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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 3 of a multi-part deliverable covering GNSS-based Location Systems (GBLS), as identified below:

Part 1: Functional requirements;

Part 2: Reference Architecture;

Part 3: Performance requirements;

Part 4: Requirements for location data exchange protocols;

Part 5: Performance test specification.

Modal verbs terminology

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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 ETSI TR 103 183 [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.

1 Scope

The present document addresses performance requirements 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 present document defines Performance Features applicable to GBLS and specifies the conditions and requirements for these Performance Features.

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 referenced 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.

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

[1] European GNSS (Galileo™) Open Service (Issue 1.1): "Signal In Space Interface Control Document".

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

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

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

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

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

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

[8] ETSI TS 103 246-2: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 2: Reference Architecture".

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 referenced 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] IEEE 802.11™: "Wireless Local Area Networks".

[i.3] IEEE 802.15™: "Wireless Personal Area Network".

[i.4] IEEE 802.15.1™ (for Bluetooth).

[i.5] IEEE 802.15.4a™ (for low rate WPAN).

[i.6] ETSI TS 145 001: "Digital cellular telecommunications system (Phase 2+); Physical layer on the radio path; General description (3GPP TS 45.001)".

[i.7] ETSI TS 125 104: "Universal Mobile Telecommunications System (UMTS); Base Station (BS) radio transmission and reception (FDD) (3GPP TS 25.104)".

[i.8] ETSI TS 136 171: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for Support of Assisted Global Navigation Satellite System (A-GNSS) (3GPP TS 36.171)".

[i.9] R. Grover Brown and Gerald Y. Chin: "GPS RAIM: Calculation of Threshold and Protection Radius Using Chi-Square Methods - A Geometric Approach", Global Positioning System: Inst. Navigat., Volume V, pages 155-179, 1997.

[i.10] Juan Blanch et al.: "An Optimized Multiple Hypothesis RAIM Algorithm for Vertical Guidance", Proceedings of ION GNSS 2007, Fort Worth (TX) September 2007.

[i.11] Miguel Azaola et al.: "Isotropy-Based Protection Levels: a Novel Method for Autonomous Protection Level Computation with Minimum Assumptions", NAVITEC 2008, Noordwijk (The Netherlands), December 2008.

[i.12] Clark, B., Bevly, D.: "FDE Implementations for a Low-Cost GPS/INS Module", 22nd International Meeting of the Satellite Division of The Institute of Navigation, Savannah, GA, September 22-25, 2009.

[i.13] Walter, T., Enge, P., Blanch, J. and Pervan, B.: "Worldwide Vertical Guidance of Aircraft Based on Modernised GPS and New Integrity Augmentations", Proceedings of the IEEE Volume 96, Number 12, December 2008.

[i.14] Gratton, L., Joerger, M., Pervan, B: "Carrier Phase Relative RAIM Algorithms and Protection Level Derivation", Journal of Navigation Volume 63, Number 2, April 2010.

[i.15] Lee, Y: "Optimization of Position Domain Relative RAIM", ION GNSS 21st International Technical Meeting of the Satellite Division, Savannah, GA, September 16-19, 2008.

[i.16] M. Spangenberg PhD Thesis: "Safe navigation for vehicles", Ecole doctorale Mathématiques, Informatique et Télécommunications de Toulouse, Laboratoire de Télécommunications Spatiales et Aéronautiques (TéSA), June 2009.

[i.17] J.L. Farrell: "Full integrity testing for GPS/INS", Journal of the institute of navigation Volume 53, Number 1, Spring 2006, USA.

[i.18] Clark, B., Bevly, D.: "FDE Implementations for a Low-Cost GPS/INS Module", 22nd International Meeting of the Satellite Division of The Institute of Navigation, Savannah, GA, September 22-25, 2009.

[i.19] DO-316: "Minimum Operational Performance Standards for Global Positioning System/Aircraft Base Augmentation System".

3 Definitions and abbreviations

3.1 Definitions

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

almanac: information transmitted by a GNSS satellite consisting of coarse orbit and status information for each satellite in the constellation, an Ionospheric model, and information to relate GPS derived time to Coordinated Universal Time (UTC)

architecture: abstract representation of a communications system, in this case representing functional elements of the system and associated logical interfaces

assistance: use of position data available from a telecommunications network to enable a GNSS receiver to acquire and calculate position (A-GNSS) under adverse satellite reception conditions

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

class A, B, C: classes categorize the performance level of the GBLS for a given performance feature

NOTE: In all cases Class A is the highest performance class and C is the lowest.

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

NOTE: Continuity aids a user to start an operation during a given exposure period without an interruption of this operation and assuming that the service was available at beginning of the operation. Related to the Continuity concept, 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 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, and that degrades the performance of this link

NOTE: Jamming is a particular case of electromagnetic interference.

Horizontal Dilution Of Precision (HDOP): measure of position determination accuracy that is a function of the geometrical layout of the satellites used for the fix, relative to the receiver antenna

integrity: measure of the trust in the accuracy of the location-related data provided by the location system

NOTE: Integrity 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 does not fulfil the condition for intended operation. Specifically, a location system is required to deliver a warning (an alert) of any malfunction (as a result of a set alert limit being exceeded) to users within a given period of time (time-to-alert). Related to the Integrity concept, 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: risk that a positioning error is greater than a protection level per independent sample of time

jamming: deliberate transmission of interference to disrupt processing of wanted signals (which in this case are GNSS or telecommunications signals)

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

latency: time elapsed between the event triggering the determination of the location-related data for (a) location target(s) (i.e. location request from external client, external or internal event triggering location reporting), and the availability of the location-related data at the user interface

localization: process of determining the position or location of a location target

location: 3-dimensional position or location

location-based application: application that is able to deliver a location-based service to one or several users

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

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

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

location system: system responsible for providing to a location based application the Location-related data of one or several location targets

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

NOTE: This entity may be mobile or stationary.

Observed Time Difference Of Arrival (OTDOA): time interval observed between the reception of downlink signals from two different cells (in a cellular telecoms system). If a signal from cell 1 is received at the moment t_1, and a signal from cell 2 is received at the moment t_2, the OTDOA is $t_2 - t_1$

performance feature: set of performance requirements for a given location-related data category produced by the GBLS

position: 3-dimensional position or location

positioning: process of determining the position or location of a location target

privacy: function of a location system that aims at ensuring that the location target user private information (identity, bank accounts, etc.) and its location-related data cannot be accessed by a non-authorized third party

Protection Level (PL): upper bound to the positioning error such that the probability: $P(\varepsilon > PL) < I_{risk}$, where I_{risk} is the integrity risk and ε is the 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.

Pseudo-Random Noise Code (PRN): unique binary code (or sequence) transmitted by a GNSS satellite to allow a receiver to determine the travel time of the radio signal from satellite to receiver

Quality of Service (QoS): 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 authenticity flag.

security: function of a *location system* that aims at ensuring 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

spoofing: transmission of signals intended to deceive location processing into reporting false *location target* data e.g. meaconing

time-to-alert: time from when an unsafe integrity condition occurs to when an alerting message reaches the user

vertical axis: axis locally defined for the *location target*, collinear to the zenith/nadir axis

3.2 Abbreviations

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

3GPP	3rd Generation Partnership Project
A-GNSS	Assisted GNSS
AL	Alarm Limit
EGNOS	European Geostationary Navigation Overlay System
EMI	Electro-Magnetic Interference
E-UTRA	Evolved - UMTS Terrestrial Radio Access

FFS	For Further Study
FM	Frequency Modulation
GBLS	GNSS-based Location System
GEO	Geostationary Earth Orbit
GIC	GNSS Integrity Channel
GLONASS	Global Navigation Satellite System (Russian based system)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
HDOP	Horizontal Dilution of Precision
HPE	Horizontal Positioning Error
HPL	Horizontal Protection Level
INS	Inertial Navigation Sensor
ITS	Intelligent Transport Systems
LoS	Line of Sight
LTE	Long-Term Evolution
n/a	Not Applicable
OS	Open Service
OTDOA	Observed Time Difference of Arrival
PL	Protection Level
PRN	Pseudo-Random Noise code
PVT	Position, Velocity and Time
QoS	Quality of Service
RAIM	Receiver Autonomous Integrity Monitoring
RF	Radio Frequency
SF	Scale Factor
TBD	To Be Defined
TSP	Total Spoofing Power
TTFF	Time-To-Tirst-Fix
UMTS	Universal Mobile Telecommunications System
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
Wi-Fi	Wireless Fidelity
WPAN	Wireless Personal Area Network

4 Overview of GNSS-based Location System Performance, Features and Classes

4.1 GNSS-based Location System (GBLS)

The present document defines the performance requirements applicable to GNSS-based Location System (GBLS) location-related data.

GBLS Functional Requirements and Reference Architecture in ETSI TS 103 246-1 [7] and ETSI TS 103 246-2 [8] shall apply. A GBLS intends to provide one or more users with location-related data associated with one or more location targets. Figure 1 is an extract of ETSI TS 103 246-2 [8] and depicts the GBLS Architecture (level 2).

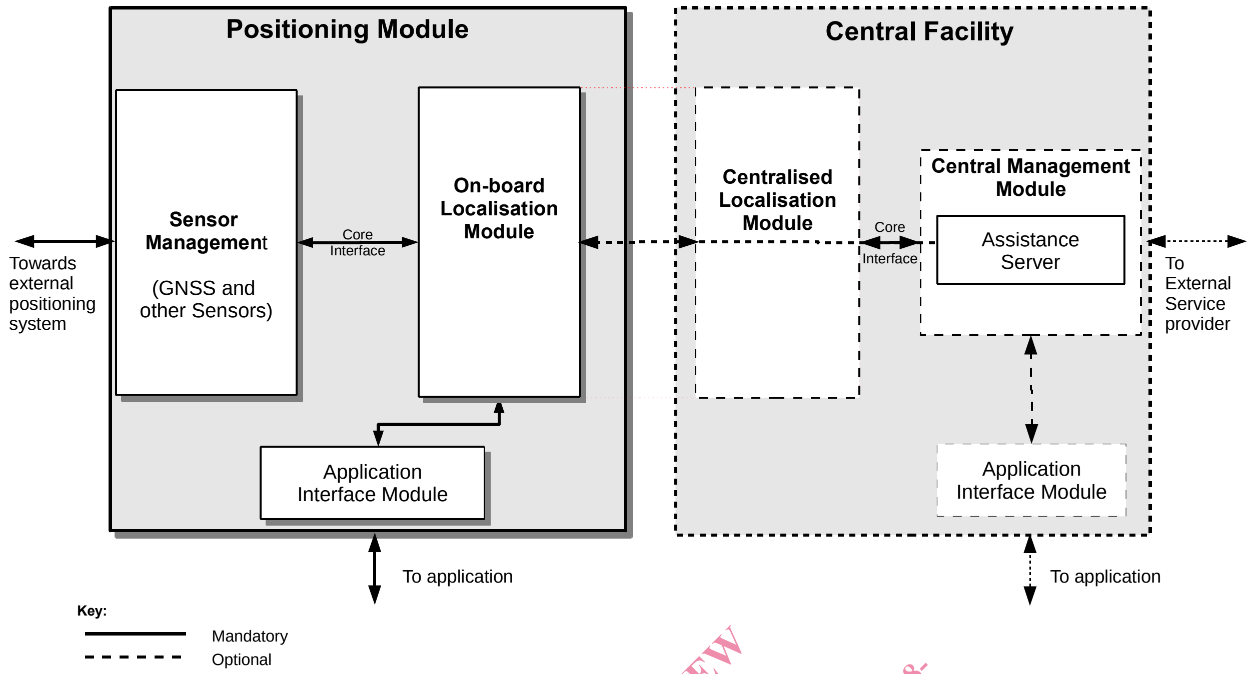

Figure 1: GNSS-based Location System (GBLS) Architecture

4.2 Performance Features

Location-related data delivered by a GNSS-based Location System is required to meet a number of performance requirements, derived from GBLS Functional requirements ETSI TS 103 246-1 [7]. These performance requirements are grouped in categories called Performance Features.

A detailed definition of each Performance Feature with its attributes and metrics is given in clause 5. Table 1 lists the Performance Features included in this technical specification and other additional features identified but left for further study (FFS):

Table 1: GBLS Performance Features

Performance Feature	Corresponding clause
Horizontal Position Accuracy	5.2
Vertical Position Accuracy	5.3
GNSS Time Accuracy	5.4
Time-To-First-Fix	5.5
Position Authenticity	5.6
Robustness to Interference	5.7
GNSS Sensitivity	5.8
Position Integrity (Protection Level)	5.9
Availability of Required Accuracy (probability that PVT data is provided with a certain level of accuracy)	*FFS*
EMI Localization Accuracy (error of location measurement of an interfering signal)	*FFS*
GNSS-Denied Accuracy (error in PVT data when there is a loss of GNSS signal reception)	*FFS*
Position Integrity (Time-to-Alert) (the time from occurrence of an unsafe integrity condition to the issue of an alerting message)	*FFS*
Position Integrity (Time-to-Recover-from-Alert) (the time from cancellation of an unsafe integrity condition to removal of an alerting message)	*FFS*
Accuracy of speed and acceleration (horizontal and vertical)	*FFS*