EENA Recommendation on emergency caller location information criteria for mobile-originated emergency communications

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Executive Summary

This document provides guidance to EU/EEA Member States on the setting of parameters for laying down criteria for the accuracy and reliability of emergency caller location information for mobile-originated emergency communications in accordance with EU legislation[1,2].

- "Accuracy" is expressed in metres and indicates the maximum radius of the horizontal search area and, if applicable, the vertical search area that is presented to the emergency services for intervention purposes.
- "Reliability" is the success rate, expressed as a percentage, of the technical solution or mix of technical solutions to establish and transmit, to the most appropriate PSAP, a search area corresponding to the accuracy criterion.

EENA recommends that Member States should:

- Lay down an initial set of criteria for the accuracy and reliability of caller location information that requires a horizontal accuracy estimate of **50m** for **80%** of all mobile-originated emergency communications. These criteria should be met through the combined use of network-based and handset-derived caller location information technologies in line with the provisions of Directive (EU) 2018/1972 as supplemented by Commission Delegated Regulation (EU) 2023/444.
- Set a subsequent date, beyond the reporting deadline of 5 March 2024, to allow stakeholders an appropriate timeframe to achieve compliance.
- Review the criteria on a periodic basis taking into account ongoing developments in technology.
- Ensure that all handset-derived location accuracy estimates are accepted by PSAPs independently of the confidence factor provided[3].

These recommendations are based on:

- An analysis of the accuracy and reliability criteria implemented in other countries around the world.
- An analysis of statistics provided by European PSAPs on the accuracy of location information derived from mobile-originated emergency communications in their respective jurisdictions for the period 01/01/2022 to 31/12/2022.

[1] Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast)Text with EEA relevance ('The European Electronic Communications Code').
[2] Commission Delegated Regulation (EU) 2023/444 of 16 December 2022 supplementing Directive (EU) 2018/1972 of the European Parliament and of the Council with measures to ensure effective access to emergency services through emergency communications to the single European emergency number '112' ('The Delegated Regulation').
[3] To help PSAPs understand how to interpret any given position estimate from a handset, it is delivered with an uncertainty factor and a confidence factor. Please read section 4.2 of this document to understand the basis for this recommendation.

- Inputs from key stakeholders on the capabilities of smartphones to establish accurate and reliable caller location information and on networks/services to transmit caller location information.

EENA considers that the recommendations made herein are technically feasible, evidence-based, and achievable in practice.

Definitions of Terms & Acronyms

Term/Acronym	Definition
5G NR	5G New Radio
A-GNSS	Assisted Global Navigation Satellite Systems
AML	Advanced Mobile Location
BEREC	Body of Regulators for Electronic Communications
CAD	Computer Aided Dispatch
Caller Location Information	Article 2(40) EECC: 'caller location information' means, in a public mobile network, the data processed, derived from network infrastructure or handsets, indicating the geographic position of an end-user's mobile terminal equipment, and, in a public fixed network, the data about the physical address of the network termination point.
Commercial Mobile Radio Service Provider (CMRS)	A regulatory classification for mobile phone services in the U.S. created by the Federal Communications Commissions in 1993. It governs cellular, specialised mobile radio (SMR), enhances specialised mobile radio (ESMR) and personal communications services (PCS) communication under a single regulatory umbrella. Under the law, mobile services are regulated as common carriers if they wish to deliver services to the general public.
Cell-ID	Cell Identification
CSFB	Circuit Switched Fall Back
E-CID	Enhanced Cell Identification
EECC	European Electronic Communications Code
EU	European Union
EEA	European Economic Area
FLP	Fused Location Provider
GIS	Geographical Information Systems
GNSS	Global Navigation Satellite Systems
HLOS	High Level Operating System
HELO	Hybridized Emergency Location
IMS	IP Multimedia Subsystem
LSS	Limited Service State
LTE	Long Term Evolution
MSISDN	Mobile Station International Subscriber Directory Number
ODTOA	Observed Time Difference of Arrival
OEM	Original Equipment Manufacturer
PIDF-LO	Presence Information Data Format – Location Object
Public Safety answering Point (PSAP)	Public Safety Answering Point or 'PSAP' means a physical location where an emergency communication is first received under the responsibility of a public authority or a private organisation recognised by the Member State (EECC Article 2(36))
RTT	Round Trip Time
SIP	Session Initiation Protocol
SMS	Short Message Service
VoLTE	Voice over LTE
VoNR	Voice over New Radio
VoWi-Fi	Voice over Wi-Fi

1. Introduction

1.1 Purpose & Scope

The purpose of this document is to provide guidance to EU/EEA Member States on the setting of parameters for laying down criteria for the accuracy and reliability of emergency caller location information for mobile-originated emergency communications in accordance with EU legislation.

- "Accuracy" is expressed in metres and indicates the maximum radius of the horizontal search area and, if applicable, the vertical search area that is presented to the emergency services for intervention purposes.
- "Reliability" is the success rate, expressed as a percentage, of the technical solution or mix of technical solutions to establish and transmit, to the most appropriate PSAP, a search area corresponding to the accuracy criterion.

The document analyses the capability to establish and transmit caller location information for mobile-originated emergency communications derived from handsets (i.e. smartphones). The document does not analyse the establishment and transmission of network-based location but EENA acknowledges the continued importance of network-based location information and the network's critical role in transmitting handset-derived caller location information to PSAPs. Moreover, the provision of network-based emergency caller location information remains a mandatory requirement and it is a key input in the calculation of handset-derived location.

The recommendations made in this document are limited to the laying down of horizontal accuracy criteria and reliability criteria. EENA considers that criteria for vertical location should be considered at some point in the future as part of a periodic review of the initial criteria laid down as more work needs to be done to make vertical location available in a meaningful and useable way by PSAPs.

The laying down of caller location criteria will result in the imposition of regulatory obligations on certain stakeholders at Member State level, mainly electronic communications networks and providers of number-based electronic communications services. Under the EECC and supplementing Delegated Regulation, there is no competence for Member States to impose additional obligations on handset providers.

Establishing caller location information and making it available for transmission to the most appropriate PSAP is the responsibility of the handset. The crucial aspect[4] that is dependent on the network for handset-derived location is the transmission mechanism which in turn affects the reliability of the caller location and this is an area that requires attention.

[4] To be complete there is a role in networks providing network access to facilitate the updating of handset operating system versions to, amongst other things, improve the speed and accuracy of location estimates, although this needs only to be intermittent access.

The document makes recommendations for the setting of parameters for the laying down of caller location criteria based on:

- An analysis of the accuracy and reliability criteria implemented in other countries;
- An analysis of statistics provided by European PSAPs on the accuracy of location information derived from mobile-originated emergency communications in their respective jurisdictions for the period 01/01/2022 to 31/12/2022; and
- Inputs from key stakeholders on the capabilities of smartphones to establish accurate and reliable caller location information and on networks/services to transmit caller location information.

This approach aims to provide as much information as possible to the Member State competent regulatory authorities to ensure that the parameters laid down in the location criteria are technically feasible, evidence-based and achieveable in practice.

The document does not make recommendations on how the criteria should be enforced. This is a matter for the national competent authorities. Member States should collaborate and exchange information on criteria they are considering and on best practices and experiences to find the most appropriate approaches. EENA considers that BEREC, whose members regulate electronic communications network and service providers at Member State level, have an important consultative role to play in this process.

1.2 Regulatory Background

Article 109(6) of the European Electronic Communications Code (EECC)[5] requires Member States to ensure that caller location information is made available to the most appropriate PSAP without delay after the emergency communication is set up. This shall include location information derived from the network conveying an emergency communication and, where available, from the handset originating an emergency communication.

To ensure that location information is useful enough to assist emergency response teams to effectively intervene in an emergency incident, the Member States are also required, if necessary after consultation with BEREC, to lay down criteria for the accuracy and reliability of the caller location information provided. These criteria shall represent the minimum requirements for accuracy and reliability.

On 16 December 2022, the European Commission (EC) adopted a Delegated Regulation[6] supplementing the requirements of EECC Article 109 by setting out

[5] Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast)Text with EEA relevance ('The European Electronic Communications Code').

[6] Commission Delegated Regulation (EU) 2023/444 of 16 December 2022 supplementing Directive (EU) 2018/1972 of the European Parliament and of the Council with measures to ensure effective access to emergency services through emergency communications to the single European emergency number '112' ('The Delegated Regulation').

parameters that the Member States shall take into account when laying down such criteria. Member States are required to report to the EC by 5 March 2024 on the criteria expressed according to the parameters referred to in Article 3 of the Delegated Regulation.

Article 3 states that:

- The accuracy criterion for mobile networks *"shall be expressed in metres to indicate the maximum radius of the horizontal search area that is presented to the emergency services for intervention purposes, including if applicable, the elevation or vertical accuracy"*.

- The reliability criterion for mobile networks *"shall be expressed as the success rate, in percentage, of the technical solution or mix of technical solutions to establish and transmit to the most appropriate PSAP a search area corresponding to the accuracy criterion"* (emphasis added).

Recital 7 of the Delegated Regulation also refers to relevant case law of the European Court of Justice[7]. The ruling of the Court explains that the criteria set should ensure that the end-user's estimated location is as accurate and as reliable as is necessary to enable the emergency services to *usefully* come to the end-user's assistance. The recital also emphasises the importance of having network-based location always available. If handset-derived location cannot be made available to the most appropriate PSAP, emergency services can rely on network-based location to *usefully* come to the end-user's assistance. "Usefulness" in this context has a direct correlation with "accuracy". The usefulness of caller location information might vary depending on the area from which the emergency communication is originated (e.g. urban or rural) and this could be reflected accordingly in the criteria set.

All smartphones sold on the EU single market must be able to provide handset-derived emergency caller location information. The features that enable it to receive, process and make available for transmission the data from GNSS and Wi-Fi is mandated in EU law through EC Delegated Regulation (EU) 2019/320[8]. The EC has issued guidelines[9] to support the Notified Bodies in charge of radio equipment compliance assessment in applying a consistent approach related to the requirements stemming from this delegated regulation. These guidelines require conformance with certain technical standards for the processing and transmission of handset-derived caller location to PSAPs.

[7] Case C 417/18; Judgment of the Court (Fourth Chamber) of 5 September 2019, AW and Others v Lietuvos valstybė.
[8] Commission Delegated Regulation (EU) 2019/320 of 12 December 2018 supplementing of Directive 2014/53/EU of the European Parliament and of the Council with regard to the application of the essential requirements referred to in Article 3(3)(g) of that Directive in order to ensure caller location in emergency communications from mobile devices, OJ L 55, 25.2.2019, p. 1–3.
[9] European Commission, April 2021 - Guidelines for compliance with delegated regulation (EU) 2019/320

2. Location accuracy & reliability criteria- International best practice

An analysis is made of location accuracy and reliability criteria that have been implemented in other countries. In some cases, these are formal regulatory requirements and in others they are guidelines or aspirational targets.

2.1 USA

Over the last decade, the Federal Communications Commission (FCC) has continuously revised and approved the E911 framework to require delivery of accurate location information to PSAPs for mobile originated calls to 911. The FCC's most recent Report and Order relating to wireless 911 calls (Sixth *Report and Order*[10]) requires Commercial Mobile Radio Service (CMRS) providers to convey coordinate-based location estimates or alternatively, where technically feasible, convey dispatchable location with an associated uncertainty c (e.g., street address, office or apartment number, etc) to the appropriate PSAP. The latest requirement (which is the 6-year benchmark set in 2015) states that, by 3 April 2021:

- Nationwide providers achieve a 50-metre horizontal accuracy (x/y location within 50 metres) or provide dispatchable location for 80% of all wireless 911 calls.
- Non-nationwide providers must achieve the 80% threshold described above by this date or within 1 year of the provider's deployment of a commercially-operating VoLTE platform in the provider's network, whichever is later.

The USA also has a requirement for vertical positioning (or z-axis). Since April 2021, there is a requirement to position handsets within a floor-level accuracy of 3 metres for 80% of all mobile calls.

The FCC provided a regulatory update to the National Emergency Number Association (NENA)'s conference in June 2022.

[10] Sixth Report and Order, PS Docket No. 07-114, adopted 16 July 2020.

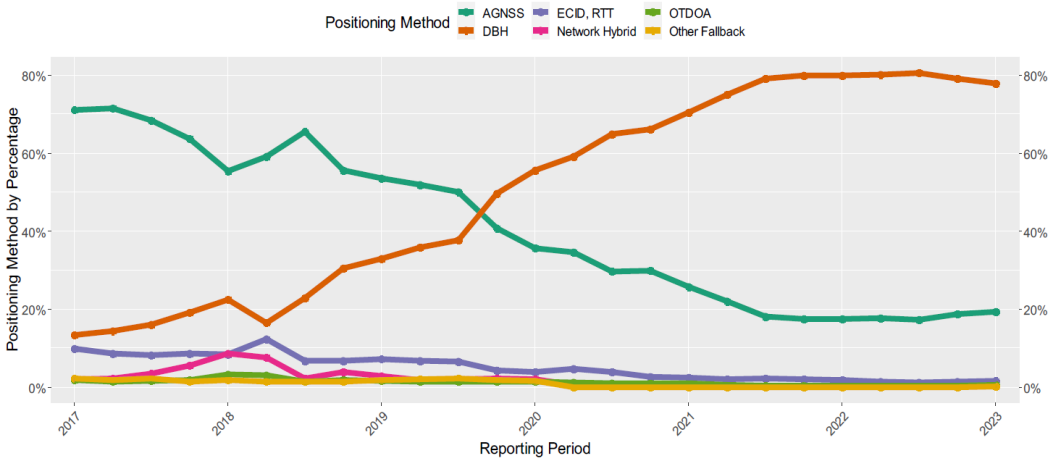

Figure 1 – Positioning method by percentage (source: FCC)

Figure 1 provides a percentage breakdown of the technologies that are used to support geolocation of live wireless 911 calls in the USA during the period Q.1 2017 – Q.1. 2023. The chart shows that the use of device-based hybrid (DBH) location (i.e. handset-derived location) for emergency caller location has increased to approximately 80% for all wireless 911 calls. A-GNSS, E-CID/RTT, OTDOA Network Hybrid and other solutions account for the other 20%.

2.2 Canada

Processes for measuring wireless/mobile originated emergency caller location accuracy have been implemented in Canada since 2015. The Canadian Radio-television Telecommunications Commission (CRTC) has issued several decisions concerning the implementation of mobile Phase 1 and 2 location technology, processes for measuring mobile location accuracy as well as researching and assessing opportunities to implement new mobile location technology in Canada to improve accuracy of the location information provided to Public Safety Answering Points (PSAPs) and first responders.

The CRTC, working with 9-1-1 stakeholders, has established an annual monitoring process in which the CRTC monitors mobile service providers' 9-1-1 compliance with caller location accuracy and reliability. As part of the monitoring process, the CRTC also established mobile location accuracy Minimum and Target Thresholds[11].

- Minimum threshold is the point below which a mobile service provider is outside the normal range of performance (more than two standard deviations), indicating a need for location accuracy improvement.
- Target threshold is the mean performance of mobile service providers (50% of which are below this figure and 50% are above) and is an aspirational target to which all providers should strive.

[11] The current thresholds were approved by the Commission in Telecom Decision 2022-91 CISC Emergency Services Working Group – Consensus report ESRE0094 – Updates to the wireless location accuracy benchmarks set out in Telecom Decision 2019-120, 29 March 2022.

Uncertainty Threshold	<150m for rural/small PSAPs		<150m for large/metro PSAPs		<1000 metres for rural/small PSAPs		<1000 metres for large/metro PSAPs	
Period	Period 7	**Period 8**	Period 7	**Period 8**	Period 7	**Period 8**	Period 7	**Period 8**
Minimum Threshold	60%	**65%**	60%	**65%**	72%	**75%**	82%	**86%**
Target Threshold	72%	**76%**	72%	**74%**	85%	**87%**	92%	**93%**

Period 7 - 1 January 2020 to 31 December 2020
Period 8 - 1 January 2021 to 31 December 2021

Canada's Emergency Services Working Group (ESWG) recommended, and the Commission approved, the implementation of handset-based location technology in CRTC Telecom Decision 2021-21015. While there have been some changes in the work required since the decision, the recommended implementation of handset-based location technology will likely start to occur in late 2023.

2.3 Norway

For emergency calls from a mobile device, the electronic communications service provider must also transfer information to the emergency services in order to indicate the location of the mobile terminal with as high a degree of accuracy as possible. The information must have a maximum margin of error of 50 metres for a minimum of 80% of the emergency calls. This requirement is set out in Norway's Electronic Communications Regulation[12] section 6-2ª.

2.4 New Zealand

The Emergency Caller Location Information (ECLI) Service enables 111 emergency call takers to receive automatically generated geographical information about the likely location of a caller when a 111 call is made from a mobile device on a cellular network.

The Location Area Service (LAS) system turns that data into information about a calling mobile device's likely location. Authorised emergency service providers — New Zealand Police, Fire and Emergency New Zealand, St John and Wellington Free Ambulance — are allowed to use this location information to help them verify the location of an emergency caller, so they can respond to the emergency as quickly as possible.

ECLI is not regulated in New Zealand though it has its own internal KPIs for location accuracy, one of which measures location accuracy in 3 bands:

- High < 50m
- Mid < 500m
- Low >500m

The target for the year ending 30 June 2023 is to achieve 50m high accuracy target for 90% of mobile-originated calls.

[12] Forskrift om elektronisk kommunikasjonsnett og elektronisk kommunikasjonstjeneste (ekomforskriften)

2.5 Comments on International best practice

The criteria described above apply to all mobile-originated calls and not just those originating on smartphones. The USA, Norway and New Zealand have set horizontal accuracy targets of 50m. Canada has not yet factored in handset location but it is planned before the end of 2023. That said, it does have accuracy targets of under 150m relying on network-based location information alone.

On the reliability criterion, USA, Norway and New Zealand have set reliability criteria of 80% (USA and Norway) and 90% (New Zealand) respectively. From this very basic analysis of international best practice, an accuracy target of 50m for 80% of mobile-originated calls seems achievable where handset-derived location is taken into account.

GSMA predicts that, by 2025, smartphones will account for nearly 85% of mobile connections in Europe. Therefore, EENA considers it feasible to meet these criteria from smartphone-originated emergency communications alone before taking into account location information provided by the network.

Only the USA has an accuracy target for vertical location at this point.

3. Caller Location Statistics

To track developments and progress on Advanced Mobile Location (AML) deployment, EENA published AML Report Cards in 2019 and 2020. The AML Report Card 2023[13] was published on 15 May 2023. In the survey to inform the latest version, respondents were asked to provide statistics on caller location information received for all mobile originated emergency communications for the period 1 January 2022 until 31 December 2022.

While some of the statistics included are not directly comparable due to implementation specificities in each country[14], the figures do provide a good overview of the accuracy and reliability of caller location information received in PSAPs today. Here are some observations from the statistics received.

- The accuracy estimates for the network-based location information reported by PSAPs ranges from 300m to 25km. Many countries rely solely on Cell-ID. The higher accuracy figures reported are from countries who have implemented advanced network location techniques based on radio measurements (e.g. Timing advanced and Round-Trip Time[15]).
- The accuracy estimates for handset-derived location range from 3m to 348m. The lower accuracy figures reported could be based on environmental factors at the time the location estimates were calculated. This could be, for example, because there was no GNSS available (e.g. indoor environment) or no Wi-Fi access points nearby (e.g. rural environment) or the estimate is relying solely on the network-based location available.
- The reliability percentage for network-based location ranges from 82% to 100%. It is most likely that the lower figure could be attributed to incorrectly configured call taking solutions or a location pull implementation using MSISDN as a primary key. In the latter case, it would be impossible to interrogate the endpoint/LIS to find the location data associated with a call in "limited service state[16]" (LSS) due to the unavailability of a valid MSISDN.
- The reliability percentage for handset-derived location ranges from 30% to 97%. The reasons for the low range on the reliability percentage were not provided in response to the survey but the main reasons for failure of transmission to the PSAP have been addressed in this document and include:

[13] EENA Document, AML Report Card 2023, 15 May 2023

[14] For example, reporting an accuracy level based on 63% confidence versus 95% confidence. See further discussion on this in Chapter 4.

[15] An evaluation of the different location solutions, both network-based and handset-derived, is detailed in Document xxx. This was a study carried out by the European Commission to inform the Delegated Regulation supplementing Article 109 of the EECC.

[16] If the mobile device is unable to find a suitable cell to camp on, or the SIM is absent, not configured or malfunctioning, or if it receives certain responses to a LR request (e.g., "illegal MS"), it attempts to camp on a cell irrespective of the PLMN identity and enters what is called a "Limited Service State" in which it can only attempt to make emergency calls. For more information please see ECC Report 324.

    - For SMS transmission, the end-user device could be roaming or in LSS where SMS would not be available.
    - For HTTPS transmission, the end-user device may not have provided a MSISDN and the location could not be retrieved from the endpoint/LIS.
    - The call originated on VoWi-Fi and HTTPS is not implemented in the country.
    - AML is not implemented for all services (e.g. SMS to 112), all emergency numbers or all regions of the country.
    - PSAP systems are not correctly configured to receive and process the location and present it to the call taker.
    - The network restricts a device from being able to send an SMS during an emergency call.
    - An error occurred on the mobile network responsible for conveying the handset-derived location. It should be noted that Google and Apple endeavour to work closely with MNOs to resolve such issues.

- There is a clear indication from the statistics received that the countries achieving the highest levels of reliability have resolved most, if not all, of the above-mentioned issues.

- Where handset-derived location was received by the PSAP

    - 81% to 94% of locations had an accuracy estimate of 100m or under.
    - 69% to 85% of locations had an accuracy estimate of 50m or under.
    - 36% to 79% of locations had an accuracy estimate of 30m or under.

- Where handset-derived location was received by the PSAP

    - 79% to 100% of locations were received within 60 seconds.
    - 62% to 99% of locations were received within 30 seconds.
    - 12% to 98% of locations were received within 15 seconds.

- These statistics clearly demonstrate that a 100m accuracy criterion is already being achieved for a very high percentage of mobile-originated emergency communications. An accuracy criterion for 30m may still be a little ambitious while 50m represents an achievable target for an initial set of accuracy criteria.

4. Establishing handset-derived caller location information

Handset-derived caller location essentially means smartphone-derived caller location as only smartphones have the capability to calculate location in this way. Apple and Android together account for 99.44%[17] of the mobile operating system market share in Europe. Any new market entrants are also required to comply with the requirements of Commission Delegated Regulation (EU) 2019/320. GSMA predicts[18] that, by 2025, smartphones will account for nearly 85% of mobile connections in Europe.

4.1 Establishment of handset-derived location

Apple and Android devices contain a variety of location sensors. When a user initiates an emergency communication, supported devices can "fuse" information from various sensors, such as Global Navigation Satellite Systems (GNSS) and nearby Wi-Fi access points. This process takes advantage of proprietary methods and network-provided assistance data (if available), to quickly calculate a high-integrity estimate of the device's location. Apple calls this capability "Hybridised Emergency Location" or "HELO." Google calls this capability "Fused Location Provider" or "FLP". Technologies such as HELO or FLP are often referred to as "Device-Based Hybrid" or "DBH".

Once established, the location information is packaged for transmission. The structure of this package depends on the transmission mechanism used. These structures and transmission mechanisms are described in sub-section 2.3 below. A simple illustration of the location establishment process is provided in Figure 1 below:

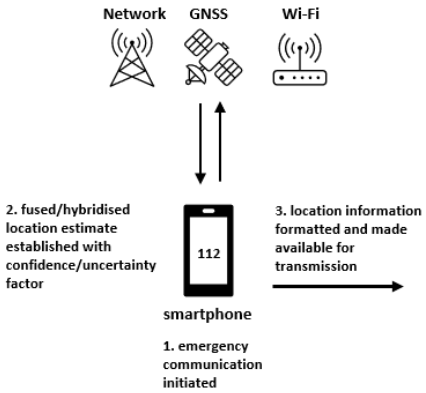

Figure 1 – handset-derived location establishment

[17] Statcounter Globalstats - Mobile Operating System Market Share in Europe - February 2023
[18] GSMA Document – The Mobile Economy – Europe 2022 (p.12)

4.2 Relationship between location accuracy confidence and uncertainty

Generating positioning estimates is a probabilistic process and from a regulatory perspective, it is important to remember that the handset provides a location estimate at a given point in time. The accuracy of the estimate, i.e. how close the estimate is to the handset's actual location, is dependent on numerous environmental parameters which vary continuously. For example, it is not correct to say that all reported estimates will be within 5 metres, or 10 metres, or 1000 metres of the true position. The bottom line is that for any position determining system, accuracy varies from estimate to estimate. It is helpful therefore to think of the location estimate in terms of confidence. How certain are we that the estimate is accurate? How close to the actual location is the estimate?

The uncertainty of the location estimate is the distance from the actual location the estimate is likely to fall within. The lower the value the more accurate the estimate. To help PSAPs understand how to interpret any given position estimate, they are delivered with uncertainty and confidence factors that help the PSAPs know approximately how accurate the position estimate is believed to be, so it can interpret and utilise it correctly. The uncertainty and confidence levels are related and this is illustrated in Figure 2 below:

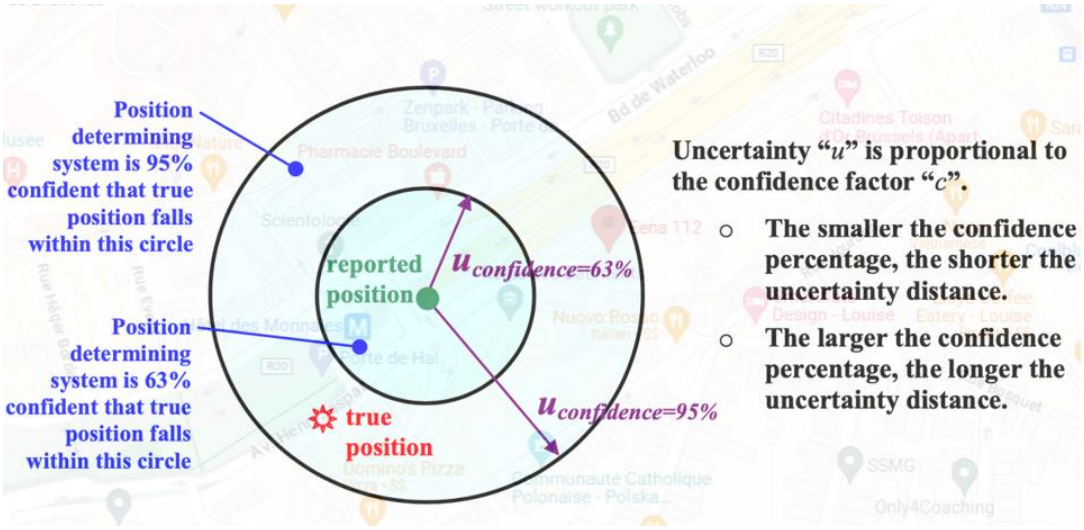

Figure 2 – relationship between confidence and uncertainty

If we want locations to be estimated within say 5m of the actual location, a difficult task using current technology, we have to recognise that often the estimate will be more than 5m so a measure of probability is needed. This is the confidence ("***c***") of the estimate and the uncertainty ("***u***") is proportional to "***c***". We can expect roughly two in every three estimates to fall within 5 metres so we would say the confidence level was 63%.

If we are happy to accept a higher level of uncertainty e.g. a larger distance from the actual position, say 30m, then we can expect more estimates to be within this

distance and the level of confidence to increase. We might find that 19 times out of 20 the estimate falls within this distance so the confidence level is 95%.

Considering this from a regulatory perspective, EENA advises a higher level of confidence even if this might mean a less accurate location estimate. 30m at 95% would mean that only 1 estimate in 20 would be more than 30m from the true location of the caller.

In current implementations within Europe, EENA understands that in some cases location estimates with a lower confidence level are rejected. This is not a desirable approach as the PSAP may have to rely solely on network-based location which in some cases may not be useful enough to support an effective emergency intervention. In most cases, the PSAP call taker will have the opportunity verify location with the caller and validate that against the handset-derived and network-based location received. Therefore, it is unadvisable to reject a location estimate with a lower confidence level. EENA recommends that locations estimates with lower confidence levels should never been rejected.

4.3 Vertical Location

Vertical location is calculated in a smartphone using various methods, including GNSS, barometric pressure sensors, Wi-Fi and mobile network access points. Smartphones also have accelerometers and gyroscopes which are used to track changes in the device's movement and orientation to estimate altitude based on changes in elevation. Like a horizontal location estimate, it needs to be interpreted in the context of confidence and uncertainty.

Vertical location is of most use to the emergency services when they are trying to locate an incident in a tall building. GNSS, Wi-Fi and mobile radio signals can be obstructed, reflected or absorbed by the materials used in the construction of the building so calculating an accurate vertical location is challenging because of the environment.

There are also other challenges with indoor location. The vertical location estimate needs to be conceptualised and related to the building in question. As buildings can have varying ceiling heights, number of floors and floor numbering conventions[19] there is a need to have the indoor environment of buildings digitally mapped. Indoor mapping can be time-consuming and expensive, but it is necessary for determining accurate indoor estimates, particularly in taller buildings and those with complex layouts. Those maps need to be integrated into the CAD/GIS systems in PSAPs so that when vertical location estimates are received, they can be presented in a meaningful and useable way.

Even outdoors, there are variations as to how a vertical location estimate can be interpreted such as height above ellipsoid, height above sea-level and height above ground which can all yield different vertical location estimates. Handset

[19] In most of Europe, the ground level is referred to as "G - ground floor" or "floor 0", In most of the United States, Russia and China, the floor at ground level is called the "first floor", the next level is called the "second floor".

elevation is always an estimate of the height above the GNSS datum. Additional processing is required to locally correct to height above mean sea level.

In EENA's view there is still a lot of work to be done before accuracy and reliability criteria can be laid down and enforced for vertical location. The handsets are already capable of providing vertical location but the PSAPs are not yet ready to be able to use it. More digital mapping of buildings is needed. CAD and GIS vendors need to integrate these in their solutions and PSAPs need to deploy them accordingly. At that point, a discussion on accuracy and reliability criteria for vertical location can begin.

5. Transmission of handset-derived caller location information

The transmission of handset-derived location information relies on electronic communications networks and the services provided on them. In Europe, Advanced Mobile Location is currently used to transmit handset-derived location.

5.1 Advanced Mobile Location (AML)

In each country, the national emergency services authority can establish an endpoint (i.e. a Location Information Service (LIS)) to receive AML-formatted location data and forward that data to local PSAPs. When a user initiates an emergency communication, high-accuracy, high-integrity location information established by the handset is transported to the national endpoint. AML information arrives after the emergency communication session has been established with the call taker. AML uses two user-plane transmission mechanisms, SMS and HTTPS. These transmission mechanisms are described in ETSI TS 103 625[20].

5.2 Session Initiation Protocol (SIP) location conveyance

SIP is a globally standardised, general-purpose protocol deployed in IMS-based 4G/5G networks for initiating, maintaining, and terminating real-time emergency communications sessions based on voice, video and messaging. SIP also supports location conveyance as specified in IETF RFC 6442[21] and described in ETSI TS 103 479[22].

5.3 Impact of transmission mechanisms on “reliability”

The percentage of mobile originated emergency communications delivered to the most appropriate PSAP is dependent on the success rate (i.e. reliability) of the transmission mechanisms used. To maximise the success rate, the following issues need to be considered:

[20] ETSI TS 103 625 V1.3.1, Emergency Communications (EMTEL); Transporting Handset Location to PSAPs for Emergency Calls - Advanced Mobile Location, March 2023.
[21] IETF RFC 6442 - Location Conveyance for the Session Initiation Protocol – December 2011.
[22] ETSI TS 103 479 v.1.2.1 - Core elements for network independent access to emergency services, March 2023.

SMS

- The SMS Service Centre Address (SC Address) identifies a node in the home network to which an SMS is sent. AML transmission is therefore limited while roaming as the SMS message will be sent to the home network. The AML specification describes two options that can be implemented to support roaming using SMS. If implemented, roaming end-user devices can also provide handset-derived location to the most appropriate PSAP.
- An SMS message is constrained to a maximum of 160 characters which means that there is limited scope for the provision of additional contextual data in the future.
- SMS will not work on a device in LSS as access to the SMS service is not available. EENA considers that one of the main reasons why the number of LSS calls[23] is significant is because Circuit-Switched Fallback (CSFB[24]) for emergency calls remains widely used.

HTTPS

- The MSISDN may not always be available in the HTTPS message string. This is problematic as the MSISDN is the key to retrieving location information from the LIS in most implementations. Some implementations in Europe use pattern matching between the SMS/HTTPS messages received to determine the MSISDN. A resolution to the MSISDN is currently being investigated.

SIP

- For SIP location conveyance to work effectively, an end-to-end SIP environment is needed and this will take time to roll out. Importantly, SIP location conveyance can co-exist with AML which will be crucial in ensuring seamless delivery of handset-derived location to PSAPs during the migration to an all-IMS environment.

5.4 Other factors affecting successful transmission of location information to PSAPs

The implementation and operation of the platforms where network-based and handset-derived caller location information is gathered into a coherent set of civic or geodetic data differs from country to country and, in some cases, from region

[23] EENA has anecdotal evidence that LSS calls are as high as 20% of all emergency calls in some countries.
[24] When an emergency call is initiated from an LTE-capable device, the device attempts to set up the call using VoLTE. However, if the 4G network is not available or cannot be connected to, the device will automatically fall back to the circuit-switched network using CSFB. This ensures that the emergency call is connected to the appropriate emergency services, even if VoLTE is not yet available or supported. During the de-registration from the 4G network the device may enter LSS rather than fully registering on the available 2G/3G network.

to region within the same country. The PSAPs must have the technical and operational capacity to receive, process and visualise caller location information in a meaningful way e.g. a street address or an area on a map with the estimated location of the end-user. This requires CAD/GIS systems to be able to process and display location information in a meaningful and useable way in the PSAP.

The Delegated Regulation requires Member States to prepare and report to the Commission by 5 December 2023 with a roadmap for upgrading the national PSAP system to be able to receive, answer and process emergency communications (including contextual data) through packet-switched technology.

6. Conclusions

7. The Member States' focus should be on leveraging, to the greatest extent possible, location information derived from smartphones given the high accuracy levels achieved and the GSMA's prediction that, by 2025, smartphones will account for nearly 85% of mobile connections in Europe.

8. The technology for establishing and transmitting handset-derived location information is widely used today in all EU/EEA Member States. Therefore, it is feasible to coordinate and introduce a common set of accuracy and reliability criteria in every Member State.

9. The criteria for vertical location should be considered at some point in the future as part of a review of the initial criteria laid down. More work needs to be done to make vertical location available in a meaningful and useful way by PSAPs.

10. To help PSAPs understand how to interpret any given position estimate from a handset, it is delivered with an uncertainty factor and a confidence factor. All location accuracy estimates should be accepted by PSAPs independently of confidence factor provided.

11. Solutions to support the transmission of handset-derived location to the most appropriate PSAP for SMS-to-112 and for roaming end-users (based on either SMS or SIP) need to be implemented. These steps will help reduce the large disparity in the reliability percentages.

12. The large disparity in the reliability percentages (30%-82%) of AML locations successfully transported in the mobile networks needs to be improved upon. Member States should pay particular attention to ensuring that network originated error rates are reduced to a minimum by encouraging electronic communications networks and service providers to engage with handset OS providers and PSAPs to resolve these issues expediently.

13. As 2G/3G networks are phased out, the LSS issue should eventually be resolved. In the meantime, Member States should encourage mobile network operators to phase out CSFB and accelerate the implementation of emergency calling over VoLTE/VoNR. This would have a direct positive impact on the success rate of handset location transmission to the PSAP.

14. PSAP solutions based on ETSI TS 103 479[25] can ensure continued support for the receipt and processing of location information during the migration to packet-switched technologies. Member State roadmaps[26]

[25] ETSI TS 103 479 v.1.2.1 - Core elements for network independent access to emergency services, March 2023.
[26] Article 7(2) of Delegated Regulation (EU)2023/444 requires Member States to prepare and report to the EC, no later than on 5 December 2023, a roadmap for upgrading the national PSAP system in order to be able to receive, answer and process emergency communications through packet-switched technology.

for PSAP upgrades to packet-switched technology should take utmost account of this technical specification.

7. Recommendations

Based on the analysis carried out in this document, EENA recommends that Member States should:

- Lay down an initial set of criteria for the accuracy and reliability of caller location information that requires a horizontal accuracy estimate of **50m** for **80%** of all mobile-originated emergency communications. These criteria should be met through the combined use of network-based and handset-derived caller location information technologies in line with the provisions of Directive (EU) 2018/1972 as supplemented by Commission Delegated Regulation (EU) 2023/444.
- As these criteria need to be adopted and reported to the European Commission by 5 March 2024, Member States should set a subsequent date within an appropriate timeframe to facilitate compliance by stakeholders.
- Review the criteria on a periodic basis taking into account ongoing developments in technology.
- Ensure that all handset-derived location accuracy estimates are accepted by PSAPs independently of the confidence factor provided[27].

[27] To help PSAPs understand how to interpret any given position estimate from a handset, it is delivered with an uncertainty factor and a confidence factor. Please read section 4.2 of this document to understand the basis for this recommendation.