EENA Case Study Document

Advanced Mobile Location (AML) in the UK

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Table of contents

1 Executive Summary

Accurate location information is one of, if not, the most important pieces of information that an emergency call-taker needs. It is used on many levels such as the routing of the call to the most appropriate Public Safety Answering Point (PSAP) and for deciding which emergency resource is dispatched, the quickest route to get to the incident and so forth. The outcome for the citizen is fundamentally improved when the location information is accurate and timely.

Despite the existence of legislation to mandate accuracy and reliability targets, no Member State in Europe has set any. In the absence of this, the UK Stage 1 PSAP operator, BT, along with its partners EE (Mobile Network Operator) and HTC (handset manufacturer) in the UK, set out a project to resolve the impasse by designing and implementing its own solution. The project is known as the AML (Advanced Mobile Location) project and it uses existing technologies with an already available SMS solution to transport the information from the handset to the BT PSAP and match it with the voice call based on the Calling Line Identity (CLI) details.

At the time of writing this document (January 2015), BT was handling approximately 1000 emergency calls per week using this solution, improving accuracy levels by over 4000 times. The solution doesn't ignore the cell-id information that already existed but rather supplements it with either GPS information or Wifi information taken from the handset.

GPS information is received in approximately 45%-50% of cases with Wifi/Cell information received in about 40%-45% of cases. In terms of accuracy improvements, BT estimates that the accuracy level is approximately 50 metres in 90% of cases with the accuracy typically down to 5-10 meters. Because the GPS and Wifi information is always compared with the network information, there are very few cases where the information is inconsistent providing a stable and reliable source of information.

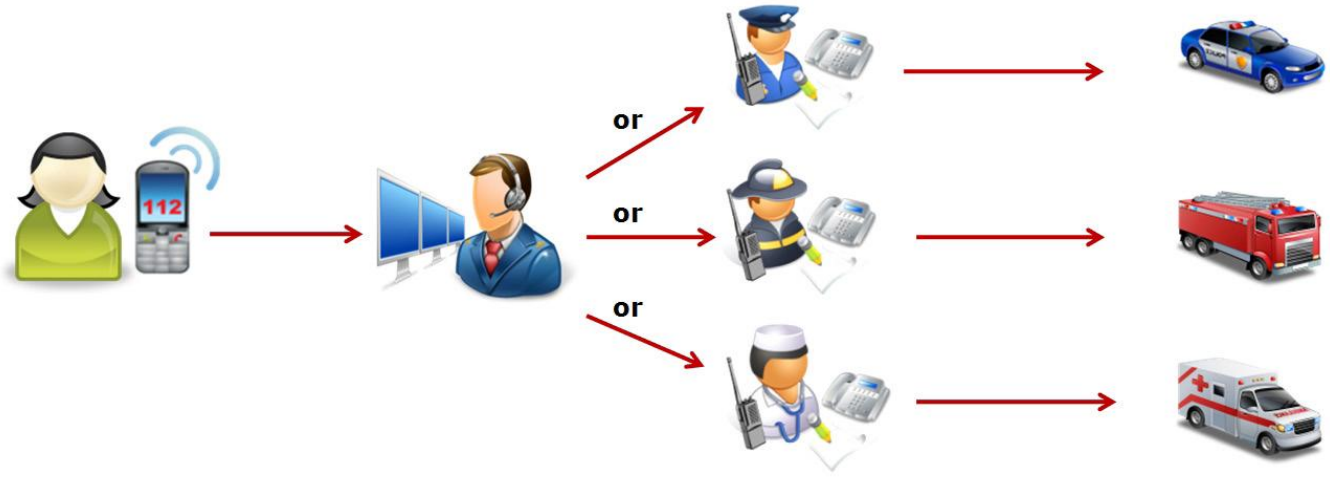
No major capital investment was needed by either EE or HTC or by the emergency services themselves or by the citizen but the impact has been significant.

Surely this is an example to us all where existing technologies are re-used to help resolve the current location information deficit, at least in the short term.

2 Introduction

This case study document provides information about BT's Advanced Mobile Location (AML) system, which has been developed through discussion with the Mobile Networks operating in the UK. AML is a 'value add' service that enhances BT's core 999/112 call handling product.

The UK uses a two-stage (PSAP) model. In the two-stage model, a 999 or 112 caller will speak to the stage 1 PSAP, in this case a BT 999 Advisor, who will manage the call until it is handed over to the requested stage 2 PSAP, a Fire, Police, Ambulance or Coast Guard Call-taker. The figure below outlines the call flow in the UK.



[Source: EENA]
One of the biggest challenges facing the Emergency Services is determining the location of mobile callers. Since 2003 cell based location has been available to the Emergency Services via BT's EISEC (Enhanced Information System for Emergency Calls) Service. Whilst cell data can help with verbal establishment of a caller's location, a more precise location will allow an even quicker response to emergencies. Ambulance Service measurements show that on average 30 seconds per call can be saved, and several minutes can be saved where callers are unable to verbally describe their location to stress, injury, language or simple unfamiliarity with an area. Further it is estimated that each year there are about 36,000 cases in the UK where the Emergency Services have to spend a significant amount of time searching for an incident because precise location information could not be provided.

The purpose of the AML project is to use the native and existing smart phone technology to pass GPS or Wifi based location data to the Emergency Services. These technologies can provide a location precision as good as 5 meters (and averaging to within ~25m circular areas), a significant improvement on existing cell coverage, which on average across the UK is within 1.75km radius circular areas.

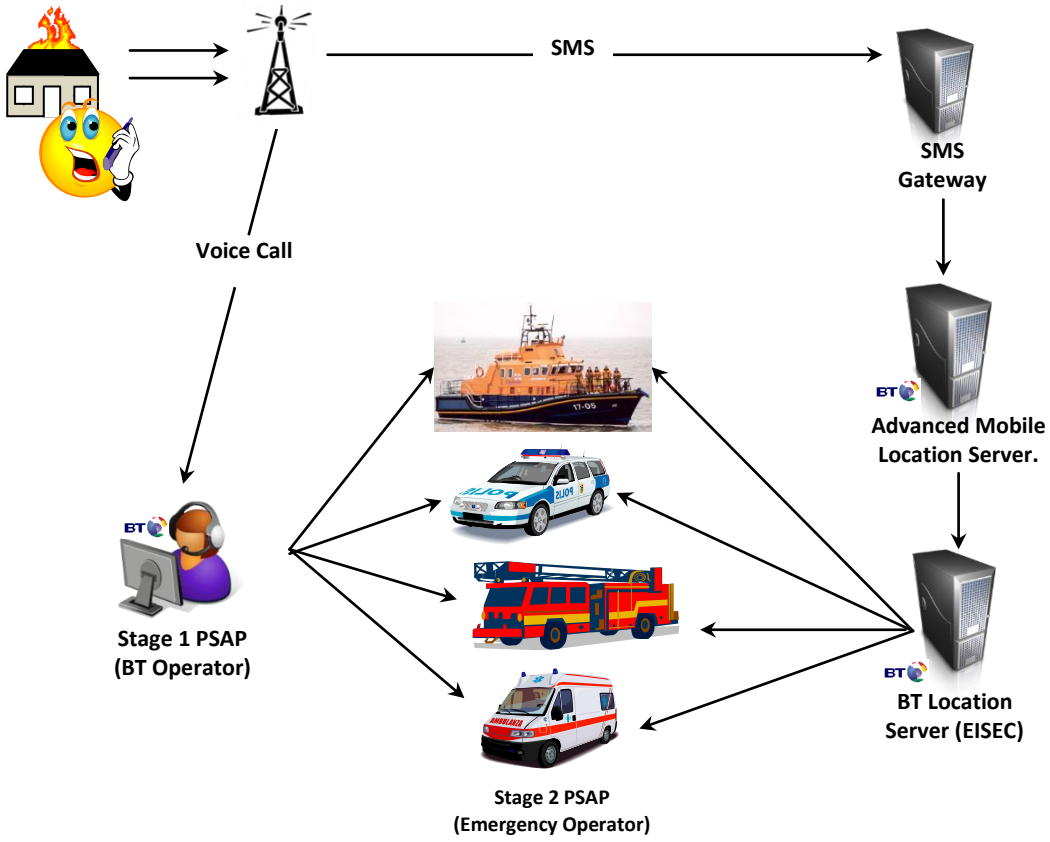
The AML functionality is an enhancement of the standard GSM voice emergency service, i.e. with some acknowledgement of limitations in GPS or Wifi availability and time to acquire location of GPS particularly for positioning inside buildings, in between tall buildings, etc.
Handset locations obtained through the AML functionality are be compared to the location provided by mobile networks (using cell coverage information), using an algorithm that analyses factors such as time of positioning and the separation of the two locations.

3 System overview

The objective of the AML product is to produce a simple, cost effective solution to the mobile location problem. Once the mobile handset knows its location it is sent to BT using a simple, already available, Short Message Service (SMS) based protocol (which gives 160 characters of data). SMS offers the best geographic coverage, especially in remote areas, and additionally in the UK, SMS messages sent to 999 are not charged due to zero rate billing.

As an important development consideration, AML was designed so that it does not interfere with the voice call so if this solution is replicated in other EU countries, developers should confirm that both the handset and mobile network can simultaneous support a standard GSM emergency voice call GPS/Wifi location and SMS transmission to the PSAP over the GSM network.

The data path for AML data is shown below.



[Source: BT]

4 System overview Handset software considerations

There were several issues considered when developing the AML handset software.

4.1 Process automation

The software must be integrated into all existing emergency call mechanisms available on the handset including manual dial of 999 /112 or use of the Emergency Call button (as appropriate).

In an emergency callers are often stressed or panicking so it was important that the AML functionality and transmission of the SMS message is automatically triggered without any manual intervention by the user. The handset software must be invisible to the user so as not to confuse them when they are trying to get help. BT also decided that no record of the SMS message should be available to the user either during or after the emergency call. It was also decided that the SMS message must be sent to 999 (if replicated in other EU countries, then the most appropriate emergency number should be used) irrespective of the method used to instantiate the emergency call.

Finally, it was decided that no new ways of accessing the Emergency Services should be introduced as part of this development.

4.2 Battery life

When a caller initiates an emergency call it is essential that the voice call is protected even at the expense of location data. The BT solution first checks the mobile handset battery strength before switching on any devices with a high battery current drain, example.g. GPS or Wifi. Because the safety threshold for battery life will vary between handsets, BT did not recommend a minimum percentage; the handset manufacturer will be best able to give this type of advice.

If battery life is a barrier to using GPS or Wifi location methods, the AML solution decrees that a cell based method, which does not involve high drain devices, should be used. BT already receives cell based location directly from the MNOs, however cell data from handsets can sometimes return a smaller area.

4.3 Calls from abroad - AML does not function

The AML functionality is currently only included in handsets that are sold in the UK, although this may clearly change in the future. If an emergency call is initiated when a UK handset has roamed/camped on a non UK Network BT has advised that the handset should not run the AML location functionality as any voice call or SMS will not be routed to BT. This is also the case when a non-UK handset roams/camps on the EE network in the UK (At the time of writing, EE is the only UK MNO supporting the AML solution but others are expected to follow shortly).

4.4 Positioning method

GPS normally offers the best location information but is slower than other methods. At the other end of the spectrum cell based location is quick but typically returns a large location area. The general rule is that BT needs the best data as long as it doesn't take too long to determine so a 'send us what you have now' timeout was introduced.

BT concluded that it is good practice to make timeouts configurable so here we will refer to T1 as the timeout period. BT decided that if possible this timeout should be changeable with an 'over the air' update and as it currently stands, BT uses and recommends a T1 timeout period of 20 seconds.

As soon as the emergency call is initiated the handset should switch the following on (if not already switched on):

- GPS (subject to a battery check).
- Wifi (subject to a battery check).
- Mobile Data[1] (optional) for AGPS data and to translate Wifi or Cell IDs to a location.

In the AML, the handset immediately attempts to determine location via all methods in parallel, so as not to delay transmission of location after the T1 timeout.

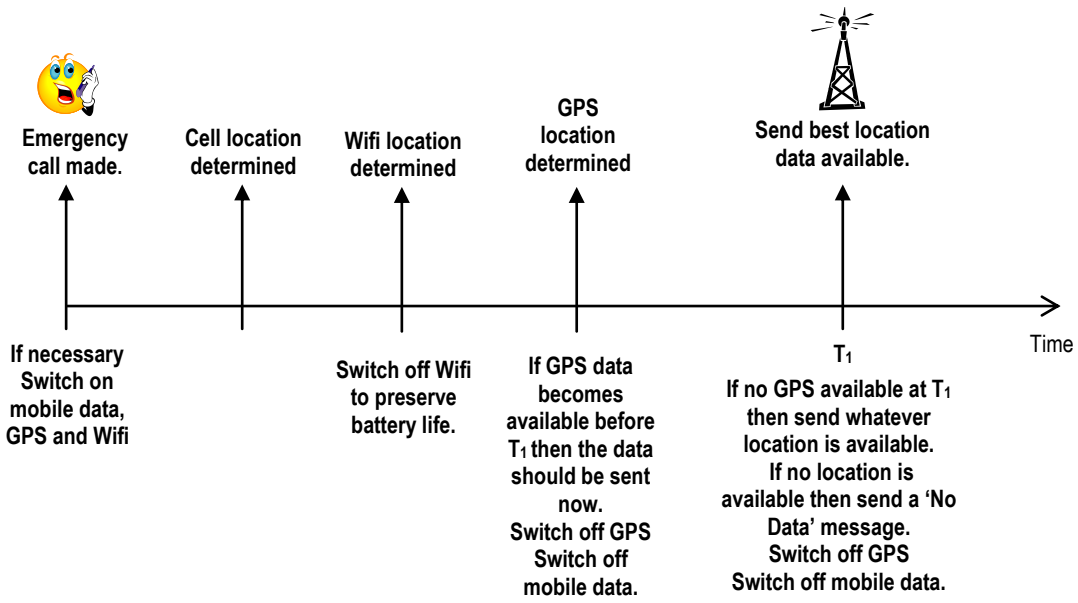
If GPS data becomes available before T1 seconds then that data is sent to BT without waiting for the timeout. If after T1 seconds no GPS data is available but location is available based on Wifi signals then the Wifi location is sent to BT.

If no Wifi based location is available then the cell ID based location data is sent to BT.

If Mobile Data, GPS or Wifi was switched on when the emergency call was initiated, then it should be then switched off as soon as it is no longer needed.

If it's not been possible to get a location from any method then an SMS is be sent to BT indicating that all positioning methods have failed (see section 4.7).

The following timeline shows the process.

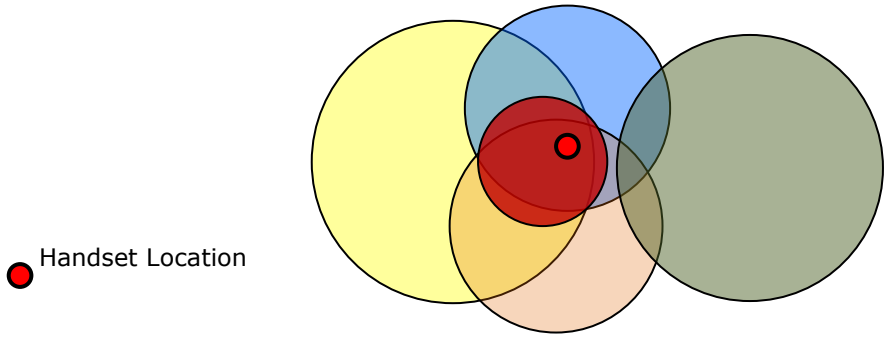


[Source:BT]

When Wifi or Cell IDs are used to determine location, BT has stated that the handset should try to minimise the location area by using as much information as possible. Some 'Wifi to location' APIs require that multiple Wifi MAC addresses be supplied. This is important as it can eliminate situations where an incorrect location is given because a Wifi router has been moved and its location has not been updated on the location server.

[1] BT suggests this as an optional requirement. In some cases switching mobile data on will cause the end user to incur charges, developers should confirm with the relevant Mobile Network Operator whether this is to be implemented.

BT has recommended that this approach should be adopted for all AML locations based on Wifi and that similarly, multiple cell identifiers should be used to generate a smaller location circle by identifying the overlap areas for cells (red circle below).



4.5 Limited service state

If an emergency call is attempted when a mobile has no home network coverage then the voice call may be routed to BT via another mobile network; in the UK this is known as a Limited Service State (LSS) emergency call.
In such cases BT has decided that the AML location process should still function and an SMS message be created. If it is not possible to send the SMS due to the LSS state then the message should be stored on the handset and transmission retried every 30 seconds. If after 30 seconds the handset has not been able to transmit the SMS message, BT has recommended that no further attempt should be made to transmit the SMS and it should be discarded.

4.6 Repeat 999/112 voice calls

The BT systems can handle multiple SMS messages from the same handset. If the caller makes a repeat 999/112 voice call within the T1 period and the handset is still trying to determine location, BT has determined that the handset should then continue based on the original call trigger. If the repeat call is made after location has been determined and the SMS sent or queued then the handset should restart the location determination process.

4.7 'No location data' procedure

There are a few circumstances when the handset will be unable to determine its location. When this happens BT has decided that a 'no data' SMS message should be sent to BT. This is an important message as it allows BT to tell the Emergency Services that location must be established by other means up to and including the dispatch of additional search vehicles.

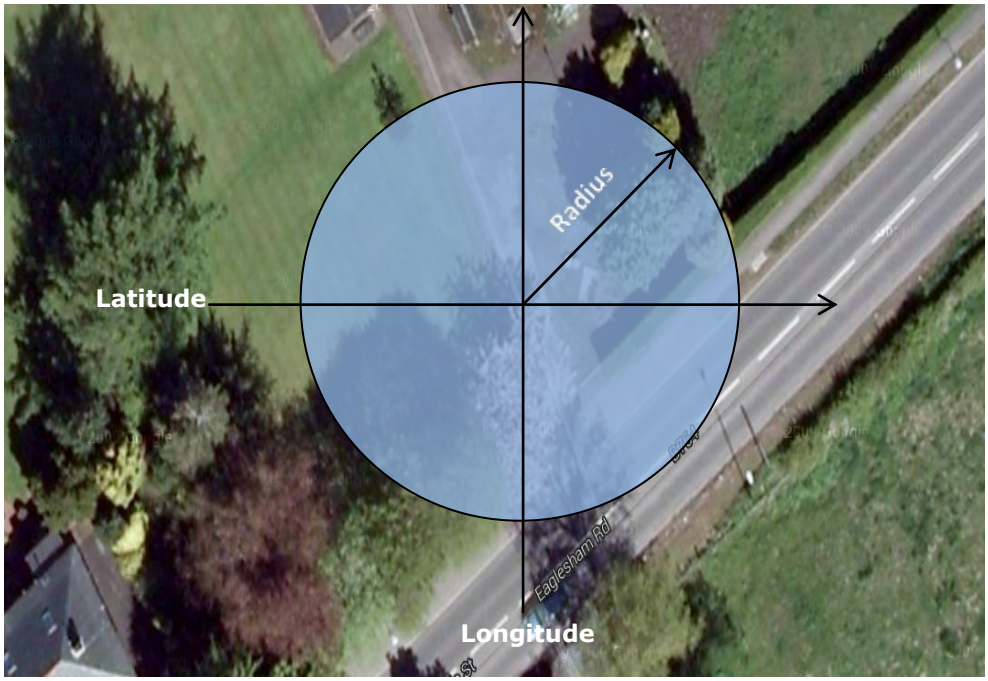
The contents of this 'no data' SMS is detailed in sections 5.1&5.2.2.

5 System overview

The interface is designed to communicate a single location in the form of a circle. Some additional information is also sent with the location. The location and size of the circle is communicated using a WGS84[2] latitude/longitude measured in decimal degrees and a radius measurement in metres.

There are several different co-ordinate systems used by the UK Emergency Services, however because BT already converts WGS84 to the co-ordinate systems preferred by each Emergency Service, the handset should always communicate location using WGS84 decimal degrees. To save space in the SMS message an accuracy of no more than 5 decimal degrees is required which will equate to 1.1 metre accuracy on the ground.

Location technologies all have a margin of error caused by various factors such as terrain, buildings or weather conditions. Communicating this margin of error is done by specifying a Level of Confidence (LoC) figure. A LoC is a percentage figure that describes the probability that the caller is within the location area described by the latitude, longitude and radius figures.



[Source: BT]

BT has also concluded that a Time of Positioning (TOP) must also be sent with the location data. The TOP must use Greenwich Mean Time (UTC) for the UK. The accuracy of this date and time is important as BT filters out any messages that appear to be too old or have a time in the future. BT has stated that the handset should first attempt to use an (Network Time Protocol) NTP server to establish the time and this should be possible if a network connection is available. If NTP is not available then GPS can be used to give time.
BT has decided that only if these two methods fail, then, as a last resort, the handset time and date can be used.

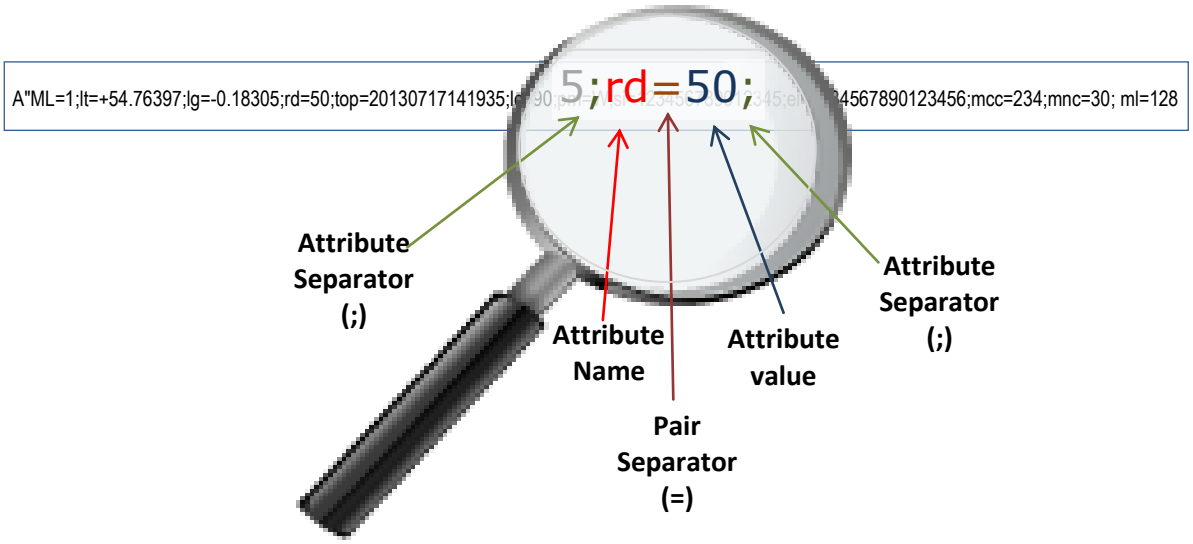
The AML interface protocol consists of a series of message attributes separated by a semi colon (;) character

[2] World Geodetic System

without spaces. Each attribute consists of a name/value pair where names and values are separated by an equals (=) character again without any spaces.

BT has stated that a header record must always appear at the start of the SMS, this is important as the Header will be used to route the SMS to the 999 AML system. A message length attribute must always be the last attribute in the SMS message.

The diagram below gives an example of the SMS message used in the AML solution.



[Source: BT]

BT has specified that more important attributes (latitude, longitude, radius) will appear at the beginning of the SMS with less important towards the end. The following table gives a detailed description of each attribute with the ordering of attributes in the table below also how they should appear in the SMS.

5.1 Attributable definitions

BT has decided that unless explicitly stated in the description data, values should not include white space or zero padded values. Data should be passed using the ASCII[3] standard character set only.

Attribute	Attribute Name	Attribute Size (chars)			Attribute Description
		Name	Value (Max)	Total incl '='	
Header	A"ML	4	3	8	The header must appear at the beginning of the SMS message as it's used to differentiate AML messages from other 999 related SMS messages The header must be in upper case and have a double quotes character (") in the character 2 position. The attribute value will indicate the interface version number. This is version 1 of the interface. No left padding with zeros is required. The field is a maximum of three characters allowing 999 iterations of the interface if required. An example of the Header would be **A"ML=1;**lt=…

[3] American Standard Code for Information Exchange II

Attribute	Attribute Name	Attribute Size (chars)			Attribute Description
		Name	Value (Max)	Total incl '='	
Latitude	lt	2	9	12	The WGS84 latitude and longitude of the centre of the location area given in decimal degrees up to 5 decimal places giving resolution to 1.1 metres.
Longitude	lg	2	10	13	The format of the attribute value will be <sign><decimal degrees>where: **<sign>** This can either be a + or -. For latitude values in the UK the sign will always be positive. For longitude a '-' indicates a location to the west of the meridian and a '+' indicates a position to the east of the meridian. If no sign is present then a '+' will be assumed as default. **<degrees>** This is a numeric value representing the latitude or longitude in terms of decimal degrees relative to the equator or meridian. This field consists of numeric and a single decimal point character (.) Latitude values fall in the range of +/-90 degrees (2 digits before the decimal point) character, whereas Longitudes fall in the range +/-180 degrees (3 digits), therefore Latitude is one character less than Longitude. Examples of the latitude and longitude are given below. AML=1**;lt=+55.74317;lg=-4.26881;**rd=… If it is not possible to determine a location the SMS should still be sent to BT with latitude and longitude set to +00.00000(lat), +000.00000 (long) and positioning method set to N.

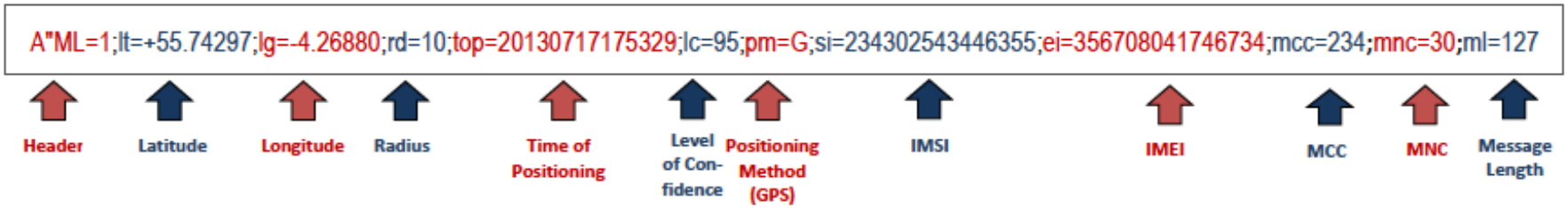
Attribute	Attribute Name	Attribute Size (chars)			Attribute Description
		Name	Value (Max)	Total incl '='	
Radius	rd	2	5	8	The radius of the location area in metres. This field is all numeric. An example of a radius attribute is given below …576**;rd=50;**top=… If it is not possible to determine a location the SMS should still be sent to BT with a radius set to 'N' and a positioning method set to 'N'.
Time of Positioning (TOP)	top	3	14	18	The date and time that the handset determined the location area specified in GMT (UTC). This must be the time that location was determined and no other time. The field format is YYYYMMDDhhmmss Where: **YYYY** is the year. **MM** is the month in the range 01 to 12. **DD** is the month in the range 01 to 31 **hh** is the hour in the range 00 to 23 **mm** is the minute in the range 00 to 59 **ss** is the second in the range 00 to 59. An example of a Time of Position attribute is shown below: ……**;top=20130717175329;**…… When the handset is unable to determine its location the TOP should be the date and time that the location process was deemed to have failed.

Attribute	Attribute Name	Attribute Size (chars)			Attribute Description
		Name	Value (Max)	Total incl '='	
Level of Confidence (LOC)	lc	2	2	5	It is recognised that methods for determining mobile handset location are not infallible. Terrain and weather conditions introduce a margin of error into location calculations. Different methods will have different error factors that need to be communicated to the Emergency Services. The Level of Confidence is a percentage probability that the mobile handset is within the area being communicated, for example a 95% value tells the Emergency Services that there is a 5% probability that the caller is not within the location area specified by the lat, long and radius values. It is assumed that we will never have 100% certainty hence the two character field. An example of a Level of Confidence (LOC) message is shown below: ….=50**;lc=95;**pm=…. If it is not possible to determine the location the SMS should still be sent to BT with a level of confidence set to 0 (zero).
Positioning Method	pm	2	1	4	The method used to determine the location area. A single upper case character that can be one of: **G** - GPS. **W** - Wifi signal **C** – Cell **N** – It has not been possible to determine the location. An example of a Positioning Method attribute is shown below: ….lc=95**;pm=G;**si=…..

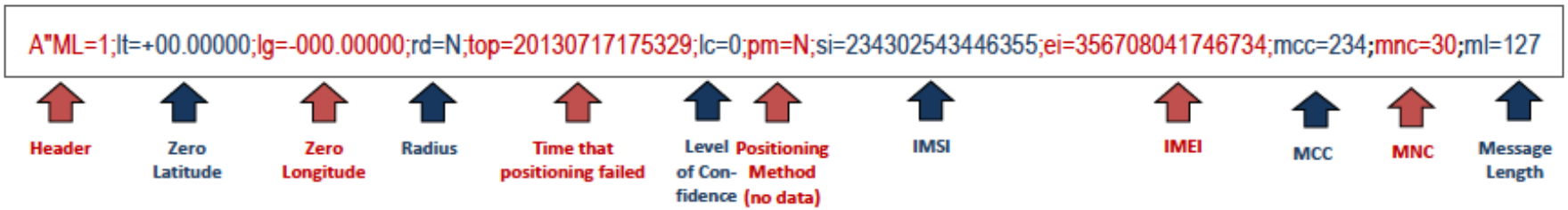
Attribute	Attribute Name	Attribute Size (chars)			Attribute Description
		Name	Value (Max)	Total incl '='	
International mobile subscriber identity (IMSI)	si	2	15	18	The SIM card identifier of the handset that has made the emergency call. ….=G**;si=234302543446355;**ei=….
International mobile equipment identity (IMEI)	ei	2	16	19	The identifier of the handset that made the emergency call. …55**;ei=356708041746734;**ml…
MCC	mcc	3	3	7	Mobile Country Code, used to determine the network country that the emergency call was made on. …..34**;mcc=234;**mnc…..
MNC	mnc	3	2	6	Mobile Network Code, used to determine the mobile network used to make the emergency call. In most cases this will be the home network MNC but in some cases will be another network code. **It is important that this field is filled in correctly as BT will use this to identify data relating to Limited Service State (LSS) calls.** ...234**;mnc=30;**ml=…..
Message Length	ml	2	3	6	The length of the entire SMS message including the header and the length attribute. The message length name should be in lower case and the value should be all numeric. An example of the message length message would be ……**;ml=124**

5.2 Example AML messages

5.2.1 GPS based location SMS message



5.2.2 Unable to Determine Location AML Message.



6 Results to date

At the time of writing, BT has advised EENA that it is currently handling 1000 emergency calls per week that avail of the AML technology. These calls originate solely from the EE network and use HTC handsets. The O2 network in the UK will also be handing the AML solution shortly.

From the 1000 emergency calls, approximately 10% of calls are presented with no additional caller location information. 40-45% of the emergency calls use Wi-Fi location information ad 45-50% use GPS location information. In 90% of cases accuracy location is approximately within 50meters and usually it is between 5-10 meters. Because the Wi-Fi and GPS location data is always compared with network location, the data is practically always consistent and with high levels of confidence. Because this information is always matched with the network location (Cell-ID), there is an increased level of assurance that the information is reliable, resulting in the mitigation of any risks and liability.

7 Glossary of terms

AML	**Advanced Mobile Location.** BT's SMS based location service for emergency calls and the subject of this document.
EISEC	**Enhanced Information System for Emergency Calls.** A BT service used to electronically pass location data to the emergency services when an emergency call is received by BT.
LSS	**Limited Service State.** When a mobile phone in unable to communicate with its home mobile network but does have a signal from another mobile network it enters a limited service state which allows emergency calls to be made.

8 Conclusions

EENA welcomes this initiative in the UK and applauds BT, EE and HTC for their solution. It serves to prove that the improvement of location information for emergency calls is not technically difficulty or costly to implement. It also serves to prove that with collaboration, solutions even if in the short-term can be found. Long-term solutions need to found also but this first step is to be recognised and hopefully will inspire other emergency services, Government officials, MNOs and handset manufacturers to follow suit.