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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 2 of a multi-part deliverable. Full details of the entire series can be found in part 1 [10].

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The increasing proliferation of location-based services is based on several trends in user applications and devices; these include notably the widespread adoption of multi-functional smart-phones etc., and the wider adoption of tracking devices (e.g. in transport). This need for new and innovative location-based services is generating a need for increasingly complex location systems. These systems are designed to deliver location-related information for one or more location targets to user applications.

The wide spectrum of technical features identified in [i.1] calls for a new and broader concept for location systems, taking into account hybrid solutions in which GNSS technologies are complemented with other technology sensors to improve robustness and the performance.

Hence a set of standards for GNSS-based Location systems is defined of which the present document is part 2.

1 Scope

The present document addresses generic architectures for GNSS-based Location Systems (GBLSs) that combine Global Navigation Satellite Systems (GNSS - e.g. Galileo™) and other navigation technologies with telecommunication networks for delivery of location-based services.

The architecture specified herein is a "functional" architecture, meaning that the system is defined in terms of discrete functional elements connected to other internal or external functional elements via associated "logical" interfaces. These functional elements and interfaces are derived from service requirements.

The functional architecture is not necessarily related to the "physical architecture" (i.e. the relationship between equipment which may implement all or some of these functions, and the physical interfaces between them).

The present document can be considered as the Stage 2 functional specification according to the ITU/3GPP approach [i.4].

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] IS-GPS-200: "Revision D, Navstar GPS Space Segment/Navigation User Interfaces", March 7th, 2006.

[2] IS-GPS-705: "Navstar GPS Space Segment/User Segment L5 Interfaces", September 22, 2005.

[3] IS-GPS-800: "Navstar GPS Space Segment/User Segment L1C Interfaces", September 4, 2008.

[4] "Galileo OS Signal in Space ICD (OS SIS ICD)", Issue 1.2, EU/GSA.

[5] BDS-SIS-ICD-B1I-2.0 (December 2013): "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.0)".

[6] "Global Navigation Satellite System GLONASS Interface Control Document", Version 5, 2002.

[7] IS-QZSS, Quasi Zenith Satellite System Navigation Service Interface Specifications for QZSS, Ver.1.0, June 17, 2008.

[8] DTFA01-96-C-00025 (2001): "Specification for the Wide Area Augmentation System (WAAS)", US Department of Transportation, Federal Aviation Administration.

[9] RTCM-SC104 (V3.2): "RTCM Recommended Standards for Differential GNSS Service", February 2013.

[10] ETSI TS 103 246-1: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 1: Functional requirements".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 183: "Satellite Earth Stations and Systems (SES); Global Navigation Satellite Systems (GNSS) based applications and standardisation needs".

[i.2] ETSI TS 103 246-4: "Satellite Earth Stations and Systems (SES); GNSS based location systems Part 4: Requirements for location data exchange protocols".

[i.3] ETSI TS 103 246-5: "Satellite Earth Stations and Systems (SES); GNSS based location systems Part 5: Performance Test specification".

[i.4] Recommendation ITU-T I.130: "Method for the characterization of telecommunication services supported by an ISDN and network capabilities of an ISDN".

[i.5] M. A. Abdel-Salam, "Precise Point Positioning Using Un-Differenced Code and Carrier Phase Observations", PH.D. Thesis, Department of Geomatics Engineering, Calgary, Alberta(CAN), September 2005.

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3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

authentication: provision of assurance that the location related data associated with a location target has been derived from real signals associated with the location target

NOTE: Authentication is one of the key performance features that may be required of a location system.

architecture: abstract representation of a communication system

NOTE: Three complementary types of architecture are defined:

- Functional Architecture: the discrete functional elements of the system and the associated logical interfaces.
- Physical (Network) Architecture: the discrete physical (network) elements of the system and the associated physical interfaces.
- Protocol Architecture: the protocol stacks involved in the operation of the system and the associated peer relationships.

availability: measures percentage of time that a *location system* is able to provide the required *location-related data*

NOTE 1: The required location-related data might vary between location based applications.

NOTE 2: It may contain more than a required information type (e.g. position and speed), but also a required quality of service (e.g. accuracy, protection level, authentication).

continuity: likelihood that the navigation signal-in-space supports the accuracy and integrity requirements for the duration of the intended operation

NOTE: It guarantees that a user can start an operation during a given exposure period without an interruption of this operation, assuming that the service was available at beginning of the operation. Conversely, a Loss of Continuity occurs when the user is forced to abort an operation during a specified time interval after it has begun (the system predicts service was available at start of operation).

continuity risk: probability of a detected but unscheduled navigation interruption after initiation of an operation

electromagnetic interference: any source of RF transmission that is within the frequency band used by a communication link, which degrades the performance of this link

NOTE: Jamming is a particular case of electromagnetic interference, where an interfering radio signal is deliberately broadcast to disrupt the communication.

integrity: function of a *location system* that measures the trust that can be placed in the accuracy of the *location-related data* provided by the *location system*

NOTE: In the present technical context, it is expressed through the computation of a *protection level*. The *Integrity* function includes the ability of the location system to provide timely and valid warnings to users when the system should not be used for the intended operation. Specifically, a location system is required to deliver a warning (an *alert*) of any malfunction (as a result of an alert limit being exceeded) to users within a given period of time (*time-to-alert*). Conversely, a Loss of Integrity event occurs when an unsafe condition occurs without annunciation for a time longer than the time-to-alert limit.

integrity risk: probability that the *actual error* of the *location-related data* is larger than the *protection level*, in case of system availability (i.e. protection level lower than the alert limit)

jamming: deliberate transmission of interference to disrupt reception of desired signals, which in this case are GNSS or telecommunication signals

NOTE: Spoofing is considered to be a deceptive form of jamming.

latency: measure in a location system of the time elapsed between the event triggering the determination of the *location-related data* for one or more *location targets* (i.e. a location request from an external client, an external or internal event triggering location reporting), and the availability of the *location-related data* at the user interface

location-based application: application for delivering a *location-based service* to one or more users

location-based service: service built on the processing of the *Location-related data* associated with one or more *location targets*

location-related data: set of data associated with a given *location target*, containing one or more of the following time-tagged information elements: target position, target motion indicators (velocity and acceleration), and Quality of service indicators (estimates of the position accuracy, reliability or authenticity)

NOTE: This is the main output of a *Location system*.

location target: physical entity on whose position the *location system* builds the *location-related data*

NOTE: This entity may be mobile or stationary.

privacy: function of a *location system* designed to ensure that the location target user's private information (identity, bank accounts, etc.) and its *location-related data* cannot be accessed by an unauthorized third party

Protection Level (PL): upper bound to the position error such that: $P(\varepsilon > PL) < I_{risk}$, where I_{risk} is the *Integrity risk* and ε is the *actual position error*

NOTE: The protection level is provided by the location system, and with the integrity risk, is one of the two sub-features of the integrity system. The protection level is computed both in the vertical and in the horizontal position domain and it is based on conservative assumptions that can be made on the properties of the GNSS sensor measurements, i.e. the measurement error can be bounded by a statistical model and the probability of multiple simultaneous measurement errors can be neglected.

pseudo-range: distance between a satellite and a GNSS receiver as estimated by the receiver without correction for the receiver's time error

Quality of Service (QoS): associated with a location-based service is a set of indicators that can accompany the *location target*'s position/motion information and is intended to reflect the quality of the information provided by the *location system*

NOTE: QoS indicators can be an *accuracy* estimate, a *protection level* statistic, *integrity risk*, and authentication flag.

spoofing: transmission of signals intended to deceive location processing into reporting false target data

security: function of a *location system* designed to ensure that the *location-related data* is safeguarded against unapproved disclosure or usage inside or outside the *location system*, and that it is also provided in a secure and reliable manner that ensures it is neither lost nor corrupted

Time-to-alert: time from when an integrity breach occurs to when an alerting message reaches the user

Time-To-First-Fix: time needed by the receiver to perform the first position and time fix whose accuracy is lower than a defined accuracy limit, starting from the moment it is switched on

vertical axis: axis locally defined for the location target, co-linear to the zenith/nadir axis

3.2 Symbols

For the purposes of the present document, the following symbols apply:

φ	Carrier phase
εAccel	Error on sensor acceleration (from INS)
εAtt	Error on sensor attitude (from INS)
εGyro	Error on sensor gyroscopes (from INS)
εPos	Error on sensor position (from INS)
εPos_{3D}	Uncertainty on sensor position (from GNSS)
εV	Error on sensor attitude (from INS)
εV_{3D}	Uncertainty on sensor speed (from GNSS)
d	Carrier Doppler
P_{GNSS}	Position estimate coming from GNSS sensor
P_{INS}	Position estimate coming from the INS
V_{GNSS}	Speed estimate coming from GNSS sensor
V_{INS}	Speed estimate coming from the INS

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

3GPP	3rd Generation Partnership Project
A-GNSS	Assisted GNSS
AOA	Angle Of Arrival
CF	Central Facility
CID	Call IDentifier
CLM	Centralized Location Module
CMM	Central Management Module
DGNSS	Differential GNSS
D-GNSS	Differential GNSS
DGPS	Differential Global Positioning System
EGNOS	European Geostationary Navigation Overlay System
EMA	EMI Mitigation Algorithm
EMI	Electro-Magnetic Interference
GAGAN	GPS Aided Geo Augmented Navigation System
GBAS	Ground Based Augmentation Systems
GBLS	GNSS-based Location System
GEO	Geostationary Earth Orbit
GLONASS	Global Navigation Satellite System (Russian based system)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications

IBA	Integrity Building Algorithm
IMU	Inertial Measurement Unit
INS	Inertial Navigation Sensor
ITS	Intelligent Transport Systems
LAAS	Local Area Augmentation System
LBS	Location-based Services
LHA	Location Hybridization Algorithm
LTE	Long Term Evolution
MD	Map Database
MSAS	Multi-functional Satellite Augmentation System
NDGPS	Nationwide Differential Global Positioning System (US)
OTD	Observed Time Difference
OTDOA	Observed Time Difference Of Arrival
PL	Protection Level
PM	Positioning Module
PPP	Precise Point Positioning
PVT	Position, Velocity and Time
QoS	Quality of Service
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RSS	Received Signal Strength
RTK	Real Time Kinematic
SBAS	Satellite Based Augmentation System
SNR	Signal-to-Noise Ratio
TDOA	Time difference Of Arrival
TOA	Time Of Arrival
WAAS	Wide Area Augmentation System
WARTK	Wide Area RTK
WIFI	Wireless Fidelity

4 Requirements for GNSS-based Location Systems

The Reference Architecture for GNSS-based Location Systems (GBLS), as defined in the following clauses, is derived from the GBLS Functional Requirements [10] which are intended to provide one or more users with location-related data (as defined in [10]) associated with one or more Location Targets. An overview of these requirements is given below.

The GBLS is intended to be a "generic" location system, and thus to encompass a wide range of functions associated with GNSS Location-based Services (LBS). The functions defined as "mandatory" form the basis of the GBLS, whilst the optional functions are also included in the architecture to provide the additional choices to allow different architectural implementations to be included, and additional location-related data to be provided.

A particular GNSS-based application may require only a subset of the range of data available in the GBLS architecture. Therefore a subset of the GBLS architecture, with alternative combinations of subsystems, may only be needed for many applications. For example, the location data provided can range from simple position-reporting in the case of low-end asset management, to reliable information (e.g. authenticated and with a known uncertainty) on the target's trajectory for liability-critical services such as road charging or Intelligent Transport Systems (ITS).

Some examples of location system implementations (or Implementation Profiles) are given in [i.3] where different combinations of architecture elements are subject to testing.

The functional requirements of the GBLS for location-related data provision are illustrated in Figure 4-1.