ETSI TS 103 246-5 V1.3.1 (2020-10)

TECHNICAL SPECIFICATION

Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 5: Performance Test Specification

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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 5 of a multi-part deliverable covering the GNSS based location systems, 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".

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Introduction

The increasing expansion of location-based applications aims to satisfy more and more complex and diversified user requirements: this is highlighted for example by the widespread adoption of multi-functional smart-phones or by the ever wider adoption of tracking devices (e.g. in transport), etc. This requirement for new and innovative location-based applications is generating a requirement for increasingly complex location systems.

The wide spectrum of location-based applications identified in ETSI TR 103 183 [i.1] calls for a new and broader concept for location systems, taking into account solutions in which GNSS technologies are complemented with other technologies to improve robustness and performance. The notion of **GNSS-based location systems** is introduced and defined in the present document.

Additional clauses and information related to the implementation in **GNSS-based location systems** of the various differential GNSS technologies, namely D-GNSS, RTK and PPP are also included in order to facilitate the use of this set of standards by manufacturers and service providers.

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1 Scope

The present document specifies the procedures for testing conformance of complex GNSS Based Location System (GBLS) with the performance requirements specified in ETSI TS 103 246-3 [3].

ETSI TS 103 246 part 1 [1], part 2 [2], part 3 [3] and part 4 [4] address integrated GNSS Based Location Systems (GBLS) that combine Global Navigation Satellite Systems (GNSS), with other navigation technologies, as well as with telecommunication networks in order to deliver location-based services to users. As a consequence the present document is not applicable to GNSS only receivers.

ETSI TS 103 246 part 1 [1], part 2 [2], part 3 [3] and part 4 [4] propose a list of functional and performance requirements and related test procedures. For each performance requirement, different classes are defined allowing the benchmark of different GNSS Based Location Systems (GBLS) addressing the same applications.

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 https://docbox.etsi.org/Reference/.

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

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

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

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

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

2.2 Informative references

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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 137 571-1: "Universal Mobile Telecommunications System (UMTS); LTE; User Equipment (UE) conformance specification for UE positioning; Part 1: Conformance test specification (3GPP TS 37.571-1)".

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[i.3] IEEE 802.11™: "IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications".

[i.4] IEEE 802.15.1™: "IEEE Standard for Telecommunications and Information Exchange Between Systems - LAN/MAN - Specific Requirements - Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Wireless Personal Area Networks (WPANs)".

[i.5] IEEE 802.15.4a™: "IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs): Amendment 1: Add Alternate PHY".

[i.6] ETSI TS 145 001: "Digital cellular telecommunications system (Phase 2+) (GSM); GSM/EDGE 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] M.M. Desu, D. Raghavarao: "Non-parametric Statistical Methods For Complete and Censored Data", CRC press, 29th September 2003.

[i.10] RINEX: "The Receiver Independent Exchange Format", Version 2.10.

[i.11] RINEX: "The Receiver Independent Exchange Format", Version 3.02.

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3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 246-1 [1] and the following apply:

accuracy (or error): difference between a measured or estimated value and its real value

almanac: information providing coarse orbit and coarse clock model information for GNSS satellites. Database providing location information for a reference network used for positioning

assistance: use of position data from, typically, a telecommunications network to enable a GBLS to acquire the GNSS signals and to calculate position or time more quickly

EXAMPLE: A-GNSS.

authentication: process/protocol to provide authenticity

authenticity: assurance that the location-related data associated with a location target has been derived from real and not falsified signals

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

class A, B, C: categorization of 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.

coarse time assistance: use of a rough estimate of current time (typically to within two seconds) to enable a GBLS to acquire the GNSS signals and to calculate position or time more quickly

EXAMPLE: Part of A-GNSS.

cold-start: condition of the GBLS GNSS receiver having no accurate prior information on the position, velocity and time of the location target, or on the positions of any of the GNSS satellites

continuity: likelihood that the location system functionality will be available during the complete duration of the intended operation if the system is operational at the beginning of the operation

D-GNSS: technique aiming at enhancing position accuracy and integrity of a GNSS receiver by using differential pseudorange corrections and "do not use flag" for faulty satellites delivered by a GNSS reference station located at a known location

NOTE: In the present document, the term D-GNSS refers to conventional differential GNSS.

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

estimator: rule in statistics for calculating an estimate of a given quantity based on observed data

fine time assistance: use of a good estimate of current time (typically to within ten micro-seconds) to enable a GBLS to acquire the GNSS signals and to calculate position or time more quickly

EXAMPLE: Part of A-GNSS.

GNSS Based Location System (GBLS): location system using GNSS as the primary source of positioning or timing

GNSS only receiver: location receiver using GNSS as the unique source of positioning or timing

GNSS Signal Generator (GSG): device or system capable of generating simulated GNSS satellite transmissions in order to create the required test environment for the GNSS sensor under test

integrity: measure of the trust in the accuracy of the location-related data provided by the location system and the ability to provide timely and valid warnings to users when the location system does not fulfil the condition for intended operation

NOTE: Integrity is expressed through the computation of a protection level. The Integrity function is designed to deliver a warning (or alert) of any malfunction 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 (i.e. a positioning error higher than the protection level) occurs without a warning to the users for a time longer than the time-to-alert limit.

jamming: deliberate transmission of interference to disrupt communications

location: 3-dimensional position or location

location-based application: application which is able to deliver a service to one or several users, built on the processing of the location information (location-related data) related to one or several targets

location-related data: set of data associated with a given location target

NOTE: Containing at least one or several of the following time-tagged information elements: location target position, location target motion indicators (velocity and acceleration) location target timing, and Quality of Service indicators (estimates of the position accuracy, reliability or authenticity).

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 (mobile or stationary) whose position is the focus of the location related data to be built by the location system

percentile: percentage of a set of observations of a parameter which give a successful result (i.e. success rate)

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

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Precise Point Positioning (PPP): differential GNSS technique that uses a worldwide distributed network of reference stations to provide, in quasi real time, a highly accurate geodetic positioning of a receiver

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.

pseudorange: pseudo distance between a satellite and a navigation receiver computed by multiplying the propagation delay determined by the receiver with the speed of light

Pseudorange Correction (PRC): simple difference between a pseudorange measured by a GNSS reference station, set at a known location and the estimated range between the satellite and this known location

Real Time Kinematic (RTK): particular Differential GNSS technique that provides, in real time, highly accurate positioning of a target based on carrier phase measurements

spoofer: device or system that generates false GNSS signals intended to deceive location processing into reporting false location or timing target data

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

target: See location target

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

WGS84: reference coordinate system used by the Global Positioning System

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3.2 Symbols

For the purposes of the present document, the symbols given in ETSI TS 103 246-1 [1] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 246-1 [1] and the following apply:

3GPP	3rd Generation Partnership Project
A-GNSS	Assisted GNSS
AT	Along-Track
BDS	BeiDou Navigation Satellite System
CL	Confidence Level
CT	Cross-Track
DGE	Data Gathering Equipment
D-GNSS	Differential GNSS
DUT	Device Under Test
ENU	East/North/Up reference frame
EN	East/North reference frame
E-UTRA	Evolved - UMTS Terrestrial Radio Access
FFS	For Further Study
GBLS	GNSS Based Location System
GLONASS	Global Navigation Satellite System (Russian based system)
GMLC	Gateway Mobile Location Centre
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSG	GNSS Signal Generator
GSM	Global System for Mobile communications
HPE	Horizontal Positioning Error
HPL	Horizontal Protection Level
IP	Implementation Profile
ITS	Intelligent Transport Systems

LoS	Line of Sight
LPP	LTE Positioning Protocol
LPPe	LTE Positioning Protocol extension
LTE	Long-Term Evolution
n/a	not applicable
PL	Protection Level
PRC	PseudoRange Correction
PVT	Position, Velocity and Time
RF	Radio Frequency
RTK	Real Time Kinematic
SMLC	Serving Mobile Location Centre
SNR	Signal-to-Noise Ratio
TBD	To Be Defined
TTFA	Time-To-Fix Ambiguity(ies)
TTFF	Time-To-First-Fix
UMTS	Universal Mobile Telecommunications System
UTRA	UMTS Terrestrial Radio Access
Wi-Fi®	Wireless Fidelity
WPAN	Wireless Personal Area Network

4 General

4.1 GBLS Performance Features

Clauses 6 to 13 define the test procedures required to test conformance with the Performance Features defined in ETSI TS 103 246-3 [3].

These Features are:

1) Horizontal Position Accuracy.
2) Vertical Position Accuracy.
3) Time-To-First-Fix (TTFF).
4) Position Authenticity.
5) Robustness to Interference.
6) GNSS Sensitivity.
7) Position Integrity (Protection Level).
8) Position day-to-day repeatability (in the Horizontal Plane and in the Vertical Plane.
9) Time-To-Fix Ambiguity (TTFA).

NOTE: The test procedure for the feature "GNSS Time Accuracy" defined in ETSI TS 103 246-3 [3] is FFS.

The tests specified are of a complete GBLS, considered as "Black Box" i.e. the tests are made at outputs of the system in response to stimuli applied at the inputs. The tests are defined for laboratory testing only, and not in the "field".

4.2 Conformance Test Statistics

Performance requirements in ETSI TS 103 246-3 [3] are expressed either as a single value or, when it has a statistical nature, as a success rate.

When testing a parameter with a statistical nature, a confidence level is set in the conformance test defined herein which establishes the probability that the GBLS passing the test meets the requirement and determines how many times a test has to be repeated.

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4.3 GBLS Performance Class Determination

Performance features are defined in ETSI TS 103 246-3 [3] for GBLS performance classes A, B and C.

Results of the conformance tests herein allow a GBLS to be allocated to one of the three classes according to the definition in ETSI TS 103 246-3 [3], unless otherwise specified.

5 General test conditions

5.1 Introduction

This clause defines the common test conditions required for all tests in the remainder of the present document, unless otherwise specified.

5.2 Environmental conditions

The environmental conditions for test will be defined by the GBLS vendor.

5.3 GNSS signal conditions

5.3.1 Applicable GNSS constellations

The applicable GNSSs are defined in clause A.2 of ETSI TS 103 246-3 [3].

Each test defined in the following clauses shall be performed with the combination of GNSS constellation(s) and satellite signal(s) simultaneously supported by the GBLS under test.

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5.3.2 GNSS signal level

The GNSS signal is defined at the GNSS antenna connector of the GBLS. For a GBLS with only an integral GNSS antenna, this is assumed to be an antenna with a gain of 0 dBi. The reference input signal power levels are defined in table 5.1.

Table 5.1: Reference Power and Relative signal power levels for each GNSS signal type

	Galileo		GPS/Modernized GPS		GLONASS		BDS (note 2)	
Reference power (dBm)		-130		-128,5		-131		-130
Signal power level relative to reference power level (dB)	E1	0	L1 C/A	0	G1	0	B1 D1	0
	E6	+2	L1C	+1,5	G2	-6	B1 D2	+5
	E5	+2	L5	+3,6				
NOTE 1: The GNSS signal power levels in the table represent the total signal power per channel for pilot and data channels.								
NOTE 2: For test cases which involve "BeiDou", D1 represents MEO/IGSO satellites of B1I signal type and D2 represents GEO satellites of B1I signal type.								

5.3.3 GNSS frequency

GNSS signals shall be transmitted with a frequency accuracy of ±0,025 PPM.

5.3.4 GNSS Multi-system Time Offsets

If more than one GNSS is used in a test, the accuracy of the GNSS-GNSS Time Offsets at the GSG shall be better than 1 ns. The particular case where the GBLS uses D-GNSS, RTK or PPP is FFS.