 to 372	124 to 164	333	13	35	3	119	2	144
373 to 465	165 to 205	416	16	40	3	36	3	24
466 to 558	206 to 246	499	20	19	4	99	3	107
559 to 651	247 to 287	582	23	24	4	16	3	190
652 to 744	288 to 328	665	26	29	5	79	4	80
745 to 837	329 to 369	748	29	34	5	32	4	153
838 to 930	370 to 410	831	32	39	6	59	5	33
931 to 1023	411 to 451	914	36	18	7	122	5	116
1024 to 1116	452 to 492	997	39	23	7	39	5	199
1117 to 1209	493 to 533	1080	42	28	8	50	6	79
1210 to 1302	534 to 574	1163	45	33	8	19	6	162
1303 to 1395	575 to 615	1246	48	38	9	78	7	42

Table 4.6 shows the number of segments required to transmit various number of display characters with smaller number of bits available per SIB12 segment.

As shown in Table 4.6, if the number of displayable characters is 280 (with GSM 7-bit), then the 333 octets of CB Data, with 217 octets per segment, would need 2 segments, and with 160 octets per segment, would need 3 segments, and with 40 octets per segment, would need 13 segments.

4.2.3 Summary

The analysis shown in clause 4.2.2 illustrates that the number of segments required to transmit the display characters over the air depends on the number of bits available to the SIB12 segment. Some points to note:

- The total number of octets to be transmitted over the air will have an impact on the number of segments needed. However, the total number of octets to be transmitted over the air is determined based on the number of CB Data octets to be transmitted.
- The number of CB Data octets to be transmitted over the air is determined based on the number of CB Data Pages required.
- The number of CB Data Pages required is determined based on the number of display characters.

- But, a range of display characters end up having the same number of CB Data Pages. When the character size is at the lower end of the range, CB Data Page will carry more padded bits.

Because of the padding bits, unless an optimal number is carefully chosen, one may end up transmitting data over the air that do not carry any useful information (such as display characters).

For example, a 279 character GSM 7-bit WEA message would require 3 CB Data Pages resulting in a total of 250 octets of CB Data. But, a 280 character GSM 7-bit WEA message would require 4 CB Data Pages resulting in 333 octets of CB Data. The number 279 is at the higher end of the range 167 to 279, whereas the number 280 is at the lower end of the range 280 to 372. Therefore, there are more padded bits with 280 character WEA message as compared to a 279 character WEA message.

One cannot really have a say on how many segments are required to transmit 250 octets or 333 octets. As shown in the analysis, the number of segments required would depend on the number of bits the physical layer makes available to the SIB12. With 277 octets per segment, 250 octets of CB Data (e.g., 279 GSM 7-bit display characters) would require 1 segment, whereas 333 octets of CB Data (i.e., 280 GSM 7-bit display characters) would require 2 segments. However, with the smaller the number of bits available per segment, more segments may be required. Table 4.6 shows that with 320 bits (40 octets) per segment, a 280 character (GSM 7-bit) WEA message would require 13 SIB12 segments and a 280 character (UCS-2) message would require 23 segments. The same numbers with 1228 bits (160 octets) per segment are 3 and 4.

4.3 Transmission Delay

4.3.1 Background

In LTE, the SIB12 messages are transmitted with a CMSP defined periodicity (pre-configured at the eNB) which can take any of the following values:

- 80ms, 160 ms, 320 ms, 640 ms, 1.28 s, 2.56 s and 5.12 s.

This periodicity defines the time-difference between the two SIB12 segments. So, when a comparison is made between the time taken for the transmission of one WEA message that has one segment and the time taken for the transmission of another WEA message that has 2 segments, the latter one will have a delay of one SIB12 periodicity. For example, if the pre-configured value of SIB12 periodicity is 5.12 s (which is the maximum possible value), then a WEA message that has 2 segments would require an additional 5.12 s as compared to the WEA message that has one segment. Lower value of periodicity would reduce the delay, but could increase the battery consumption at the mobile devices.

4.3.2 Analysis

To understand the implication, the Table 4.7, Table 4.8, Table 4.9, and Table 4.10 illustrate the possible delay when the periodicity value set for SIB12 happens to be 80 ms (least), 320 ms (typical) or 5.12 ms (maximum) for various segment sizes illustrated in clause 4.2.2.

Table 4.7 – 40 Octet Segment – Transmission Delay

Display Characters		# of Segments	Additional Transmission Delay		
GSM 7-bit	UCS-2		Periodicity 80 ms	Periodicity 320 ms	Periodicity 5.12 s
1 to 93	1 to 41	4	240 ms	960 ms	15.36 s
94 to 186	42 to 82	7	480 ms	1.92 s	30.72 s
187 to 279	83 to 123	10	720 ms	2.88 s	46.08 s
280 to 372	124 to 164	13	960 ms	3.84 s	61.44 s
373 to 465	165 to 205	16	1.2 s	4.8 s	76.8 s
466 to 558	206 to 246	20	1.52 s	6.08 s	97.28 s
559 to 651	247 to 287	23	1.76 s	7.04 s	112.64 s
652 to 744	288 to 328	26	2 s	8 s	128 s
745 to 837	329 to 369	29	2.24 s	8.96 s	143.26 s
838 to 930	370 to 410	32	2.48 s	9.92 s	158.72 s
931 to 1023	411 to 451	36	2.8 s	11.2 s	179.2 s
1024 to 1116	452 to 492	39	3.04 s	12.16 s	194.56 s
1117 to 1209	493 to 533	42	3.28 s	13.12 s	209.92 s
1210 to 1302	534 to 574	45	3.52 s	14.08 s	225.28 s
1303 to 1395	575 to 615	48	3.76 s	14.04 s	240.64 s

Table 4.8 – 160 Octet Segment – Transmission Delay

Display Characters		# of Segments	Additional Transmission Delay		
GSM 7-bit	UCS-2		Periodicity 80 ms	Periodicity 320 ms	Periodicity 5.12 s
1 to 93	1 to 41	1	0	0	0
94 to 186	42 to 82	2	80 ms	320 ms	5.12 s
187 to 279	83 to 123	2	80 ms	320 ms	5.12 s
280 to 372	124 to 164	3	160 ms	640 ms	10.24 s
373 to 465	165 to 205	3	160 ms	640 ms	10.24 s
466 to 558	206 to 246	4	240 ms	960 ms	15.36 s
559 to 651	247 to 287	4	240 ms	960 ms	15.36 s
652 to 744	288 to 328	5	320 ms	1.28 s	20.48 s
745 to 837	329 to 369	5	320 ms	1.28 s	20.48 s
838 to 930	370 to 410	6	400 ms	1.6 s	25.6 s
931 to 1023	411 to 451	7	480 ms	1.92 s	30.72 s
1024 to 1116	452 to 492	7	480 ms	1.92 s	30.72 s
1117 to 1209	493 to 533	8	560 ms	2.24 s	35.84 s
1210 to 1302	534 to 574	8	560 ms	2.24 s	35.84 s
1303 to 1395	575 to 615	9	640 ms	2.56 s	40.96 s

Table 4.9 – 217 Octet Segment – Transmission Delay

Display Characters		# of Segments	Additional Transmission Delay		
GSM 7-bit	UCS-2		Periodicity 80 ms	Periodicity 320 ms	Periodicity 5.12 s
1 to 93	1 to 41	1	0	0	0
94 to 186	42 to 82	1	0	0	0
187 to 279	83 to 123	2	80 ms	320 ms	5.12 s
280 to 372	124 to 164	2	80 ms	320 ms	5.12 s
373 to 465	165 to 205	3	160 ms	640 ms	10.24 s
466 to 558	206 to 246	3	160 ms	640 ms	10.24 s
559 to 651	247 to 287	3	160 ms	640 ms	10.24 s
652 to 744	288 to 328	4	240 ms	960 ms	15.36 s
745 to 837	329 to 369	4	240 ms	960 ms	15.36 s
838 to 930	370 to 410	5	320 ms	1.28 s	20.48 s
931 to 1023	411 to 451	5	320 ms	1.28 s	20.48 s
1024 to 1116	452 to 492	5	320 ms	1.28 s	20.48 s
1117 to 1209	493 to 533	6	400 ms	1.6 s	25.6 s
1210 to 1302	534 to 574	6	400 ms	1.6 s	25.6 s
1303 to 1395	575 to 615	7	480 ms	1.92 s	30.72 s

Table 4.10 – 277 Octet Segment – Transmission Delay

Display Characters		# of Segments	Additional Transmission Delay		
GSM 7-bit	UCS-2		Periodicity 80 ms	Periodicity 320 ms	Periodicity 5.12 s
1 to 93	1 to 41	1	0	0	0
94 to 186	42 to 82	1	0	0	0
187 to 279	83 to 123	1	0	0	0
280 to 372	124 to 164	2	80 ms	320 ms	5.12 s
373 to 465	165 to 205	2	80 ms	320 ms	5.12 s
466 to 558	206 to 246	2	80 ms	320 ms	5.12 s
559 to 651	247 to 287	3	160 ms	640 ms	10.24 s
652 to 744	288 to 328	3	160 ms	640 ms	10.24 s
745 to 837	329 to 369	3	160 ms	640 ms	10.24 s
838 to 930	370 to 410	4	240 ms	960 ms	15.36 s
931 to 1023	411 to 451	4	240 ms	960 ms	15.36 s
1024 to 1116	452 to 492	4	240 ms	960 ms	15.36 s
1117 to 1209	493 to 533	5	320 ms	12.8 s	20.48 s
1210 to 1302	534 to 574	5	320 ms	12.8 s	20.48 s
1303 to 1395	575 to 615	5	320 ms	12.8 s	20.48 s

Taking 320 ms as the typical periodicity, for the transmission of a 280 character WEA message (GSM 7-bit), the tables show that a delay of about 3.84 s with 40 octet segment size, a delay of about 640 ms with 160 octet segment size, and a delay of about 320 ms with 217 and 277 octet segment sizes. These will have different values with UCS-2.

However, this is not that simple. The 3GPP TS 36.331 [Ref 3] defines the mobile device procedures in handling the SIB12 segments and the following is a pictorial representation of the pseudo-code:

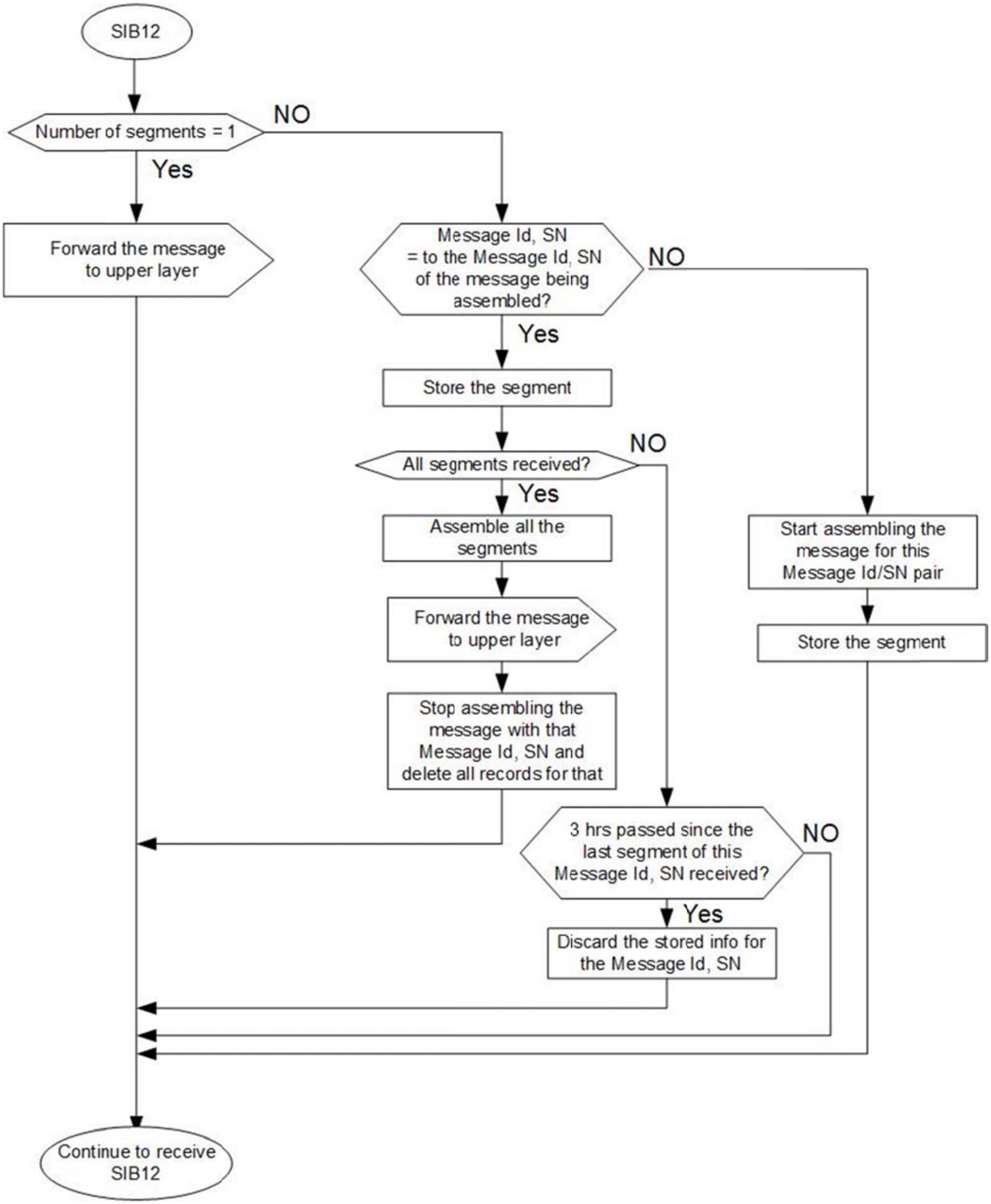

Figure 4.3 – Mobile Device Handling of SIB12 Segments Flowchart

A WEA message that has only one segment is processed as and when that segment is received. When a WEA message carries multiple segments, the mobile device will have to wait until all the segments are received. But, the flow-chart shows that while segments of one WEA message are being received, a segment of a new WEA message may come. According to 3GPP TS 36.331 [Ref 3], the segments of WEA messages are not interleaved by the eNB. But, from a mobile device perspective, the scenario will be different. For example, a mobile device may happen to receive one of the subsequent segments (not the first one) to start with – the timing actually depends when the mobile device receives the Paging command and when it reads the SIB1 that carries scheduling information for the SIB12. In other words, it is not necessary that a mobile device receives all segments at first instance of broadcasts. If a mobile device does not receive all the segments, then it will have to wait until the other segments are received. This depends on when the eNB repeats the segments of the WEA message again. Figure 4.4 below illustrates this point:

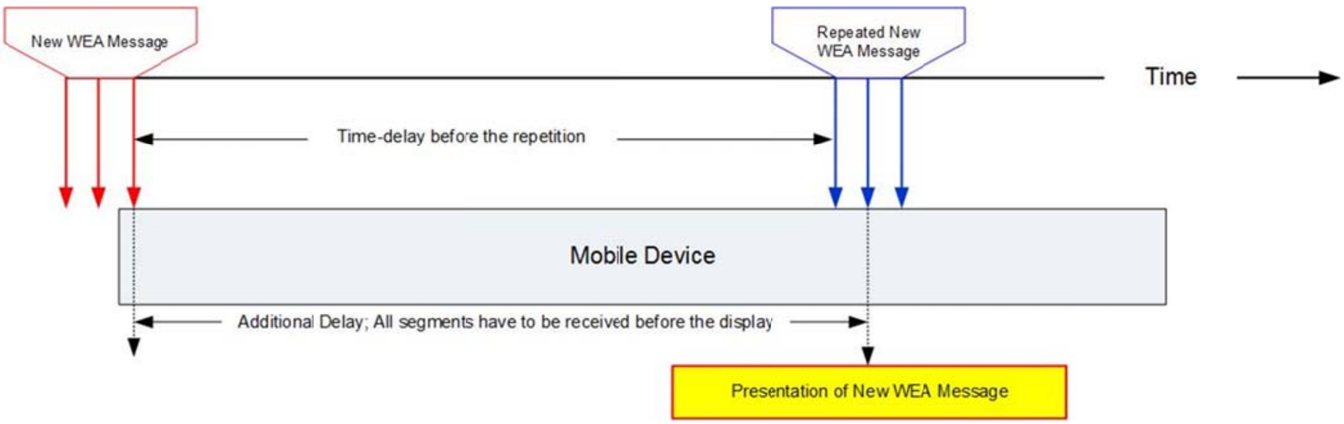

Figure 4.4 – Possible Further Delays With Multi-Segmented WEA Messages

Figure 4.4 above shows that there can be additional delays before a mobile device is ready for the presentation of new WEA message on the screen. The time-delay before the repetition is dependent on a particular implementation. For example, if the eNB repeats the message immediately after it completed the first broadcast, then the delay can be smaller. But, then number of concurrent WEA messages can interfere with such a repetition and thus add additional delay.

4.3.3 Summary

Clause 4.3.2 basically illustrates that the number of segments required to transmit a WEA message has a consequence in causing a possible delay before a mobile device can receive all the segments and present WEA message on the screen. Since the number of segments required is dependent on the carrier bandwidth and the code-rate used, the delay encountered may not be uniform among users at different regions for a given WEA message reception.

4.4 Mobile Device Screen Size

The analysis described in the previous clauses show that even though the standards allow the transmission of various sizes of WEA messages, one has to pick the optimum number for the maximum WEA message length that is technically feasible for the transmission.

However, another point to be considered is the human factor, which should take into consideration user-chosen font size and color, display size, message length, and perhaps allowing the user to see the entire message in one screen-shot. Therefore, the mobile device screen-display aspect will also contribute in determining the message length. A selection of an optimum number for the message length based on this factor is not really a technical point.

4.5 Summary of the Analysis of Maximum LTE WEA Message Length

The CB Data format of messages constructed by the CMSP may consist of up to 15 complete pages of data. Partially used pages are padded to the page boundary. As summarized in Section 4.1.3, the optimal message length from a CB Data perspective is a multiple of complete pages of 93 characters from the GSM 7-bit alphabet or 41 UCS-2 characters each.

As summarized in Section 4.2.3, the segment size can vary based on a number of deployment factors. As such, the number of SIB12 segments needed to transmit an alert message to the mobile devices cannot be uniquely identified for all deployment scenarios.

Both DCI Type 1A and 1C need to be considered. For a 20 MHz bandwidth, each SIB segment can carry 277 Octets (Type 1A) or 217 Octets (Type 1C). Transmitting the same number of octets in a smaller bandwidth (e.g., 10 MHz, 5 MHz, etc.) will require more SIB segments. Furthermore, more SIB segments will cause a delay in the reception of the alert message, or there will be a battery impact on the device if the repetition cycle is reduced (typically no less than 160 ms). Table 4.11 which is extracted from Table 4.5 in Section 4.2.2 shows the maximum message length for the cases where the number of segments is limited to 2 in case of maximum bandwidth availability.

Table 4.11 – Number Segments and CBS Pages for 2 Message Length Sizes

Message Length (GSM-7 characters)	Number of CBS Pages	Number of 1A Segments	Numbers of 1C Segments
372	4	2	2
279	3	1	2

As summarized in Section 4.3.3, the more segments that need to be transmitted the higher the likelihood of delays incurred due to the fact that the first segment that is received may not be the first segment of the message and the device will have to wait till the first segment is repeated.

So, based on this technical analysis, ATIS recommends the maximum WEA text message length to be fewer than 372 GSM-7 characters for the following considerations:

- Readability
- Mobile device battery consumption
- Delay in reception of the message

5 Conclusions & Recommendations

5.1 Conclusion

The data structure of alert messages constructed by the alert originator and broadcasted by the CMSP network infrastructure, the segmentation of WEA alert messages over the air interface, and the readability of the WEA alert message on the screen of the mobile device are considered in this study.

As discussed, there is a direct relationship between the WEA message length, potential transmission delay, and the mobile device power consumption. As the message length increases, CMSP network may require additional segments to transmit the WEA alert message. The mobile device has to receive all the segments in order to present the WEA message to the user, which could introduce delays. The system can change the broadcast periodicity to reduce the delay, but that will negatively impact the battery life of the mobile device. Maintaining battery life is critical in disaster situations where the user may not have commercial power to recharge their mobile device. This chain of events can be summarized as follows:

Large message length → more segments → delay in reception of the WEA alert and/or impact on battery life

Furthermore, to broadcast WEA messages, the CMSP infrastructure is using a mechanism that was designed to transmit critical system information required to support voice and data services for users on the system, and not user data. If this critical system resource is overused, there may be potential negative impact on the overall system operation. This potential negative impact could happen at a time when there is a critical event and the cellular system needs to be fully available and operational.

User comprehension of the critical information requires the message to contain all relevant information, but should not require the reader to scroll through too many screens [Ref 5]. This will limit the messages length as well.

However, providing pertinent information to the user in a timely fashion is also very important and must be balanced against the system impacts. Consequently, ATIS strived to find a maximum WEA message length that has a manageable impact on the CMSP network and system operation, has the capability to be broadcast in a reasonable amount of time given the best effort nature of WEA, and provides sufficient information as a “bell ringer” alert service for which it is designed.

5.2 Recommendation

Based on the technical analysis of this feasibility study and considering all factors, ATIS recommends a maximum WEA message length of 360 displayable characters of displayable text based upon the GSM 7-bit alphabet.

This recommendation is based solely on increasing the maximum English language WEA message length processed by a participating CMS provider per FCC rules [47 CFR 10.430]. If additional WEA enhancements are considered[5] such as additional languages, additional information (e.g., map information, polygon, etc.), then the maximum 360 displayable characters will be re-evaluated in conjunction with these additional enhancements and may result in a decrease due to the impacts of any WEA enhancements.

Note that changes to the maximum WEA message length will require modifications to the FCC rules. Once the rule changes are made, the industry will undertake standards changes to ATIS and 3GPP standards, modifications to the “C” interface between the FEMA IPAWS Federal Alert Gateway and the CMSP Gateway, and modifications to CMSP infrastructure and mobile devices. Backwards compatibility with the existing 90-character limit will have to be maintained. In addition, the Alert Originator policies and equipment will need to support the maximum length change.

[5] Additional enhancements are described in the FCC CSRIC IV Working Group 4 Report [Ref 1].