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Universal Mobile Telecommunications System (UMTS);  
LTE;  
5G;  
Location Services (LCS);  
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# Foreword

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# 1 Scope

This document provides the Stage One description of Location Services (LCS). A Stage One description provides an overall service description, primarily from the service subscriber's and user's points of view, but not dealing with the details of the Man Machine Interface (MMI). This TS includes information applicable to network operators, service providers and terminal, base station system, switch, and data base manufacturers.

NOTE: Location Services may be considered as a network provided enabling technology consisting of standardized service capabilities which enable the provision of location-based applications. These applications may be service provider specific. The description of the numerous and varied possible location applications which are enabled by this technology are outside the scope of this specification. However, clarifying examples of how the functionality being specified may be used to provide specific location services is included in various sections of the specification.

This document provides core requirements to an extent sufficient to derive a complete definition of location services at the service level. However, the present document also provides additional requirements which may suggest in a non-normative manner certain ways the system may be implemented to support location services.

LCS can be offered without subscription to basic telecommunication services. LCS is available to the following categories of LCS clients:

- Value Added Services LCS Clients – use LCS to support various value-added services. These clients can include UE subscribers as well as non-subscribers to other services.
- PLMN Operator LCS Clients – use LCS to enhance or support certain O&M related tasks, supplementary services, IN related services and bearer services and teleservices.
- Emergency Services LCS Clients – use LCS to enhance support for emergency calls from subscribers.
- Lawful Intercept LCS Clients – use LCS to support various legally required or sanctioned services.

LCS is applicable to any target UE whether or not the UE supports LCS, but with restrictions on choice of positioning method or notification of a location request to the UE user when LCS or individual positioning methods, respectively, are not supported by the UE.

LCS is being developed in phases with enhancements added in 3GPP releases.

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## 2. References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

### 2.1 Normative references

- [1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".
- [2] 3GPP TS 23.032: "Universal Geographical Area Description".
- [3] 3GPP TS 22.101: "Service principles".
- [4] 3GPP TS 22.105: "Services and Service Capabilities".



- [5] 3GPP TS 22.115: "Charging and Billing"
- [6] Open Mobile Alliance (OMA): OMA-RD-Parlay\_Service\_Access-V1\_0-20100427-A
- [7] 3GPP TS 23.110: " UMTS Access Stratum; Services and Functions".

## 2.2 Informative references

- [8] 3GPP TR 25.923: "Report on Location Services (LCS)".
- [9] PD 30.lcs: "Project Plan for location services in UMTS".
- [10] Third generation (3G) mobile communication system; Technical study report on the location services and technologies, ARIB ST9 December 1998.
- [11] The North American Interest Group of the GSM MoU ASSOCIATION: Location Based Services, Service Requirements Document of the Services Working Group
- [12] FCC, Fourth Report and Order: Wireless E911 Location Accuracy Requirements, February 3, 2015, <https://www.fcc.gov/document/fcc-adopts-new-wireless-indoor-e911-location-accuracy-requirements-0>
- [13] FCC, Erratum, Wireless E911 Location Accuracy Requirements, March 3, 2015, [https://apps.fcc.gov/edocs\\_public/index.do?document=332342](https://apps.fcc.gov/edocs_public/index.do?document=332342)

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## 3 Definitions and abbreviations

### 3.1 Abbreviations

For the purposes of the present document, in addition to 3GPP TR.21.905, the following abbreviations apply:

BDS	BeiDou Navigation Satellite System
BLE	Bluetooth Low Energy
EGNOS	European Geographic Navigation Overlay System
E-OTD	Enhanced Observed Time Difference
GAGAN	GPS Aided Geo Augmented Navigation (or GPS and Geo Augmented Navigation)
GLONASS	GLOBAL NAVIGATION SATELLITE SYSTEM
GNSS	Global Navigation Satellite System
IPDL-OTDOA	Idle Period Downlink- Observed Time Difference Of Arrival
LCS	Location Service
MSAS	Multi-functional Satellite Augmentation System
NA-ESRD	North American Emergency Services Routing Digits
NA-ESRK	North American Emergency Services Routing Key
NANP	North American Numbering Plan
PSAP	Public Safety Answering Point
QZSS	Quasi Zenith Satellite System
SBAS	Satellite Based Augmentation Systems
TBS	Terrestrial Beacon Systems
U-TDOA	Uplink Time Difference of Arrival
WAAS	Wide Area Augmentation System

NOTE: In the present document, acronyms are used in the text as if they are read either in their fully expanded form or in their alphabet names with no consistent principle.

### 3.2 Definitions

For the purposes of the present document the following definitions apply:

**Change of Area:** is one event supported for deferred Location Requests. Change of Area means that the network is required to report the location or the occurrence of the event of the requested subscriber in triggered fashion immediately after the network (MSC/SGSN) processes the mobility event for the new location of the subscriber. Usually new location is noticed after the Location Update, Tracking Area Update, Handover, RAU, Registration or RANAP Location Report, e.g. when the SAI changes.

**Codeword:** access code, which is used by a Requestor or LCS Client in order to gain acceptance of a location request for a Target UE. The codeword is part of the privacy information that may be registered by a Target UE user.

**Current Location:** after a location attempt has successfully delivered a location estimate or Dispatchable Location and its associated time stamp, the location estimate or Dispatchable Location and time stamp are referred to as the 'current location' at that point in time.

**Deferred location request:** a location request where the location response (responses) is (are) required after specific event has occurred. Event may or may not occur immediately. In addition, event may occur many times.

**Dispatchable Location:** The civic location of a UE and/or a valid Mobile Equipment (ME), expressed as civic data (e.g. floor, street number, city.) The Dispatchable Location shall be represented in a well-defined universal format. Regional regulations may specify the mandatory and optional elements in this universal format to be included in a Dispatchable Location.

**Immediate location request:** a location request where a single location response only is required immediately.

**Initial Location:** in the context of an originating emergency call the location estimate or Dispatchable Location and the associated time stamp at the commencement of the call set-up is referred to as 'initial location'.

**Last Known Location:** The current location estimate or Dispatchable Location and the associated time stamp for Target UE stored in the LCS Server is referred to as the 'last known location' and until replaced by a later location estimate or Dispatchable Location and a new time stamp is referred to as the 'last known location'.

**LCS Client:** a software and/or hardware entity that interacts with an LCS Server for the purpose of obtaining location information for one or more Mobile Stations. LCS Clients subscribe to LCS in order to obtain location information. LCS Clients may or may not interact with human users. The LCS Client is responsible for formatting and presenting data and managing the user interface (dialogue). The LCS Client is identified by a unique international identification, e.g. E.164.

NOTE: The LCS Client may reside inside or outside the PLMN.

**LCS Client Access barring list:** an optional list of MSISDNs per LCS Client where the LCS Client is not allowed to locate any MSISDN therein.

**LCS Client Subscription Profile:** a collection of subscription attributes of LCS related parameters that have been agreed for a contractual period of time between the LCS client and the service provider.

**LCS Feature:** the capability of a PLMN to support LCS Client/server interactions for locating Target UEs.

**LCS Server:** a software and/or hardware entity offering LCS capabilities. The LCS Server accepts requests, services requests, and sends back responses to the received requests. The LCS server consists of LCS components which are distributed to one or more PLMN and/or service provider.

**Location Estimate:** the geographic location of a UE and/or a valid Mobile Equipment (ME), expressed in latitude and longitude data. The Location Estimate shall be represented in a well-defined universal format. Translation from this universal format to another geographic location system may be supported, although the details are considered outside the scope of the primitive services.

**NG-RAN:** a radio access network connecting to the 5G core network which uses NR, E-UTRA, or both.

**North American Emergency Services Routing Digits (NA-ESRD):** a telephone number in the North American Numbering Plan (NANP) that can be used to identify a North American emergency services provider and its associated LCS client. The ESRD also identifies the base station, cell site or sector from which a North American emergency call originates.

**North American Emergency Services Routing Key (NA-ESRK):** a telephone number in the North American Numbering Plan (NANP) assigned to an emergency services call by a North American VPLMN for the duration of the call. The NA-ESRK is used to identify (e.g. route to) both the emergency services provider and the switch in the

VPLMN currently serving the emergency caller. During the lifetime of an emergency services call, the NA-ESRK also identifies the calling mobile subscriber.

**PLMN Access barring list:** an optional list of MSISDN per PLMN where any LCS Client is not allowed to locate any MSISDN therein except for certain exceptional cases.

**Privacy Class:** list of LCS Clients defined within a privacy exception class to which permission may be granted to locate the target UE. The permission shall be granted either on activation by the target UE or permanently for a contractual period of time agreed between the target UE and the service provider.

**Service Identifier:** A service provided by an LCS Client is identified by a Service Identifier. One LCS client may have one or more services. The combination of the LCS client Identifier and the Service Identifier constitutes a unique identification of a service.

**Privacy Exception List:** a list consisting of various types of privacy classes (i.e. operator related, personal etc.). Certain types of classes may require agreement between the service provider and the target UE.

**Requestor:** an originating entity, which has requested the location of the target UE from the LCS client.

**Target UE:** The UE being positioned.

**Target UE Subscription Profile:** the profile detailing the subscription to various types of privacy classes.

**UE available:** deferred Location Request event in which the MSC/SGSN has established a contact with the UE. Note, this event is considered to be applicable when the UE is temporarily unavailable due to inaction by the UE user, temporarily loss of radio connectivity or IMSI detach and so on. Note that IMSI detach is only applicable in the case UE has previously been registered and information is still kept in the node.

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## 4 Functional Requirements

### 4.0 General

3GPP standards shall support location service features, to allow new and innovative location-based services to be developed. It shall be possible to identify and report in a standard format (e.g. geographical co-ordinates) the current location of the user's terminal and to make the information available to the user, ME, network operator, service provider, value added service providers and for PLMN internal operations.

The location is provided to identify the likely location of specific MEs. This is meant to be used for charging, location-based services, lawful interception, emergency calls, etc., as well as the positioning services.

The standard shall support NG-RAN, E-UTRAN, GERAN and UTRAN to facilitate determination of the location of a mobile station.

The following subsections provide general descriptions of attributes that can be used to describe or characterize various location services.

The relative importance of these attributes varies from service to service. However, accuracy, coverage, privacy and transaction rate may be considered the primary distinguishing attributes that define a value-added service. Briefly:

- accuracy is the difference between actual location and estimated location,
- coverage is an expression of the geographic area in which the UE user will receive an adequate perceived quality of service,
- privacy describes the user's perception of confidentiality of the location information, and
- transaction rate indicates how frequently network messaging is required to support the service.

A general comparison of the specific attributes of various location-based services is provided in Annex C of this document.

### 4.1 High Level Requirements

The following high-level requirements are applicable:

- 1 The supporting mechanisms should incorporate flexible modular components with open interfaces that facilitate equipment interoperability and the evolution of service providing capabilities.
- 2 The network should be sufficiently flexible to accommodate evolving enabling mechanisms and service requirements to provide new and improved services.
- 3 It shall be possible to provide multiple layers of permissions to comply with local, national, and regional privacy requirements.
- 4 Multiple positioning methods should be supported in the different Access Networks, including (but not limited to):
  - Modernized GPS;
  - SBAS (Satellite Based Augmentation Systems: EGNOS, WAAS, GAGAN, MSAS);
  - QZSS (Quasi Zenith Satellite System);
  - GLONASS
  - BDS
  - Galileo
  - U-TDOA
  - E-OTD
  - IPDL-OTDOA
  - Network Assisted GNSS (e.g. Network Assisted GPS or Network Assisted GALILEO)
  - UE ambient condition sensors-based positioning
    - Motion sensors (e.g. accelerometers, gyroscopes)
    - Environmental sensors (e.g. barometer)
    - Position sensors (e.g. magnetometers, orientation sensors)
  - TBS
  - Beacon identity for location lookup (e.g. WiFi access points or BLE beacons)
  - RF Pattern Matching
  - Methods using cell site or sector information and Timing Advance or RoundTrip Time measurements.
- 5 The location determining process should be able to combine diverse positioning techniques and local knowledge when considering quality of service parameters to provide an optimal positioning request response.
- 6 It should be possible to provide position information to location services applications existing within the PLMN, external to the PLMN, or in Mobile Equipment;
- 7 Support should be provided for networks based on Intelligent Network architecture (i.e. with specific support for CAMEL based Location Services).
- 8 Support may optionally be provided to enable the routing of emergency calls based on the geographic coordinates (latitude and longitude) of the calling party.
- 9 It shall be possible to provide the originating party's serving cell id to the LCS client.

## 4.2 Location Information

Location Information consists of Geographic Location, Velocity, Civic Location and Quality of Service information, as described in the subsequent sections.

### 4.2.1 Geographic Location

Provision of the geographic location of a target UE is applicable to all LCS services.

Note: For services other than LCS the network may also determine within which Cell, Service Area, or Tracking Area the Target UE is located ("Service Area" and "Tracking Area" are UTRAN and E-UTRAN concepts respectively and both may consist of one (in R99) or more than one cell). The Service or Tracking Area information or Cell ID may be used for routing of calls or for CAMEL applications, if supported.

It should be noted that the Service and Tracking Area concepts are different from the Localized Service Area concept used for SoLSA.

### 4.2.2 Velocity

Velocity is the combination of speed and direction of a Target UE. It shall be possible for a UE to provide its velocity to the LCS server.

Note: This requirement only applies to satellite-based positioning systems.

For Value Added Services and PLMN Operator Services, the following is applicable:

Provision of the velocity of a target UE is application driven. Location Services may allow an LCS Client to request or negotiate the provision of velocity.

For Emergency Services there is no requirement to provide velocity.

### 4.2.3 Dispatchable Location

Provision of the Dispatchable Location of a target UE in civic form is applicable to Emergency Services based on regional regulatory requirements.

An example of Dispatchable Location regional regulatory requirements for the United States can be found in [12] and [13].

## 4.3 Quality of Service

### 4.3.1 Horizontal Accuracy

The accuracy that can be provided with various positioning technologies depends on a number of factors, many of which are dynamic in nature. As such the accuracy that will be realistically achievable in an operational system will vary due to such factors as the dynamically varying radio environments (considering signal attenuation and multipath propagation), network topography in terms of base station density and geography, and positioning equipment available.

The accuracy for location services can be expressed in terms of a range of values that reflect the general accuracy level needed for the application. Different services require different levels of positioning accuracy. The range may vary from tens of meters (navigation services) to perhaps kilometers (fleet management).

The majority of attractive value-added location services are enabled when location accuracies of between 25m and 200m can be provided.