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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 GNSS-based Location Systems (GBLS), as identified in part 1 [1].

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 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.

1 Scope

This multi-part deliverable addresses 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.

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].

This multi-part deliverable proposes 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.

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".

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

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] ETSI TS 137 571-1: "Universal Mobile Telecommunications System (UMTS); LTE; Universal Terrestrial Radio Access (UTRA) and Evolved UTRA (E-UTRA) and Evolved Packet Core (EPC); User Equipment (UE) conformance specification for UE positioning; Part 1: Conformance test specification (3GPP TS 37.571-1)".

[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+); 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.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions 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 more quickly (e.g. A-GNSS)

availability: 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.

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 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 refer 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

GNSS-based location system (GBLS): location system using GNSS as the primary source of positioning

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

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, 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)

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

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: $P(\varepsilon > \mathrm{PL}) < I_{risk}$, 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

Pseudo Range 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 target data

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

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
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
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
PVT	Position, Velocity and Time
RF	Radio Frequency
SMLC	Serving Mobile Location Centre
SNR	Signal-to-Noise Ratio
TBD	To Be Defined
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.

9) Time To Fix Ambiguity.

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

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.

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 GNSS's 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.

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 ±2,5 × 10E-8.

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.

5.4 Operational Environments

General operational environments are as defined in clause A.3 of ETSI TS 103 246-3 [3], and specifically in each of the clauses for Performance Features in ETSI TS 103 246-3 [3].

5.5 Assistance Data

Any assistance data required by the GBLS shall relate to the scenario(s) being generated and shall be provided by the appropriate means (e.g. by simulating a server such as an SLP, GMLC, SMLC and by transmission over a suitable telecommunications link).

5.6 Differential Data

Any GNSS differential data required by the GBLS shall relate to the scenario(s) being generated and shall be provided by the appropriate means:

- Simultaneous simulation of the GNSS signals as received differentially by one reference station and by the location target from a common scenario.
- Simultaneous simulation of the GNSS signals as received by the location target and of a communication link carrying the corresponding differential messages simulated as supplied by a differential service provider from a network of stations.

5.7 Test Configurations

5.7.1 General Set-Up

In general the tests for GBLS signal performance shall be conducted using RF simulators generating GNSS and telecoms transmission and reception signals and other sensor simulators, connected either:

1) using antennas in an anechoic chamber (e.g. if the GBLS has integral antennas); or
2) with wired RF connections only when access to the GBLS antenna connectors is available.

5.7.2 GNSS Signal Generator

In each case the test set-up consists of a GNSS Signal Generator (GSG) connected to the GBLS input and generating a set of emulated GNSS RF signals as defined in clause 5.3 and in annex A of ETSI TS 103 246-3 [3].

The GSG shall simulate atmospheric effects (ionosphere, etc.) as specified in annex B.

The GSG shall simulate the satellites that satisfy all the following conditions:

- elevation > 5 degrees from the GBLS GNSS sensor position (clause B.1);
- those that are practically visible by the GBLS in sky attenuation conditions applicable to the relevant test (see clause A.3.2 of ETSI TS 103 246-3 [3]) (i.e. where sky attenuation < 100 dB).

In any case the maximum number of satellites to be simulated per constellation is given in table 5.2. The selection of these visible satellites shall be at the discretion of the test operator.

Table 5.2: Maximum number of visible Satellites to be simulated by the GSG

GNSS receiver capability of the GBLS	Maximum number of satellites to be simulated
Single constellation receiver	8
Dual constellation receiver	8
Triple constellation receiver	8
Quad constellation receiver	6

When the GBLS under test is to be tested in GNSS differential mode and when only one reference station is used (conventional D-GNSS and RTK), then the GSG shall generate a set of emulated GNSS RF signals as defined in clause 5.6 and in ETSI TS 103 246-3 [3] on at least two RF outputs, one for the location target GNSS sensor and one for the GNSS sensors included in the reference stations. For both RF outputs the satellite transmitters are the same and at the same location, but the geometric range used to generate the received signal are different (target location and reference station location).

When the GBLS under test is to be tested in GNSS differential mode and when a network of stations is used (NRTK or PPP), then the GSG shall generate a set of emulated GNSS RF signals as defined in clause 5.6 and in ETSI TS 103 246-3 [3], and a simulator of a network of reference stations shall simultaneously compute the consistent observable and/or correction data that could have been sent by an appropriate differential GNSS service provider network.

5.7.3 Sensor Simulators/Stimulators

One or more sensor simulators are needed to test some GBLS implementations which include such sensors and where an interface to the relevant external sensor is provided by the GBLS.

Otherwise if the sensor is embedded in the GBLS, a sensor stimulator for the laboratory environment (if possible) is needed.

The requirements for sensor simulators or stimulators are shown in table 5.3.

Table 5.3: GBLS requirements for sensor simulators/stimulators

GBLS Sensor	Simulator	Stimulator
Odometer	Digital input of distance travelled (metres)	Rolling road
Magnetometer	Digital input of magnetic field strength	Rotating platform
Inertial Sensor	Digital input of orientation and acceleration (ms^{-2})	N/A
Beam-Forming Network	Digital input of (relative) signal levels to antenna connectors.	Rotating platform relative to RF source(s)

5.7.4 Telecoms RF Simulators

Telecoms RF Simulators are needed to test some GBLS implementations which include telecoms sensors for:

- Wi-Fi® [i.3].
- Wireless Personal Area Network (short range wireless) [i.3]:
  - Bluetooth® [i.4].
  - WPAN [i.5].
- Cellular:
  - GSM [i.6].
  - UTRA [i.7].
  - E-UTRA [i.8].

These simulators shall include simulation of the operational environment masking effects and beacon densities defined in annex A of ETSI TS 103 246-3 [3]. Other parameters, such as the minimum SNR of cells to be simulated, are FFS.

5.7.5 GBLS output measurement data

Performance measurements during testing shall be made using the GBLS output data on its external interface to which a Data Gathering Equipment (DGE) shall be connected.

The exact form of this data at its external interface depends on the GBLS implementation, and hence the DGE (Data Gathering Equipment) shall be adapted to the GBLS under test. However, the GBLS output data content is defined in ETSI TS 103 246-1 [1] and ETSI TS 103 246-4 [4].

The rate at which the GBLS output data is sampled by the DGE during testing is given in each test. If possible the GBLS should be configured to provide data at this rate. If not possible then the DGE shall select samples for testing at the required rate. If the GBLS does not provide data at the required rate (i.e. the rate is slower than required) then the DGE shall use the GBLS output data at the rate provided and adjust the test conditions accordingly.

6 Horizontal and Vertical Position Accuracy

6.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS in estimating the location target position in both horizontal and vertical planes.

The horizontal and vertical accuracy tests can be combined since each position measurement can be used to derive both parameters.

The position accuracy test shall be repeated for all the combinations of location target environments and motion types as defined in table 6.1 and completely specified in clauses 5.2 and 5.5 of ETSI TS 103 246-3 [3].

Table 6.1: Horizontal and Vertical Position Accuracy test cases

Test case	Operational Environment	Location target dynamic conditions	Applicable Implementation Profile (Annex E)
T-HVA-01	Open Area	Moving Location Target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-HVA-02	Urban area	Moving Location Target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-HVA-03	Asymmetric area	Moving Location Target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-HVA-04	Open Area	Static location target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-HVA-05	Urban area	Static location target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-HVA-06	Asymmetric area	Static location target	IP1, IP2, IP3, IP4, IP5, IP6, IP7
NOTE: Tests for IP's 2,3,5 and 6 listed in this table are FFS.			

6.2 Method of Test

6.2.1 Introduction

The test procedure is defined as two overall steps which are performed for each test case:

1) measurement procedures (data collection);

2) measurement data analysis.

The steps are specified in clauses 6.2.2 to 6.2.6.

6.2.2 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

6.2.3 Measurement Procedures

6.2.3.1 Test cases T-HVA-01/02/03: Moving location target

Repeat all steps below for Test Cases T-HVA-01 to T-HVA-03:

1) Set the GSG parameters to generate the following scenario:

- the location target to start at a random point within a 3 km radius of the reference location defined in clause B.1, with an altitude randomly selected between 0 m and 500 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
- the appropriate operational environment as defined in clause A.3 of ETSI TS 103 246-3 [3];
- the GNSS input signal power level as defined in clause 5.3.2.

2) Reset and start the GBLS.

3) Collect 200 GBLS position data samples at a rate of one per 120 s (to guarantee statistically independent PVT samples).

NOTE: This interval between samples ensures that GBLS position data samples are statistically independent.

6.2.3.2 Test cases T-HVA-04/05/06: Static location target

The procedure for these test cases is the same as in clause 6.2.3.1 except for step 1, where the location target shall remain stationary at its initial location.

6.2.4 Measurement Data Analysis

6.2.4.1 General

Process the data collected during the measurement phase as follows.

For each position measurement, calculate the position error $\varepsilon_i^{(ENU)}$ with respect to the true position using coordinates in the East-North-Up (ENU) reference frame, whose local origin is the true position of the target at the same instant. The subscript *i* is used to indicate the *i-th* measurement of *N*, the total number of measurement samples.

$\varepsilon_i^{(ENU)} = \{\varepsilon_i^E, \varepsilon_i^N, \varepsilon_i^U\}$ is a three-dimensional vector, whose elements are:

- ε_i^E is the error along the East axis;
- ε_i^N is the error along the North axis;
- ε_i^U is the error along the Up axis.

The $\varepsilon_i^{(ENU)}$ values are used in clauses 6.2.4.2.1 and 6.2.4.3.

6.2.4.2 Horizontal Position Error

6.2.4.2.1 Moving location target

For each $\varepsilon_i^{(ENU)}$ sample, calculate the horizontal position error ($\varepsilon_i^{(AC)}$) in the Along Track - Cross Track (AT, CT) frame using the formulae in annex C.

NOTE: $\varepsilon_i^{(AC)}$ are two-dimensional vectors.

Calculate the statistics of the horizontal position errors $\varepsilon_i = \varepsilon_i^{(AC)}$, as required for the "metrics" of this Performance Feature in ETSI TS 103 246-3 [3], using the formulae in table 6.2.

Table 6.2: Metrics for Horizontal Position Accuracy

Metric	Estimator
Mean value	$\hat{m}_{\varepsilon} = \frac{1}{N}\left\Vert \sum_{i=1}^{N} \varepsilon_i \right\Vert$ where: $\Vert x \Vert$ is the Euclidean norm of the vector x.
Standard deviation	$\hat{\sigma}_{\varepsilon} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} \Vert \varepsilon_i - \hat{\mu}_{\varepsilon} \Vert^2}$ where: $\hat{\mu}_{\varepsilon} = \frac{1}{N}\sum_{i=1}^{N} \varepsilon_i$ is a two-dimensional vector.
p^{th} percentile	Use the nearest rank estimator for the p^{th} percentile: $\hat{\Gamma}_p^{(AC)} = Y^{(AC)}[n]$; where: $Y^{(AC)} = sort\{\Vert \varepsilon^{(AC)} \Vert\}$ is a magnitude-ordered vector of N elements; $\varepsilon^{(AC)}$ is the vector of the N measured errors $\varepsilon_i^{(AC)}\ i = 1 \ldots N$; $n = \left\lceil \frac{p}{100} \cdot N \right\rceil$.
Mean CT/AT errors	$\hat{m}_{\varepsilon,CT} = \vert \hat{\mu}_{\varepsilon,CT} \vert$ $\hat{m}_{\varepsilon,AT} = \vert \hat{\mu}_{\varepsilon,AT} \vert$ where: $\hat{\mu}_{\varepsilon,CT}, \hat{\mu}_{\varepsilon,AT}$ are the CT and AT components of the vector $\hat{\mu}_{\varepsilon}$.
CT/AT errors, and corresponding p^{th} percentile	Estimate the standard deviation of the CT or AT errors: $\hat{\sigma}_{\varepsilon,X} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N} \left(\varepsilon_{i,X} - \hat{\mu}_{\varepsilon,X} \right)^2}$ where: $X = \{CT, AT\}$; Use the nearest rank estimator for the corresponding p_X^{th} percentile $\hat{\Gamma}_p^X$: $\hat{\Gamma}_p^X = Y^X[n]$; where: $Y^X = sort\{\vert \varepsilon^X \vert\}$ is a magnitude-ordered vector of N elements; ε^X is the vector of the N measured errors $\varepsilon_i^{(X)}\ i = 1 \ldots N$, with $X = \{CT, AT\}$; $n = \left\lceil \frac{p}{100} \cdot N \right\rceil$.

6.2.4.2.2 Static location target

Calculate the statistics of the horizontal position errors using the formulae above in clause 6.2.4.2.1 for Mean value, Standard Deviation and p^{th} percentile, but using the $\varepsilon_i^{(ENU)}$ error coordinates in East/North (EN) axes to replace Along Track/Cross Track (AC) coordinates.

6.2.4.3 Vertical Position Error

For the $\varepsilon_i^{(ENU)}$ samples, calculate the statistics of the vertical position errors, as required for the "metrics" of this Performance Feature in ETSI TS 103 246-3 [3], using the formulae in table 6.3.

Table 6.3: Metrics for Vertical Position Accuracy

Metric	Estimator
Mean value	$\hat{m}_\varepsilon = \frac{1}{N}\left\vert\sum_{i=1}^{N}\varepsilon_i^U\right\vert$ where: $\vert x \vert$ is the absolute value of the scalar quantity x.
Standard deviation	$\hat{\sigma}_\varepsilon = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left\vert\varepsilon_i^U - \hat{\mu}_\varepsilon\right\vert^2}$ where: $\hat{\mu}_\varepsilon = \frac{1}{N}\sum_{i=1}^{N}\varepsilon_i^U$ is a scalar quantity.
p^{th} percentile	Use the nearest rank estimator for the p^{th} percentile: $\hat{\Gamma}_p^U = Y^U[n]$; where: $Y^U = sort\{\vert\varepsilon^U\vert\}$ is a magnitude-ordered vector of N elements; ε^U is the vector of the N measured errors ε_i^U $i = 1 \ldots N$; $n = \left\lceil \frac{p}{100} \cdot N \right\rceil$.

6.2.4.4 Confidence Intervals

Calculate the 95 % Confidence Intervals as defined in clause D.3 for:

a) the mean value of the AT and CT and vertical positioning errors, for a moving location target;

b) the mean value of the vertical positioning errors, for a static location target.

Calculate the confidence level for the estimated percentiles as defined in clause D.4.

6.2.5 Pass/fail criteria

Compare the metrics calculated in clause 6.2.4 for each Test Case against the corresponding values specified for horizontal and vertical position performance requirements in ETSI TS 103 246-3 [3], and consider the test result as "pass" for each metric if:

a) The position accuracy requirement is met.

b) The upper bound of the 95 % confidence intervals of the mean values of the positioning errors is less than the maximum value specified in ETSI TS 103 246-3 [3].

c) The confidence level for the estimated percentiles is higher than 90 %.

Otherwise the test result for the relevant Test Case and metric is "fail".

6.2.6 GBLS Class Allocation

The allocation of GBLS test results to GBLS classes shall also be done at this stage according to the definition in ETSI TS 103 246-3 [3].

7 Time-to-First-Fix (TTFF)

7.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS in terms of TTFF within a given positional accuracy. The following test cases cover TTFF conformance in the combinations of GBLS implementation profiles, location target dynamic conditions and operational environments as defined in ETSI TS 103 246-3 [3].

The GBLS shall be tested under the following starting conditions of the GNSS sensor (as defined in ETSI TS 103 246-3 [3]), according to the implementation profile under test which may determine whether fine or coarse assistance is required:

- Assisted cold-start with fine time assistance.
- Assisted cold-start with coarse time assistance.
- Cold-start without assistance.

For each of the above starting conditions a set of sub-tests shall be made as defined in table 7.1. The operational environments for these sub-tests are defined in clause 5.5 of ETSI TS 103 246-3 [3].

Table 7.1: TTFF Sub-tests definition for applicable scenarios and implementation profiles

Test case	Operational Environment	Location target dynamic conditions	Interference (min. background noise power density)	Applicable Implementation Profile (Annex E)
T-TTF-01	Open Area	Moving (outdoor)	N/A	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-TTF-02	Urban area	Moving (outdoor)	N/A	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-TTF-03	Urban area	Moving (outdoor)	-195 dBW/Hz	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-TTF-04	Asymmetric area	Moving (indoor)	N/A	IP1, IP5, IP7
T-TTF-05	Asymmetric area	Moving (indoor))	-195 dBW/Hz	IP1, IP5, IP7
T-TTF-06	Open Area	Static	N/A	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-TTF-07	Urban area	Static	N/A	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-TTF-08	Asymmetric area	Static	N/A	IP1, IP5, IP7
NOTE: Tests for IP's 2,3,5 and 6 listed in this table are FFS.				

7.2 Method of Test

7.2.1 Introduction

The TTFF is evaluated in terms of response time of the GBLS. The response time is defined as the time starting from the moment that the GNSS sensor is reset (Autonomous Cold start) to the time of issue of the GBLS measurement report containing the first position estimate.

7.2.2 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

7.2.3 Measurement Procedures

7.2.3.1 Test cases T-TTF-01 to -05: Moving location target

Repeat all steps below for all these Test Cases:

1) Set the GSG parameters to generate the following scenario:

    - The location target to start at a random point within a 3 km radius of the reference location defined in clause B.1, with an altitude randomly selected between 0 m and 500 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3].
    - The scenario start time shall be randomly delayed by 0 to 30 s from start time given in clause B.1.
    - The operational environment applicable (defined in clause A.3 of ETSI TS 103 246-3 [3]).
    - The GNSS input signal power level as defined in clause 5.3.2.

2) Start the GBLS from a "cold-start" state: the GBLS GNSS sensor shall discard any stored GNSS reference time, location, and any other assistance data obtained or derived during a previous test instance (e.g. expected ranges and Doppler).

3) If the subsequent GBLS location target position output data:

   a) is generated within the max. TTFF response time specified for 95 % success rate in ETSI TS 103 246-3 [3]; and

   b) the horizontal and vertical position errors, calculated from the difference between the measured and true position, are less than 100 m;

   then record one Good Result;

   else record one Bad Result.

4) Repeat steps 1 to 3 until the statistical requirements for 95 % success rate and 95 % confidence level are met, as defined in clause D.1. Record a Pass or Fail for the relevant test case as a result of these measurements.

7.2.3.2 Test cases T-TTF-05 to -08: Static location target

The procedure for these test cases is the same as in clause 7.2.3.1 except for step 1, where the location target shall remain stationary at its initial location.

7.3 Pass/fail criteria

The GBLS shall meet the requirements for 95 % success rate specified for TTFF in ETSI TS 103 246-3 [3] for each test case according to the method defined in clause 7.2.3.1.

7.4 GBLS Class Allocation

The allocation of test results of TTFF to GBLS classes shall be done after determining the pass/fail criteria according to the definition in ETSI TS 103 246-3 [3].

8 Position Authenticity

8.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS in:

1) avoiding false alarms under nominal GNSS signal conditions and no interfering signals (Clear scenario);

2) detecting a spoofing attack (Threat scenario).

The position authenticity test shall be repeated for the combinations of location target motion types and threat scenarios defined in the table below, and specified in clause 5.6 of ETSI TS 103 246-3 [3].

Table 8.1: Position Authenticity test cases

Test case	Performance Feature	Location target dynamic conditions	Scenario	Applicable Implementation Profile (Annex E)
T-PA-01	Probability of False Alarm	Moving Location Target	Clear scenario	IP2
T-PA-02	Probability of Detection	Moving Location Target	Threat scenario: M-1, M-2, M-3	IP2
T-PA-03	Probability of False Alarm	Static Location Target	Clear scenario	IP2
T-PA-04	Probability of Detection	Static Location Target	Threat scenario: S-1, S-2, S-3	IP2

8.2 Method of test

8.2.1 Introduction

The test procedure is defined as two overall steps which are performed for each test case:

1) measurement procedures (data collection);

2) measurement data analysis.

The steps are specified in clauses 8.2.2 to 8.2.4.

8.2.2 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

The Spoofer shall generate the set of simulated GNSS-like signals defined in clause A.7 of ETSI TS 103 246-3 [3].

NOTE: If the GSG is able to generate shadowed spoofing attacks, a separate Spoofer is not needed.

The GBLS authentication data output *auth_flag* (Yes/No) is defined in ETSI TS 103 246-4 [4]. An authentication "No" flag signifies an "alarm" for the PVT output data.

8.2.3 Measurement procedures

8.2.3.1 Test cases T-PA-01 and T-PA-02: Moving location target

Repeat all steps below for each Test Case.

1) Set the GSG parameters to generate the following scenario:

   - The location target at a random point within a 3 km radius of the reference location defined in clause B.1, with an altitude randomly selected between 0 m and 500 m, and to continue moving along the trajectory defined in clause A.5 of ETSI TS 103 246-3 [3].

   - The scenario start time shall be randomly delayed by 0 to 30 s from start time given in clause B.1.

   - The appropriate operational environment (open sky conditions) as defined in clause A.3 of ETSI TS 103 246-3 [3];

2) For T-PA-02 only, set the RF spoofer to generate false GNSS signals according to the scenario under test (i.e. M-1, M-2, or M-3) defined in clause A.7 of ETSI TS 103 246-3 [3].

3) Reset and start the GBLS.

4) Collect 1 000 authentication data samples at the output of the GBLS at intervals of 1 s, and for each of these collect the associated GBLS PVT data. If statistically independent authentication data measurements cannot be guaranteed at 1 s sample intervals, this interval shall be increased to 30 s.

NOTE: The GBLS authentication data output is determined by algorithms that detect, and possibly mitigate, the presence of structured RF interference. These algorithms determine the minimum periods for which authentication data samples are statistically independent.

5) For T-PA-02 only. repeat steps 2 to 4 above for each of the Total Spoofing Power values as given in the performance requirements in table 31 of ETSI TS 103 246-3 [3].

8.2.3.2 Test cases T-PA-03 and T-PA-04: Static location target

Repeat all steps below for each Test Case.

1) Set the GSG to generate the following scenario:

   - the location target at a random point within a 3 km radius of the reference location defined in clause B.1 and with an altitude randomly selected between 0 m and 500 m;

   - the scenario start time shall be randomly delayed by 0 to 30 s from start time given in clause B.1;

   - the appropriate operational environment (open sky conditions) as defined in clause A.3 of ETSI TS 103 246-3 [3].

2) For T-PA-04 only, set the RF spoofer to generate false GNSS signals according to the scenario under test (i.e. S-1, S-2, or S-3) defined in clause A.7 of ETSI TS 103 246-3 [3].

3) Reset and start the GBLS.

4) Collect 1 000 authentication data samples at the output of the GBLS at intervals of 1 s, and for each of these collect the associated GBLS PVT data. If statistically independent authentication data measurements cannot be guaranteed at 1 s sample intervals, this interval shall be increased to 30 s.

5) For T-PA-04 only, repeat the steps 2 to 4 above for each of the Total Spoofing Power values as given in the performance requirements in table 33 of ETSI TS 103 246-3 [3].

8.2.4 Measurement Data Analysis

8.2.4.1 Probability of False Alarm (Test cases T-PA-01 and T-PA-03)

Process the data collected during the measurement phase as follows.

$\hat{P}_{FA}$ is calculated (in %) as: $\hat{P}_{FA} = \frac{N_A}{K} \cdot 100$

where: N_A is the number of authentication data detections collected where *auth_flag* = No;

K is the total number of observations.

8.2.4.2 Probability of Detection (Test cases T-PA-02 and T-PA-04)

Process the data collected during the measurement phase as follows.

If the PVT data associated with any authentication data where *auth_flag* = Yes exceeds the time or position error specified in clause 5.6 of ETSI TS 103 246-3 [3], then this sample shall be changed to *auth_flag* = No.

$\hat{P}_D$ is calculated (in %) as: $\hat{P}_D = \frac{N_D}{K} \cdot 100$

where: N_D is the number of authentication data detections collected where *auth_flag* = No.

8.3 Pass/Fail Criteria

8.3.1 T-PA-01 and T-PA-03

In each case the test is passed when the calculated Probability of False Alarm ($\hat{P}_{FA}$) is lower than the values of Probability of False Alarm (P_{FA}) specified in ETSI TS 103 246-3 [3].

8.3.2 T-PA-02 and T-PA-04

In each case the test is passed when the calculated Probability of Detection ($\hat{P}_D$) is higher than the values of Probability of Detection (P_D) specified in ETSI TS 103 246-3 [3].

8.4 GBLS Class allocation

The allocation of GBLS test results to GBLS classes shall be done at this stage according to the definition in ETSI TS 103 246-3 [3].

9 Robustness to Interference

9.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS in terms of the maximum Jammer-to-GNSS signal power ratio (J/S) at the GBLS antenna that allows a position fix.

A set of sub-tests shall be made for different jamming types as defined in table 7.1. The operational environments for these sub-tests are defined in clause A.3 of ETSI TS 103 246-3 [3].

Table 9.1: Robustness to Interference test cases and applicable implementation profiles

Test case	Interference	Applicable Implementation Profile (Annex E)
T-INT-01	Jammer source J#1	IP1, IP2, IP3, IP4, IP5, IP6, IP7
T-INT-02	Jammer source J#2	IP1, IP2, IP3, IP4, IP5, IP6, IP7
NOTE: Tests for IP's 2,3,5 and 6 listed in this table are FFS.		

9.2 Method of Test

9.2.1 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

In particular the Interference Generator shall generate the set of signals defined in clause A.6 of ETSI TS 103 246-3 [3].

9.2.2 Measurement Procedures

For T-INT-01:

1) Set the GSG parameters to generate the following scenario:

    - the location target at a random point within a 3 km radius of the reference location defined in clause B.1, with an altitude randomly selected between 0 m and 500 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];

    - the scenario start time shall be randomly delayed by 0 to 30 s from start time given in clause B.1;

    - the operational environment applicable (defined in clause A.3 of ETSI TS 103 246-3 [3]).

2) Configure the Interference Generator to achieve the lowest J/S specified in clause 5.7.3 of ETSI TS 103 246-3 [3] for J#1.

3) Start the GBLS GNSS receiver in Cold Start and wait for the first position fix.

4) Collect consecutive position reports and for each:

- if the horizontal position error is equal to or less than the maximum 95 % value specified for the current value of J/S in table 34 of ETSI TS 103 246-3 [3];
- then record one Good Result and its J/S value;
- else record one Bad Result.

5) Repeat step 4 until the statistical requirements of a 95 % success rate are met as defined in clause D.1 and record a Pass, or otherwise record a Fail at this J/S level.

6) If the Jammer power has achieved the maximum J/S specified in clause 5.7.3 of ETSI TS 103 246-3 [3] for J#1 then stop the test, else increase Jammer power by 1 dB and repeat steps 3 to 6.

For T-INT-02: repeat all steps for the Test Case T-INT-01 above, except with relevant values for J#2 substituted for J#1.

9.3 Pass/fail criteria

The GBLS shall meet the requirements for 95 % success rate specified in ETSI TS 103 246-3 [3] according to the method defined in clause 9.2.2.

NOTE: Pass/fail criteria for tests of the minimum jammer distance in clause 5.7.3 of ETSI TS 103 246-3 [3] are calculated from the above J/S values as described in clause A.6 of ETSI TS 103 246-3 [3].

9.4 GBLS Class Allocation

The allocation of test results of J/S to GBLS classes shall also be done at this stage according to the definition in ETSI TS 103 246-3 [3].

10 GNSS sensitivity

10.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS in terms of the maximum masking (attenuation) values tolerated by the GBLS whilst still allowing the provision of location-related data. It is specified for both tracking and acquisition sensitivity. GNSS assistance shall be provided, if supported by the GBLS, to shorten the time to fix position.

The GNSS sensitivity test shall be repeated for the combinations of location target environments and motion types defined in table 10.1 and specified in clause 5.8 of ETSI TS 103 246-3 [3].

Table 10.1: GNSS sensitivity test cases and applicable implementation profiles

Test case	Operational Environment Clause A.3 of ETSI TS 103 246-3 [3]	Location target dynamic conditions	Assistance type	Applicable Implementation Profile (Annex E)
T-SEN-01	Open Area	Moving (outdoor)	Fine time (if supported)	IP2, IP3, IP4, IP6
T-SEN-02	Asymmetric area	Moving (indoor)	Coarse time	IP2, IP3, IP4, IP6
NOTE: Tests for IP's 2,3 and 6 listed in this table are FFS.				

10.2 Method of Test

10.2.1 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

10.2.2 Measurement Procedures

T-SEN-01 (Open Area)

Open Area Tracking sensitivity

1) Set the GSG parameters to generate the following scenario:
   - the location target at a random point within a 3 km radius of the reference location defined in clause B.1, with an altitude randomly selected between 0 m and 500 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
   - the scenario start time shall be randomly delayed by 0 to 30 s from start time given in clause B.1;
   - the operational environment applicable (defined in clause 5.8 of ETSI TS 103 246-3 [3]);
   - set the GNSS reference input signal power level as defined in clause 5.3.2.
2) Provide fine time assistance to the GBLS (if supported).
3) Select GNSS signal attenuation x1 (at the GSG) to the value defined for Tracking, Class C in table 39 of ETSI TS 103 246-3 [3].
4) Reset and start the GBLS: the GNSS sensor shall discard any stored GNSS reference time, location, and any other aiding data obtained or derived during a previous test instance (e.g. expected ranges and Doppler).
5) Collect consecutive position reports (at typically 1 second intervals), and if:
   a) it is generated within the max. TTFF response time of 300 s; and
   b) the horizontal position error calculated from the difference between the measured and true position is less than 100 m;

   then record one Good Result;

   else record one Bad Result.
6) Repeat step 5 until the statistical requirements of a success rate of 90 % are met as defined in clause D.2.
7) If the previous step has resulted in a "Fail", then stop the test and record a Fail at this level of x1.

   Else record a Pass at this x1 level and increase x1 to the value defined for Tracking, Class B level in table 39 of ETSI TS 103 246-3 [3] and repeat steps 4 to 6 then continue to step 8.
8) If the previous step has resulted in a "Fail" then stop the test and record a Fail at this level of x1.

   Else record a Pass at this x1 level and increase x1 to the value defined for Tracking, Class A level in table 39 of ETSI TS 103 246-3 [3] and repeat steps 4 to 6. then continue to step 9.
9) Stop the test.

Open Area Acquisition sensitivity

10) Repeat steps 1 and 2 above.
11) Select GNSS signal attenuation x1 (at the GSG) to the value defined for Acquisition, Class C in table 39 of ETSI TS 103 246-3 [3].

12) Reset and start the GBLS:

- The GNSS sensor shall discard any stored GNSS reference time, location, and any other aiding data obtained or derived during a previous test instance (e.g. expected ranges and Doppler).

13) Collect the first position report and if:

   a) it is generated within the max. TTFF response time of 300 s; and

   b) the horizontal error calculated from the difference between the measured and true position is less than 100 m;

   then record one Good Result;

   else record one Bad Result.

14) Repeat steps 12 and 13 until the statistical requirements of a success rate of 90 % are met as defined in clause D.2.

15) If the previous step resulted in a "Fail", then stop the test and record a Fail at this level of x1.

    Else record a Pass at this x1 level and increase x1 to the value defined for Acquisition, Class B level in table 39 of ETSI TS 103 246-3 [3] and repeat steps 10 to 14 then continue to step 16.

16) If the previous step resulted in a "Fail", then stop the test and record a Fail at this level of x1.

    Else record a Pass at this x1 level and increase x1 to the value defined for Acquisition, Class A level in table 39 of ETSI TS 103 246-3 [3] and repeat steps 10 to 14 then continue to step 17.

17) Stop the test.

T-SEN-02 (Asymmetric Area)

For both Tracking and Acquisition sensitivity tests, repeat the procedure as for T-SEN-01 above but with:

- Coarse time assistance.
- Asymmetric Area environment.
- Indoor moving target.
- Changing attenuation x3 values from table 40 of ETSI TS 103 246-3 [3] (instead of x1).

10.3 Pass/fail criteria

The GBLS shall meet the requirements specified in ETSI TS 103 246-3 [3] according to the methods defined in clause 10.2.2.

10.4 GBLS Class Allocation

The allocation of test results to GBLS classes shall be done after determining the pass/fail criteria according to the definition in ETSI TS 103 246-3 [3].

11 Position Integrity

11.1 Test Objectives & Case definitions

The purpose of this test is to verify the Position Integrity performance of the GBLS in terms of:

- Horizontal Protection Level (HPL) expressed as the horizontal position error (HPE) at 95 %; and
- Integrity Risk, expressed as the probability that the position error exceeds the HPL.

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

Integrity risk is the risk that a position error is greater than a protection level per independent sample, and is set to 10E-5.

Table 11.1 defines the test cases and operational conditions (as specified in clause 5.9 of ETSI TS 103 246-3 [3]).

Table 11.1: Position Integrity test cases and applicable implementation profiles

Test case	Operational Environment	Location target dynamic conditions	Additional environmental features	Applicable Implementation Profile (Annex E)
T-INT-01	Open area	Moving (outdoor)	N/A	IP1, IP2, IP6
T-INT-02	Urban area	Moving (outdoor)	Non-LoS, Integrity threats	IP1, IP2, IP6
NOTE: Tests for IP's 2 and 6 listed in this table are FFS.				

The HPE consists of GBLS measurement errors and non-local errors (due to simulation of satellite orbits, satellite clocks and atmospheric effects). The non-local errors shall not exceed those given in table 11.2.

Table 11.2: Non-local Errors (satellite orbit & clock, iono and tropo)

Error Source	Horizontal Position Error (m)								
	Elevation bin (degrees)								
	0-5	5-10	10-15	15-20	20-30	30-40	40-50	50-60	60-90
Residual Ionosphere	0,08	0,07	0,06	0,06	0,05	0,04	0,03	0,03	0,03
Residual Troposphere	1,35	0,75	0,51	0,39	0,27	0,21	0,18	0,16	0,14
GPS Orbit & Clock (No-GIC cases)	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95	0,95
Galileo Orbit & Clock (No-GIC cases)	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67	0,67
GLONASS Orbit & Clock (No-GIC cases)	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8	1,8
GLONASS Orbit & Clock (GIC case)	1,00	0,98	0,95	0,91	0,85	0,76	0,67	0,57	0,41
BDS	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

11.2 Method of Test

11.2.1 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

11.2.2 Measurement Procedures

For T-INT-01:

1) Set the GSG parameters to generate the location target motion, operational environment applicable (defined in clause 5.9 of ETSI TS 103 246-3 [3].

2) Start the GNSS scenario with the location target a random point within a 3 km radius of the reference location defined in B.1 and with an altitude randomly selected between 0 m and 500 m.

3) Collect consecutive GBLS horizontal position reports and calculate the horizontal position error (HPE).

NOTE 1: If position reports occur at intervals of less than 1s, they may be down-sampled to 1 Hz for the results analysis.

4) Stop GNSS scenario and receiver after a running time of 24 hours.

NOTE 2: Measurement data collection lasts for 24 hours because of the periodicity of integrity threats.

5) From the cumulative histogram calculate:

   a) the HPL value as the cumulative 95 percentile of the HPE distribution;

   b) the Integrity Risk as the cumulative probability of HPE being greater than HPL.

For T-INT-02, repeat the above tests with appropriate conditions (see table 11.1).

11.3 Pass/fail criteria

The GBLS shall meet the requirements and the success rate specified in clause 5.9.3 of ETSI TS 103 246-3 [3] over the entire duration of the test.

11.4 GBLS Class Allocation

The allocation of test results to GBLS classes shall be done after determining the pass/fail criteria according to the definition in ETSI TS 103 246-3 [3].

12 Position day-to-day repeatability (Horizontal or Vertical plane)

12.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS by estimating the location target position horizontal differences in a day-to-day configuration in both horizontal and vertical planes.

The day-to-day repeatibility test is made up three parts and each part shall be repeated for all the combinations of location target environments and motion types as defined in table 12.1 below and completely specified in clause 5.10 of ETSI TS 103 246-3 [3].

Table 12.1: Day to Day repeatability test cases

Test case	Operational Environment	Location target dynamic conditions	Applicable Implementation Profile (Annex E)
T-DDR-01	Open Area	Moving Location Target	IP4
T-DDR-02	Urban area	Moving Location Target	IP4
T-DDR-03	Asymmetric area	Moving Location Target	IP4
T-DDR-04	Open Area	Static location target	IP4
T-DDR-05	Urban area	Static location target	IP4
T-DDR-06	Asymmetric area	Static location target	IP4

12.2 Method of Test

12.2.1 Introduction

The test procedure is defined as two overall steps which are performed for each test case:

1) measurement procedures (data collection)

2) measurement data analysis

The steps are specified in clauses 12.2.2 to 12.2.6.

12.2.2 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

12.2.3 Measurement Procedures

12.2.3.1 Test cases T-DDR-01/02/03: Moving location target

Repeat all steps below for Test Cases T-DDR-01 to T-DDR-03:

1) Set the GSG parameters to generate the following scenario:

- the location target to start at the reference location defined in B.1, with an altitude of 100 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
- the first part of the test starts at 1st January 2012 20:30:00 (GPS time);
- the appropriate operational environment as defined in clause A.3 of ETSI TS 103 246-3 [3];
- the GNSS input signal power level as defined in clause 5.3.2.

2) Reset and start the GBLS.

3) Collect 200 GBLS position data samples at a rate of one per 120 s (to guarantee statistically independent PVT samples).

NOTE 1: This interval between samples ensures that GBLS position data samples are statistically independent.

4) Set the GSG parameters to generate the following scenario:

- the location target to start at the reference location defined in B.1, with an altitude of 100 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
- the second part of the test starts at 2nd January 2012 18:30:00 (GPS time)
- the appropriate operational environment as defined in clause A.3 of ETSI TS 103 246-3 [3];
- the GNSS input signal power level as defined in ETSI TS 103 246-3 [3].

5) Reset and start the GBLS.

6) Collect 200 GBLS position data samples at a rate of one per 120 s (to guarantee statistically independent PVT samples).

NOTE 2: This interval between samples ensures that GBLS position data samples are statistically independent.

7) Set the GSG parameters to generate the following scenario:

- the location target to start at the reference location defined in B.1, with an altitude of 100 m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
- the third part of the test starts at 30th June 2012 20:30:00 (GPS time);
- the appropriate operational environment as defined in clause A.3 of ETSI TS 103 246-3 [3];
- the GNSS input signal power level as defined in ETSI TS 103 246-3 [3].

8) Reset and start the GBLS.

9) Collect 200 GBLS position data samples at a rate of one per 120 s (to guarantee statistically independent PVT samples).

NOTE 3: This interval between samples ensures that GBLS position data samples are statistically independent.

NOTE 4: It is essential that the collection of 200 GBLS position data samples are taken at the same instant in the simulation for each part of the test.

It is assumed that the GBLS outputs its position time-stamped with an integer number of second in GNSS time so that the comparaison of the positioning outputs to the trajectory between parts of the tests is possible. In case this is not possible then a fine resynchronisation by interpolation will be necessary for the analysis of the data.

12.2.3.2 Test cases T-DDR-04/05/06: Static location target

The procedure for these test cases is the same as clause 12.2.3.1 except for step 1 to 9, where the location target shall remain stationary at its initial location.

12.2.4 Measurement Data Analysis

12.2.4.1 General

Process the data collected during the measurement phase as follows.

For each instant i where the position is collected (each 120 s), using coordinates in the East-North-Up (ENU) reference frame, whose local origin is the true position of the target at the given instant in the simulation, calculate the position differences between:

- ${p^*}_{i1}^{(ENU)}$ obtained during the first data collection and ${p^*}_{i2}^{(ENU)}$obtained during the second data collection;
- ${p^*}_{i1}^{(ENU)}$ obtained during the first data collection and ${p^*}_{i3}^{(ENU)}$obtained during the third data collection;

  $\delta p_{i2}^{(ENU)} = \{{p^*}_{i2}^{E} - {p^*}_{i1}^{E}, {p^*}_{i2}^{N} - {p^*}_{i1}^{N}, {p^*}_{i2}^{U} - {p^*}_{i1}^{U}\}$is a three-dimensional vector, whose elements are:

  - ${p^*}_{i2}^{E} - {p^*}_{i1}^{E}$ is the difference along the East axis between position obtained the 1st and 2nd of January;
  - ${p^*}_{i2}^{N} - {p^*}_{i1}^{N}$ is the difference along the North axis between position obtained the 1st and 2nd of January;
  - ${p^*}_{i2}^{U} - {p^*}_{i1}^{U}$ is the difference along the Up axis between position obtained the 1st and 2nd of January;

$\delta p_{i3}^{(ENU)} = \{p^{*E}_{i3} - p^{*E}_{i1}, p^{*N}_{i3} - p^{*N}_{i1}, p^{*U}_{i3} - p^{*U}_{i1}\}$is a three-dimensional vector, whose elements are:

- $p^{*E}_{i3} - p^{*E}_{i1}$is the difference along the East axis between position obtained the 1st of January and 30th of June;
- $p^{*N}_{i3} - p^{*N}_{i1}$s the difference along the North axis between position obtained the 1st of January and 30th of June;
- $p^{*U}_{i3} - p^{*U}_{i1}$is the difference along the Up axis between position obtained the 1st of January and 30th of June.

The values $\delta p_{i2}^{(ENU)}$ and $\delta p_{i3}^{(ENU)}$are used in clauses 12.2.4.2 and 12.2.4.3.

12.2.4.2 Horizontal performance

Consider $\{\delta h_{ij}\}_{(i\epsilon[1,N],j\epsilon[2,3])}$ the Euclidian norm of the projection of δp_{ij} on the **local horizontal plane** (East/North (EN) reference frame) containing the location target true position:

$$\delta h_{ij} = \sqrt{\delta p_{ij}^{N\,2} + \delta p_{ij}^{E\,2}}$$

The mean value, standard deviation, and percentile estimators are computed on this set:

$$\{\delta h_{ij}\}_{(i\epsilon[1,N],j\epsilon[2,3])}$$

The mean value of the positioning differences $\boldsymbol{m_{\delta h}}$ is estimated as follows:

$$\widehat{m_{\delta h}} = \frac{1}{400}.\left(\sum_{i=1}^{200}\sum_{j=2}^{3}\delta h_{ij}\right)$$

The standard deviation $\sigma_{\delta h}$ is estimated as follows:

$$\widehat{\sigma_{\delta h}} = \sqrt{\frac{1}{400}.\left(\sum_{i=1}^{200}\sum_{j=2}^{3}\left(\delta h_{ij} - \widehat{m_{\delta h}}\right)^2\right)}$$

The percentiles, noted $\sigma_{p^{th}}$ (i.e. respectively σ_{67} σ_{95}) are estimated using the nearest rank estimator for the p^{th} percentile. It is the solution of the following equation:

$$\frac{p}{100}.400 = numberof\ element\left(\{\delta h_{ij}\}|\ \delta h_{ij} \leq \sigma_{p^{th}}\right)$$

12.2.4.3 Vertical performance

- Consider $\{\delta v_{ij}\}_{(i\epsilon[1,N],j\epsilon[2,3])}$ the absolute value of the projection of δp_{ij} on the vertical axis (local reference frame) containing the location target true position:

$$\delta v_{ij} = \left|\delta p_{ij}^{V}\right|$$

- Note that δv_{ij} is a positive scalar, and that the test producing 3 sets of 200 time stamps will give a set of 400 positive scalars like δv_{ij}, which can be considered as an homogeneous statistic set of samples.
- The mean value, standard deviation, and percentile estimators are computed on this set:

$$\{\delta v_{ij}\}_{(i\epsilon[1,200],j\epsilon[2,3])}$$

- The mean value of the positioning differences $\boldsymbol{m_{\delta v}}$ is estimated as follows:

$$\widehat{m_{\delta v}} = \frac{1}{400} \cdot \left(\sum_{i=1}^{200} \sum_{j=2}^{3} \delta v_{ij} \right)$$

- The standard deviation $\sigma_{\delta v}$ is estimated as follows:

$$\widehat{\sigma_{\delta v}} = \sqrt{\frac{1}{400} \cdot \left(\sum_{i=1}^{200} \sum_{j=2}^{3} \left(\delta v_{ij} - \widehat{m_{\delta v}} \right)^2 \right)}$$

The percentiles, noted $\sigma_{p^{th}}$ (i.e. respectively σ_{67} σ_{95}) are estimated using the nearest rank estimator for the p^{th} percentile. It is the solution of the following equation:

$$\frac{p}{100} . 400 = \text{numberof element} \left(\{\delta v_{ij}\} | \ \delta v_{ij} \leq \sigma_{p^{th}} \right)$$

12.2.4.4 Confidence Intervals

Calculate the 95 % Confidence Intervals as defined in clause D.3 for:

a) the mean value of the horizontal difference of positioning between parts of the test, for a moving location target or a static target;

b) the mean value of the vertical difference of positioning between parts of the test, for a moving or a static location target.

Calculate the confidence level for the estimated percentiles as defined in clause D.4.

12.2.5 Pass/fail criteria

Compare the maximum value of the metrics $\alpha = \alpha_i^{(AC)}$ and $\beta = \beta_i^{(AC)}$ (calculated in clause 12.2.4) for each Test Case against the corresponding values specified for day-to-day repeatability position performance requirements in ETSI TS 103 246-3 [3], and set the test result as "pass" for each metric if:

- the day to day repeatability requirement is met; and
- the upper bound of the 95 % confidence intervals of the mean values of the positioning differences is less than the value specified in ETSI TS 103 246-3 [3]; and
- the confidence level for the estimated percentiles is higher than 90 %.

Otherwise the test result for the relevant Test Case and metric is "fail".

12.2.6 GBLS Class Allocation

The allocation of GBLS test results to GBLS classes shall also be done at this stage according to the definition in ETSI TS 103 246-3 [3].

13 Time to Fix Ambiguities (TTFA)

13.1 Test Objectives & Case definitions

The purpose of this test is to verify the performance of the GBLS when using differential data by estimating the time necessary to achieve the required accuracy defined in ETSI TS 103 246-3 [3], following the resolution of the integer or floating ambiguity of the carrier phase measurements.

This test is applicable to the GBLS that uses differential data in RTK, NRTK, and PPP with Ambiguity Resolution. The TTFA is evaluated from the time when at least one frame of each required differential data message is received. Since this time tag is normally not displayed by the GBLS and can depend on the differential GNSS service provider, a predefined time to receive all the data will be used and the test simulator shall apply the following requirement:

- 60 s for RTK.
- 150 s for NRTK.
- 200 s for PPP.

The time to fix ambiguities test shall be repeated for all the combinations of location target environments and motion types as defined in table 13.1 and completely specified in clause 13.10 of ETSI TS 103 246-3 [3].

Table 13.1: Time to Fix Ambiguities test cases

Test case	Operational Environment	Location target dynamic conditions	Applicable Implementation Profile (annex E)
T-TTFA-01	Open Area	Moving Location Target	IP4
T-TTFA-02	Urban area	Moving Location Target	IP4
T-TTFA-03	Asymmetric area	Moving Location Target	IP4
T-TTFA-04	Open Area	Static location target	IP4
T-TTFA-05	Urban area	Static location target	IP4
T-TTFA-06	Asymmetric area	Static location target	IP4

13.2 Method of Test

13.2.1 Introduction

The test procedure is defined as two overall steps which are performed for each test case:

1) measurement procedures (data collection);

2) measurement data analysis.

The steps are specified in clauses 13.2.2. to 13.2.5.

13.2.2 Initial conditions

Connect the equipment as shown in annex A and provide the test signal inputs as defined for this Performance Feature in ETSI TS 103 246-3 [3].

13.2.3 Measurement Procedures

13.2.3.1 Test cases T-TTFA-01/02/03: Moving location target

Repeat all steps below for Test Cases T-TTFA-01 to T-TTFA-03:

1) Set the GSG parameters to generate the following scenario:

   - the location target to start at the reference location defined in B.1, with an altitude of 100m and to continue moving along the trajectory defined in clause A.4 of ETSI TS 103 246-3 [3];
   - the test starts at 1st January 2012 20:30:00 (GPS time);
   - the appropriate operational environment as defined in clause A.3 of ETSI TS 103 246-3 [3];
   - the GNSS input signal power level as defined in 5.3.2;
   - the differential data simulation is ready to start but not activated.

2) Reset and start the GBLS.

3) After 120 s, start the differential data simulation and transmission using a suitable communication link, and collect 3 100 GBLS position data samples at a rate of one per second.

4) Stop the differential data communication.

5) Repeat the steps 2 to 4 until the statistical requirements for 95 % success rate and 95 % confidence level are met, as defined in clause D.1, Good Result and Bad Result being generated from the statistical analysis of the 3 100 GBLS position data sample as described in the clause 13.2.3.1.

13.2.3.2 Test cases T-TTFA-04/05/06: Static location target

The procedure for these test cases is the same as in clause 13.2.3.1 except for step 1, where the location target shall remain stationary at its initial location.

13.2.4 Measurement Data Analysis

13.2.4.1 General

For each data point collected at step 3:

- For each position measurement, calculate the position error $\varepsilon_i^{(ENU)}$ with respect to the true position using coordinates in the East-North-Up (ENU) reference frame, whose local origin is the true position of the target at the same instant.

  The subscript i is used to indicate the i-th measurement of the total number of measurement samples (3 100 in these tests).

  $\varepsilon_i^{(ENU)} = \{\varepsilon_i^E, \varepsilon_i^N, \varepsilon_i^U\}$ is a three-dimensional vector, whose elements are:

  - ε_i^E is the error along the East axis;
  - ε_i^N is the error along the North axis;
  - ε_i^U is the error along the Up axis.

  Then the horizontal position error is given by the following:

  $$\varepsilon_i^H = \sqrt{(\varepsilon_i^N)^2 + (\varepsilon_i^E)^2}$$

  Then the vertical position error is given by the following:

  $$\varepsilon_i^V = \mathrm{abs}(\varepsilon_i^U)$$

  Then, for each j from 1 to 2 100, consider each subset of values as defined by the following:

  $$\alpha(j) = \{\varepsilon_j^H, \varepsilon_{j+1}^H, \varepsilon_{j+2}^H, \ldots, \varepsilon_{j+1000}^H\}$$

  $$\beta(j) = \{\varepsilon_j^V, \varepsilon_{j+1}^V, \varepsilon_{j+2}^V, \ldots, \varepsilon_{j+1000}^V\}$$

13.2.4.2 Time to Fix Ambiguities

Compute $\rho(j)$, the 95th percentile of the subset of data $\alpha(j)$ for each second of rank j, and $\tau(j)$, the 95th percentile of the subset of data $\beta(j)$ for each second of rank j:

$$\rho(j) = 95\mathrm{thpercentile}(\alpha(j))$$

$$\tau(j) = 95\mathrm{thpercentile}(\beta(j))$$

Considering that the statistics are independant if they are sufficiently decorrelated in time, the Time To Get Required Accuracy is here defined as the smaller value of j for which all the values of the following list:

$$\rho(j),\ \ \rho(j+50),\ \ \rho(j+100)$$

$$\tau(j),\qquad \tau(j+50),\qquad \tau(j+100)$$

are simultaneously smaller than the required accuracy, namely :

- 0,03 m for ρ, 0,05 m for τ if the environment is open area
- or 0,10 m for ρ0,15 m for τ if the environment is urban or asymmetric area.

Finally the Time To Fix Ambiguities (TTFA) is the Time To Get Required Accuracy minus the predefined Time To Get all Differential Data:

- 60 s for RTK.
- 150 s for NRTK.
- 200 s for PPP.

The TTFA is then compared to the requirements for each of the classes in ETSI TS 103 246-3 [3] in order to attach a Good Result (TTFA<Req(Class)) or a Bad Result (TTFA>Req(Class)) to the test step, and to decide to repeat the test step or not according to the cumulated results as described in the statistical requirements for 95 % success rate and 95 % confidence level, as defined in clause D.1.

13.2.5 Pass/fail criteria and GBLS Class Allocation

The TTFA estimated by each test step shall be compared to each Class requirement in order to attach to it a Good/Bad result by Class. As soon as, for one Class, the number of Good result with respect to the total number of test steps meets the requirements for 95 % success rate, then that Class is allocated to the GBLS. If the GBLS meets the requirement of two or three Classes simultaneously, the better Class is retained.

Annex A (normative): Test Configurations

A.1 Anechoic Chamber Test Configuration

This test applies particularly when the GBLS has an integral antenna.

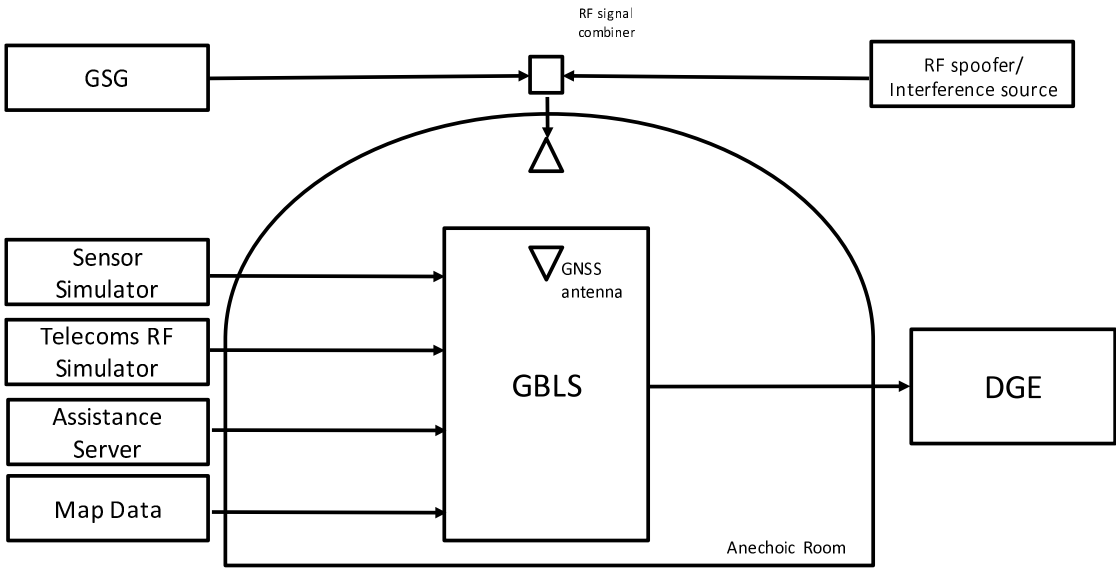

Figure A.1: System set up for tests in anechoic room

For a particular test, connections and test equipment not needed in figure A.1 may be omitted.

A.2 Wired Connections Test Configuration

This test applies when access to the GBLS antenna connector is possible.

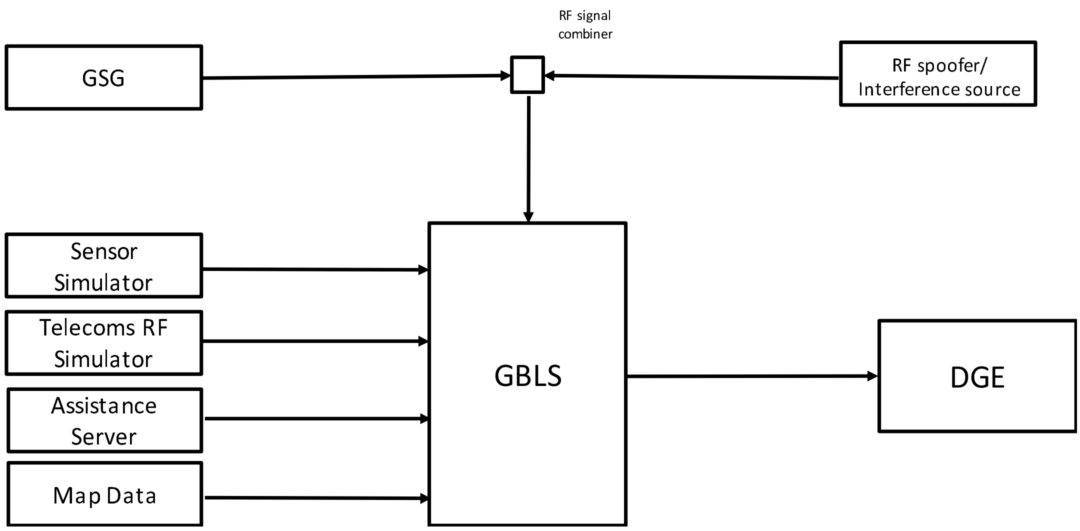

Figure A.2: System set up for tests with wired connections

For a particular test, connections and test equipment not needed in figure A.2 may be omitted.

Annex B (normative): Scenarios for tests

B.1 GNSS Scenario

B.1.1 General Scenario

The reference location to be used as the GBLS GNSS sensor starting position and time for simulation of GNSS signals in the tests defined herein, and for the generation of any necessary assistance data is Sunnyvale, USA:

- latitude: 37 degrees 24 minutes 53,391 seconds north;
- longitude: 122 degrees 1 minutes 3,722 seconds west;
- altitude: = 50 m.

Nominal start time: 1st January 2012, 00:30:00 (GPS time).

The horizontal uncertainty for the initial position is set to a radius of 3 km where relevant.

The navigation model, almanac, clock corrections and ionospheric models are defined in the RINEX file format specified in [i.10] and [i.11]. For each GNSS constellation, one RINEX file is defined. If a multi-GNSS constellation is simulated, multiple RINEX files are used. The GSG shall generate signals that conform to these files.

The following RINEX files are contained in archive ts_10324605v010201p0.zip which accompanies the present document.

Table B.1

GNSS Constellation	RINEX file
GPS	GPS.12n
GLONASS	GLO.12g
BEIDOU	BDS.12n
GALILEO	GAL.12n

B.1.2 GNSS Scenario for the Position day-to-day repeatability Test Case

For the Test Case *Position day-to-day repeatability*, the GNSS scenario follows the General Scenario (B.1.1), including two more start times:

Nominal start time for second part of test: 2nd January 2012, 20:30:00 (GPS time).

Nominal start time for third part of test: 30th June 2012, 20:30:00 (GPS time).

The following ionex files are to be used for the modelling of the ionosphere respectively above the three parts of test:

- ftp://cddis.gsfc.nasa.gov/gnss/products/ionex/2012/001/ esag0010.12i.Z/
- ftp://cddis.gsfc.nasa.gov/gnss/products/ionex/2012/002/ esag0020.12i.Z/
- ftp://cddis.gsfc.nasa.gov/gnss/products/ionex/2012/182/ esag1820.12i.Z/

B.2 Telecoms Scenarios

For Further Study.

B.3 Sensor Scenarios

For Further Study.

Annex C (normative): Formulae to convert East and North coordinates to Along- and Cross-Track coordinates

C.1 Coordinates conversion formulae

In the East North (EN) reference frame, the error is expressed as $\varepsilon^{(EN)} = \{\varepsilon^{E}, \varepsilon^{N}\}$, where:

- ε^{E} is the error along the East axis;
- ε^{N} is the error along the North axis.

In the Along-Track, Cross-Track (AT,CT) reference frame (as defined in ETSI TS 103 246-2 [2] and ETSI TS 103 246-3 [3]), the error is expressed as $\varepsilon^{(AC)} = \{\varepsilon^{A}, \varepsilon^{C}\}$, where:

- ε^{A} is the error along the Along track axis;
- ε^{C} is the error along the Cross track axis.

The EN coordinates are converted to (AT,CT) coordinates, as following:

$$\begin{cases} \varepsilon^{A} = \varepsilon^{E}\cos\alpha + \varepsilon^{N}\sin\alpha \\ \varepsilon^{C} = -\varepsilon^{E}\sin\alpha + \varepsilon^{N}\cos\alpha \end{cases}$$

where α is the angle between the East axis and the Along Track axis.

Figure C.1 shows the EN (black) and (AT,CT) (red) reference frames, the location target trajectory, the estimated position and the corresponding errors.

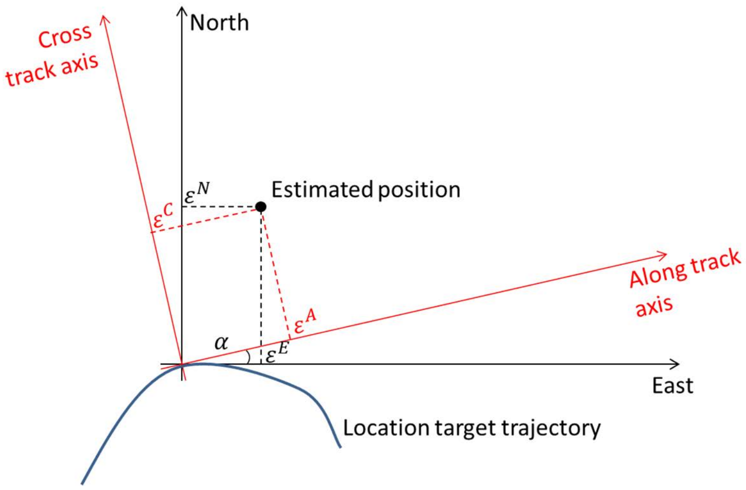

Figure C.1: EN and (AT,CT) reference frames

Annex D (normative): Rules for statistical testing

D.1 For 95 % success rate, 95 % Confidence Level

The results of a series of tests are evaluated until a minimum number of results, as defined in the table below, is reached to achieve a Pass/Fail result.

These rules (based on the procedure in annex D of ETSI TS 137 571-1 [i.2]) are designed to achieve the following parameters:

Specified Device under Test (DUT) quality: Error rate (ER = ne/ns) = 0,05

(ne: the number of bad results, ns: the number of results)

Bad DUT quality factor: M = 1,5 (selectivity)

Confidence level (CL) = 95 % (for specified DUT and Bad DUT-quality)

The procedure is as follows:

- if 0 Bad results are observed, Pass the test at ≥ 77 total results, then stop the test, otherwise continue;

  if 1 Bad results are observed, pass the test at ≥ 106 total results, then stop the test, otherwise continue;

  if 2 Bad results are observed, pass the test at ≥ 131 total results, then stop the test, otherwise continue;

  etc. until;

- if 6 Bad results are observed, pass the test at ≥ 218 total results, Fail the test at ≤ 42 total results, then stop the test, otherwise continue;

  if 7 Bad results are observed, pass the test at ≥ 238 total results, Fail the test at ≤ 52 total results, then stop the test, otherwise continue;

  etc. until;

- if 168 Bad results are observed, pass the test at ≥ 2 751 total results, Fail the test at ≤ 2 747 total results, then stop the test, otherwise continue;

  if 169 Bad results are observed, pass the test at ≥ 2 765 total results, otherwise Fail.

NOTE: An ideal DUT (Device Under Test) passes after 77 total results. The maximum test time is 2 765 results.

Table D.1: Number of Good/Bad test results required for pass/fail limits

ne	nsp	nsf	ne	nsp	nsf	ne	nsp	nsf	ne	nsp	nsf
0	77	NA	43	855	576	86	1 525	1 297	129	2 173	2 050
1	106	NA	44	871	592	87	1 540	1 314	130	2 188	2 067
2	131	NA	45	887	608	88	1 556	1 331	131	2 203	2 085
3	154	NA	46	903	625	89	1 571	1 349	132	2 218	2 103
4	176	NA	47	919	641	90	1 586	1 366	133	2 233	2 121
5	197	NA	48	935	657	91	1 601	1 383	134	2 248	2 139
6	218	42	49	951	674	92	1 617	1 401	135	2 263	2 156
7	238	52	50	967	690	93	1 632	1 418	136	2 277	2 174
8	257	64	51	982	706	94	1 647	1 435	137	2 292	2 192
9	277	75	52	998	723	95	1 662	1 453	138	2 307	2 210
10	295	87	53	1014	739	96	1 677	1 470	139	2 322	2 227
11	314	100	54	1030	756	97	1 692	1 487	140	2 337	2 245
12	333	112	55	1046	772	98	1 708	1 505	141	2 352	2 263
13	351	125	56	1061	789	99	1 723	1 522	142	2 367	2 281
14	369	139	57	1077	805	100	1 738	1 540	143	2 381	2 299
15	387	152	58	1093	822	101	1 753	1 557	144	2 396	2 317
16	405	166	59	1108	839	102	1 768	1 574	145	2 411	2 335
17	422	180	60	1124	855	103	1 783	1 592	146	2 426	2 352
18	440	194	61	1140	872	104	1 798	1 609	147	2 441	2 370
19	457	208	62	1155	889	105	1 813	1 627	148	2 456	2 388
20	474	222	63	1171	906	106	1 828	1 644	149	2 470	2 406
21	492	237	64	1186	922	107	1 844	1 662	150	2 485	2 424
22	509	251	65	1202	939	108	1 859	1 679	151	2 500	2 442
23	526	266	66	1217	956	109	1 874	1 697	152	2 515	2 460
24	543	281	67	1233	973	110	1 889	1 714	153	2 530	2 478
25	560	295	68	1248	990	111	1 904	1 732	154	2 544	2 496
26	577	310	69	1264	1 007	112	1 919	1 750	155	2 559	2 513
27	593	325	70	1279	1 024	113	1 934	1 767	156	2 574	2 531
28	610	341	71	1295	1 040	114	1 949	1 785	157	2 589	2 549
29	627	356	72	1310	1 057	115	1 964	1 802	158	2 603	2 567
30	643	371	73	1326	1 074	116	1 979	1 820	159	2 618	2 585
31	660	387	74	1341	1 091	117	1 994	1 838	160	2 633	2 603
32	676	402	75	1357	1 108	118	2 009	1 855	161	2 648	2 621
33	693	418	76	1372	1 126	119	2 024	1 873	162	2 662	2 639
34	709	433	77	1387	1 143	120	2 039	1 890	163	2 677	2 657
35	725	449	78	1403	1 160	121	2 054	1 908	164	2 692	2 675
36	742	465	79	1418	1 177	122	2 069	1 926	165	2 707	2 693
37	758	480	80	1433	1 194	123	2 084	1 943	166	2 721	2 711
38	774	496	81	1449	1 211	124	2 099	1 961	167	2 736	2 729
39	790	512	82	1464	1 228	125	2 114	1 979	168	2 751	2 747
40	807	528	83	1479	1 245	126	2 128	1 997	169	2 765	NA
41	823	544	84	1495	1 263	127	2 143	2 014			
42	839	560	85	1510	1 280	128	2 158	2 032			

NOTE: The left-most number in each column is the number of bad results (ne).
The central number in each column is the number of all results needed to achieve the pass limit (nsp).
The right-most number in each column is the number of all results needed to achieve the fail limit (nsf).

D.2 For 90 % success rate, 95 % CL

In this case the same procedure as in clause D.1 applies but with the values from table D.2.

Table D.2: Number of Good/Bad test results required for pass/fail limits

ne	ns_p	ns_f	ne	ns_p	ns_f	ne	ns_p	ns_f	ne	ns_p	ns_f
0	33	NA	43	408	283	86	737	644	129	1 056	1 021
1	46	NA	44	416	291	87	745	653	130	1 064	1 030
2	58	2	45	424	299	88	752	661	131	1 071	1 039
3	69	5	46	432	307	89	760	670	132	1 078	1 048
4	79	8	47	440	315	90	767	679	133	1 086	1 057
5	89	12	48	447	324	91	775	687	134	1 093	1 066
6	99	17	49	455	332	92	782	696	135	1 100	1 074
7	109	22	50	463	340	93	790	705	136	1 108	1 083
8	118	27	51	471	348	94	797	713	137	1 115	1 092
9	127	33	52	478	356	95	804	722	138	1 122	1 101
10	136	39	53	486	365	96	812	731	139	1 130	1 110
11	145	45	54	494	373	97	819	739	140	1 137	1 119
12	154	51	55	502	381	98	827	748	141	1 144	1 128
13	163	58	56	509	389	99	834	757	142	1 152	1 137
14	172	64	57	517	398	100	842	766	143	1 159	1 147
15	180	71	58	525	406	101	849	774	144	1 166	1 155
16	189	78	59	532	414	102	857	783	145	1 174	1 164
17	197	85	60	540	423	103	864	792	146	1 181	1 173
18	206	92	61	548	431	104	871	801	147	NA	1 182
19	214	99	62	555	440	105	879	809	148		
20	223	106	63	563	448	106	886	818	149		
21	231	113	64	571	456	107	894	827	150		
22	239	120	65	578	465	108	901	836	151		
23	248	128	66	586	473	109	909	844	152		
24	256	135	67	594	482	110	916	853	153		
25	264	142	68	601	490	111	923	862	154		
26	272	150	69	609	499	112	931	871	155		
27	281	157	70	616	507	113	938	880	156		
28	289	165	71	624	516	114	946	888	157		
29	297	173	72	632	524	115	953	897	158		
30	305	180	73	639	533	116	960	906	159		
31	313	188	74	647	541	117	968	915	160		
32	321	196	75	654	550	118	975	924	161		
33	329	204	76	662	558	119	983	933	162		
34	337	211	77	669	567	120	990	941	163		
35	345	219	78	677	575	121	997	950	164		
36	353	227	79	684	584	122	1 005	959	165		
37	361	235	80	692	592	123	1 012	968	166		
38	369	243	81	700	601	124	1 019	977	167		
39	377	251	82	707	610	125	1 027	986	168		
40	385	259	83	715	618	126	1 034	994	169		
41	393	267	84	722	627	127	1 042	1 003			
42	400	275	85	730	635	128	1 049	1 012			

D.3 Formulae to compute the confidence interval for the mean value of one-dimensional errors

Let $Y^X = \{\varepsilon_1^X,\ldots,\varepsilon_N^X\}$ $\{X_1, X_2, \ldots X_n\}$ be the magnitude-ordered vector of N one-dimensional error measurements$\{X_1 < X_2 < \cdots < X_n\}$; for a moving location target $X = \{AT, CT, U\}$, whereas for a static location target $X = \{E, N, U\}$. The confidence interval for the mean value of each such error can be found as follows:

$$I_X = \left[\hat{\mu}_{\varepsilon,X} - \frac{\hat{\sigma}_{\varepsilon,X}}{\sqrt{N}} \cdot z_{95\%},\ \hat{\mu}_{\varepsilon,X} + \frac{\hat{\sigma}_{\varepsilon,X}}{\sqrt{N}} \cdot z_{95\%}\right]$$

where $z_{95\%} = \sqrt{2} \cdot \mathrm{erf}^{-1}(0.95) = 1.96$.

Figure D.1 shows pictorially the definition of the 95 % confidence interval for the mean $\hat{\mu}_{\varepsilon,X}$ and the associated pass/fail condition. Notice that, in case of failure, the 95 % confidence interval can be reduced by increasing N.

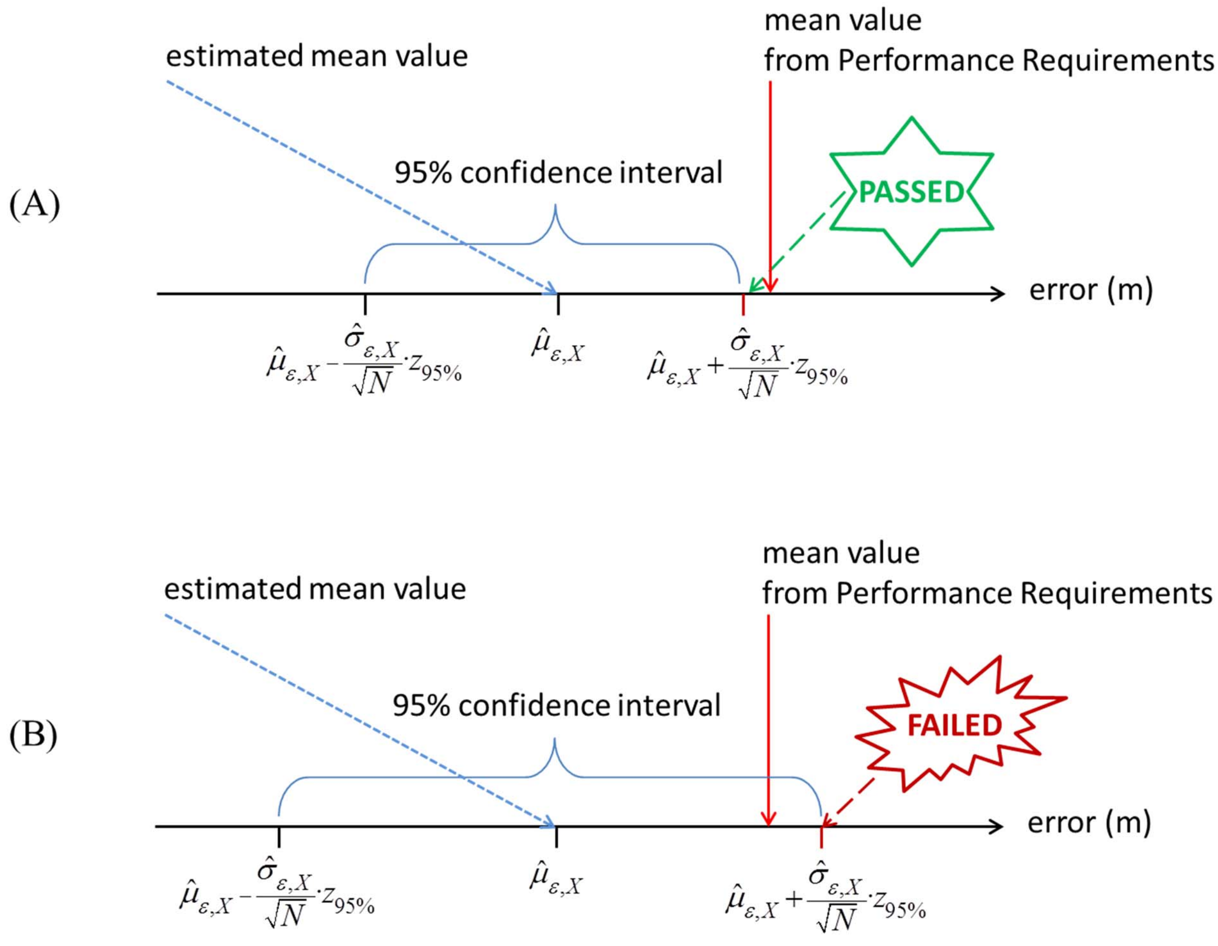

Figure D.1: Definition of the 95 % confidence interval for a one-dimensional mean error and associated criteria: (A) the test is passed; (B) the test is failed

D.4 Formulae to compute the confidence level for percentile values of one-dimensional errors

Let $Y^X = \{\varepsilon_1^X,...,\varepsilon_N^X\}$ $\{X_{1,}X_{2,}\ldots X_n\}$ be the magnitude-ordered vector of N measurements$\{X_1 < X_2 < \cdots < X_n\}$. The probability (i.e. confidence level) that the true value of the p^{th} percentile falls in the $\pi_p$interval $[\varepsilon_i^X,...,\varepsilon_j^X]$ $[X_i \ldots X_j]$is computed using the binomial distribution as follows [i.9]:

$$\hat{p}_{cl} = \sum_{k=1}^{j} \binom{N}{k} p^k (1-p)^{N-k}$$

Where:

- p is the probability that a measurement is lower than the p^{th} percentile (e.g. for the 90th percentile $p = 0{,}9$).
- ε_j^X is the highest ordered measurement within the percentile limit given by ETSI TS 103 246-3 [3].

Figure D.2 shows the confidence interval over which the confidence level is computed, the set of the N ordered measurements and the percentile limit imposed by ETSI TS 103 246-3 [3].

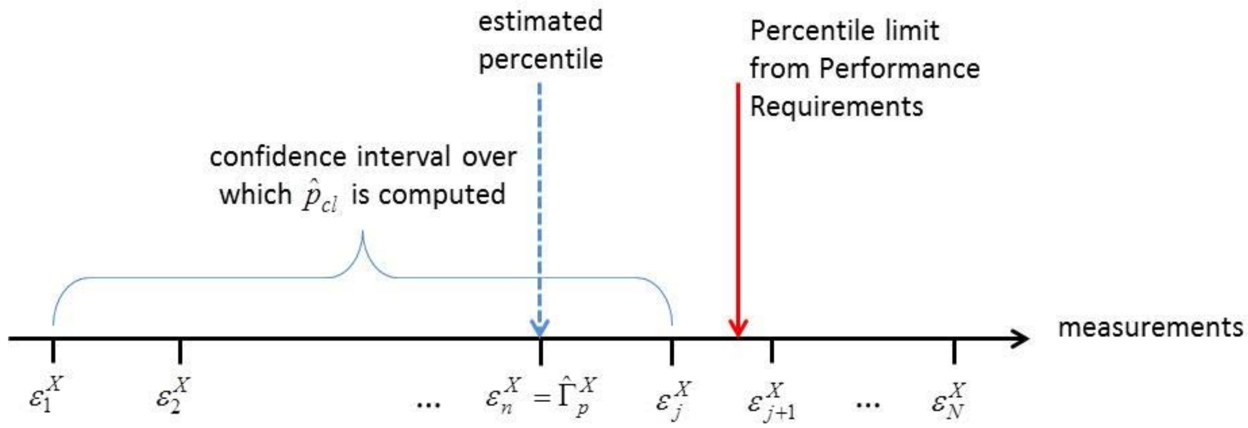

Figure D.2: Confidence interval over which the confidence level is computed for the p^{th} percentile estimate

Annex E (informative): GBLS Implementation profiles

E.1 Overview

This clause defines a number of typical implementations of the overall GBLS architecture (as defined in ETSI TS 103 246-2 [2]) in which different sets of modules from the architecture are selected to suit different applications.

Example GBLS architectures shown are:

1) System for payment-critical applications, such as electronic fee collection. The positioning module is embedded in a vehicle on-board charging unit and provides location-related information to dedicated billing facility (a remote Central Facility) which may be located in the user's central office.

2) System based on an LTE terminal, connected via IP to a SUPL location server disseminating GNSS assistance data and providing data to a local or distant application.

3) System used in precision farming, with RTK-compatible terminal, receiving RTK corrections from a reference station, and providing location-related information to an automatic guidance device.

4) System for regulatory-critical application, such as the eCall, with a built-it navigation terminal, providing location-related information from multi-sensor information (GNSS, odometer) to the car navigation software application.

5) System based on a network of GNSS monitoring stations, all connected to a central processing facility, with the objective to provide location-related information of possible interference sources to an external client.

6) System for personal navigation device. The GBLS is limited to a positioning module, embedded on a navigation terminal, such as a smartphone.

E.2 Implementation Profile #1

Typical architecture for GBLS limited to a target postioning module.

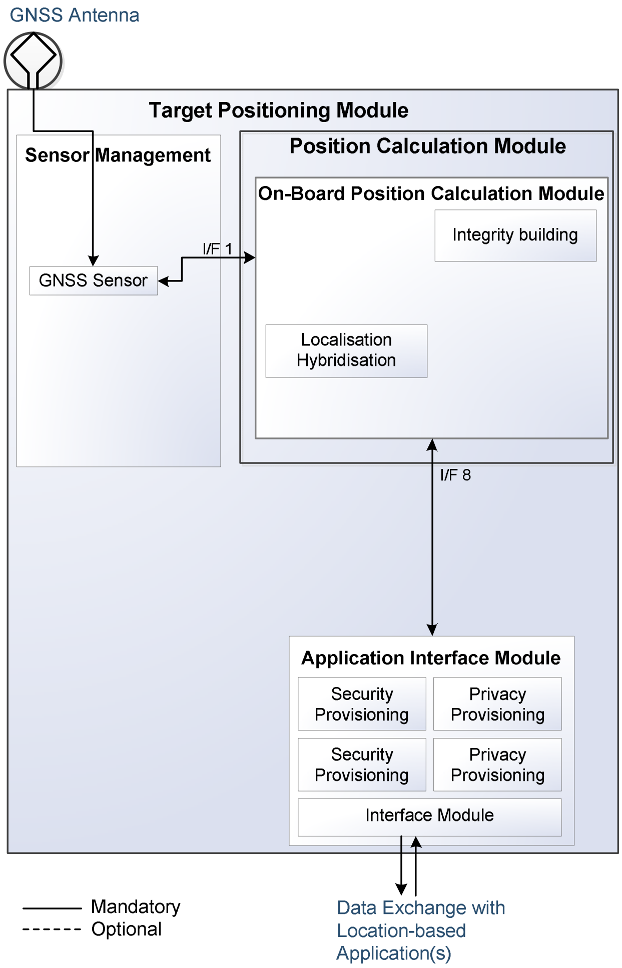

Figure E.1: IP1: GBLS used in several applications based on a standalone, multi-constellation GNSS receiver

E.3 Implementation Profile #2

Typical architecture for payment-critical applications, such as electronic fee collection system. The GBLS consists of a positioning module, embedded in an on-board charging unit, and a remote Central Facility which may be located in the user's central office.

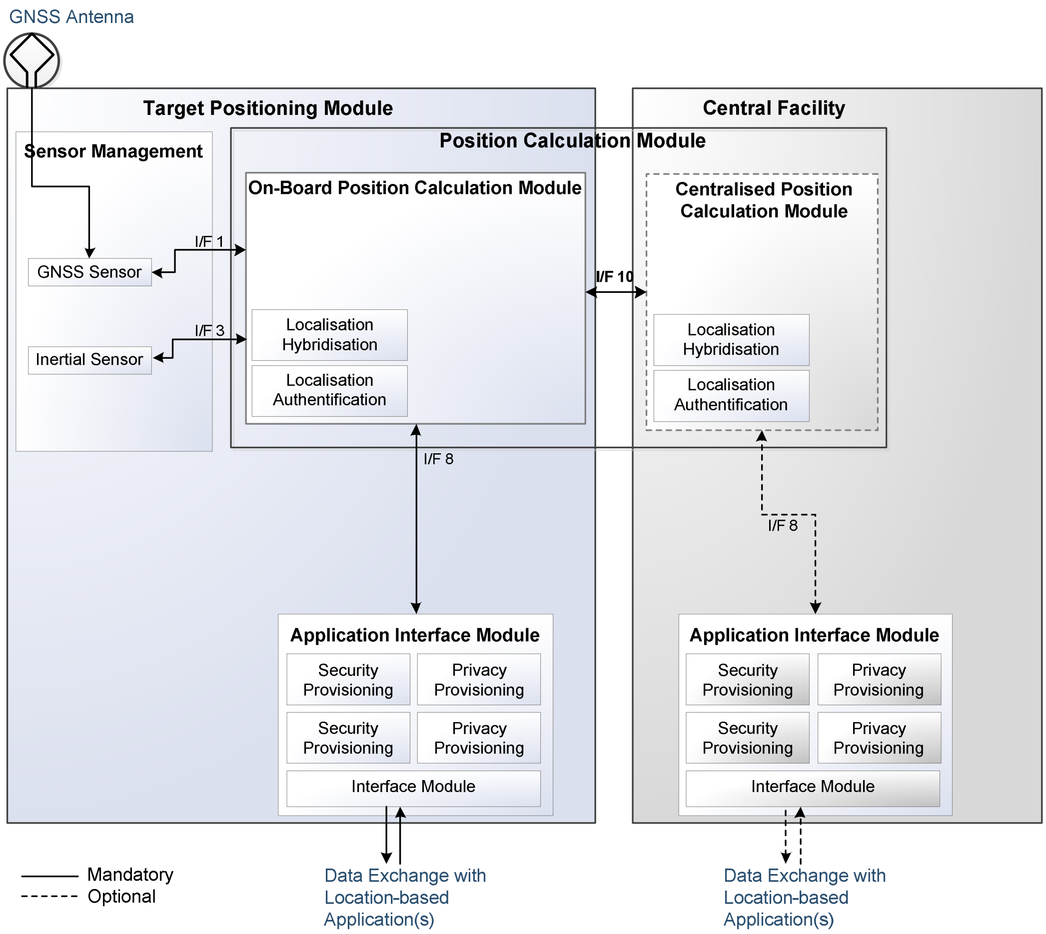

Figure E.2: IP2: GBLS used in payment-critical applications, such as Electronic Fee Collection System

E.4 Implementation Profile #3

Typical architecture mapped onto a GSM, UMTS, LTE or OMA framework. The GBLS embeds the architectural components involved in LCS provision (SMLC, GMLC, SLP) and the handset(s) (MS, UE) as application module(s).

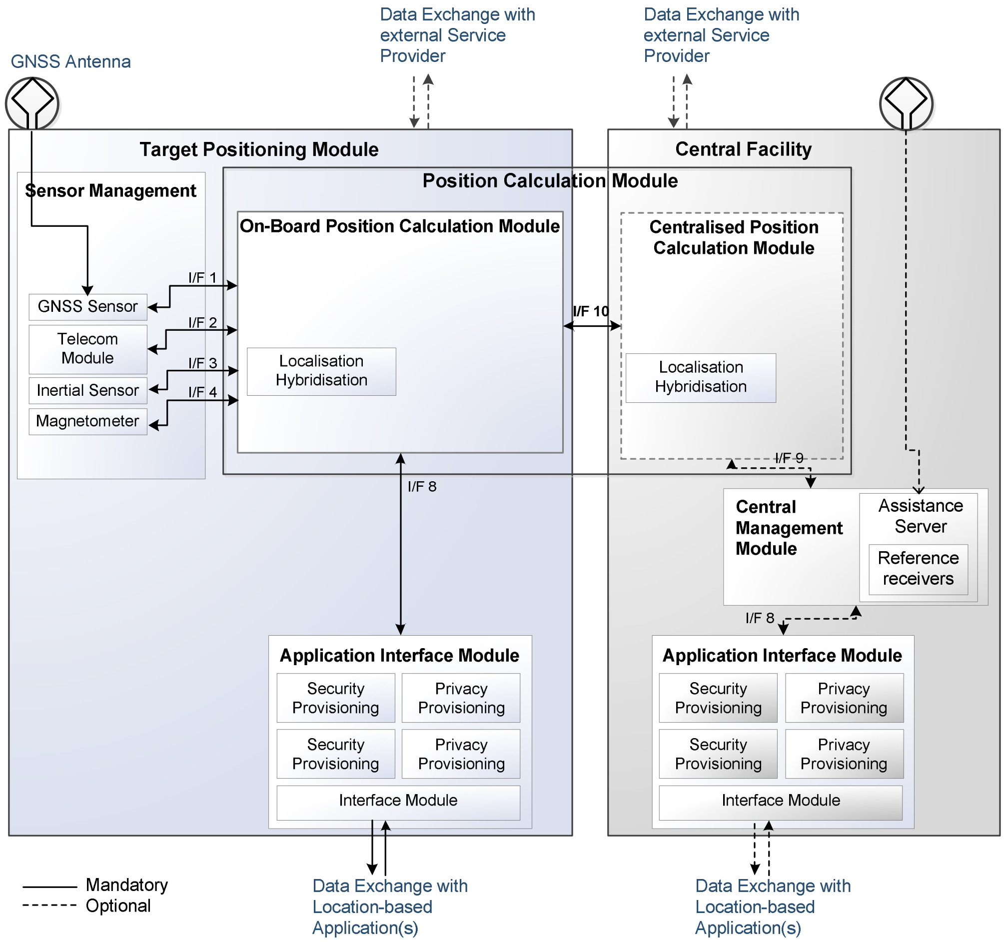

Figure E.3: IP3: GBLS featuring an architecture mapped to a GSM, UMTS, LTE or OMA framework

E.5 Implementation Profile #4

Typical architecture for a DGNSS-based or RTK-based GBLS e.g. used for precision farming guidance systems. The GBLS is then composed of a reference station (central facility), and one or several positioning modules embedded in the farming vehicles.

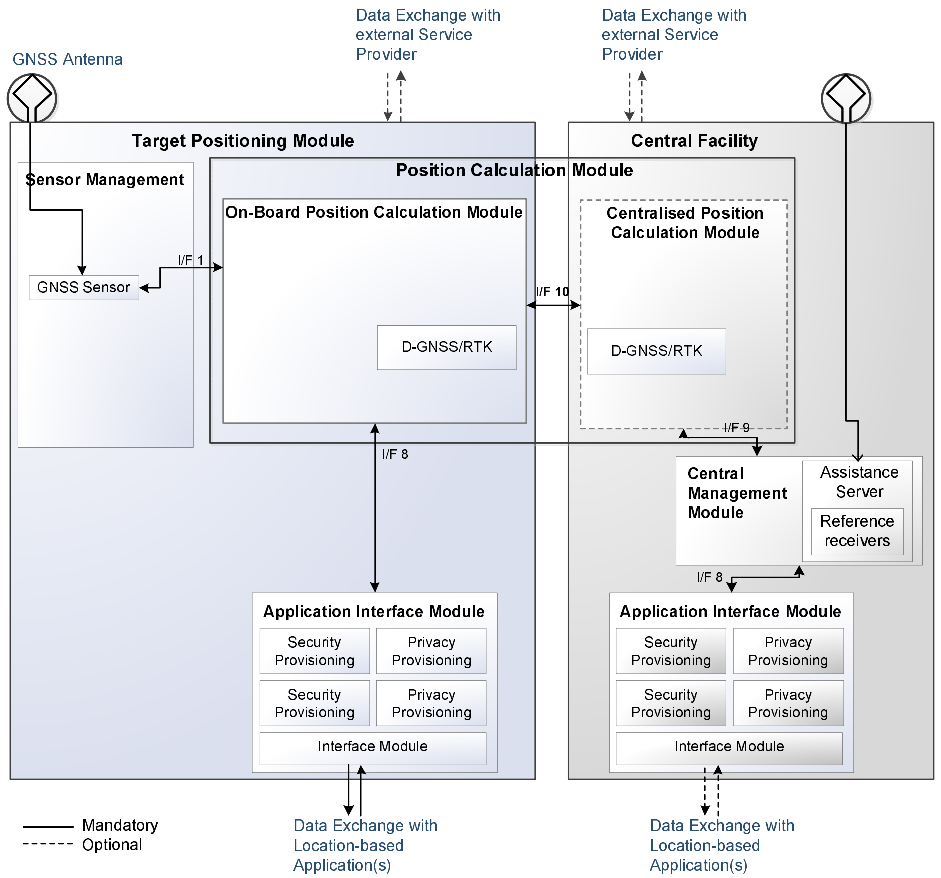

Figure E.4: IP5: GBLS used in precision farming guidance system, based on DGNSS or RTK-

E.6 Implementation Profile #5

Typical architecture for a vehicle on-board navigation device mounted on vehicles, that can serve for regulatory-critical applications, such as eCall.

The GBLS is then limited to a positioning module, embedded in an on-board navigation system.

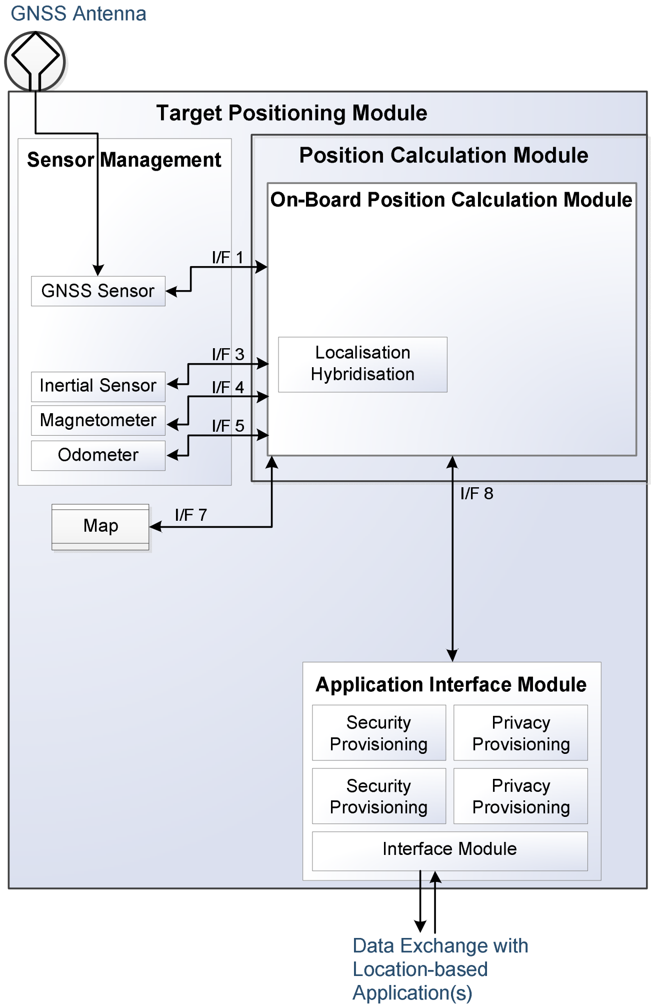

Figure E.5: IP4: GBLS for regulatory-critical applications (e.g. eCall), that use an on-board navigation device

E.7 Implementation Profile #6

Typical architecture for GBLS operating in an electro-magnetic interference environment, aimed at reliability of computed position.

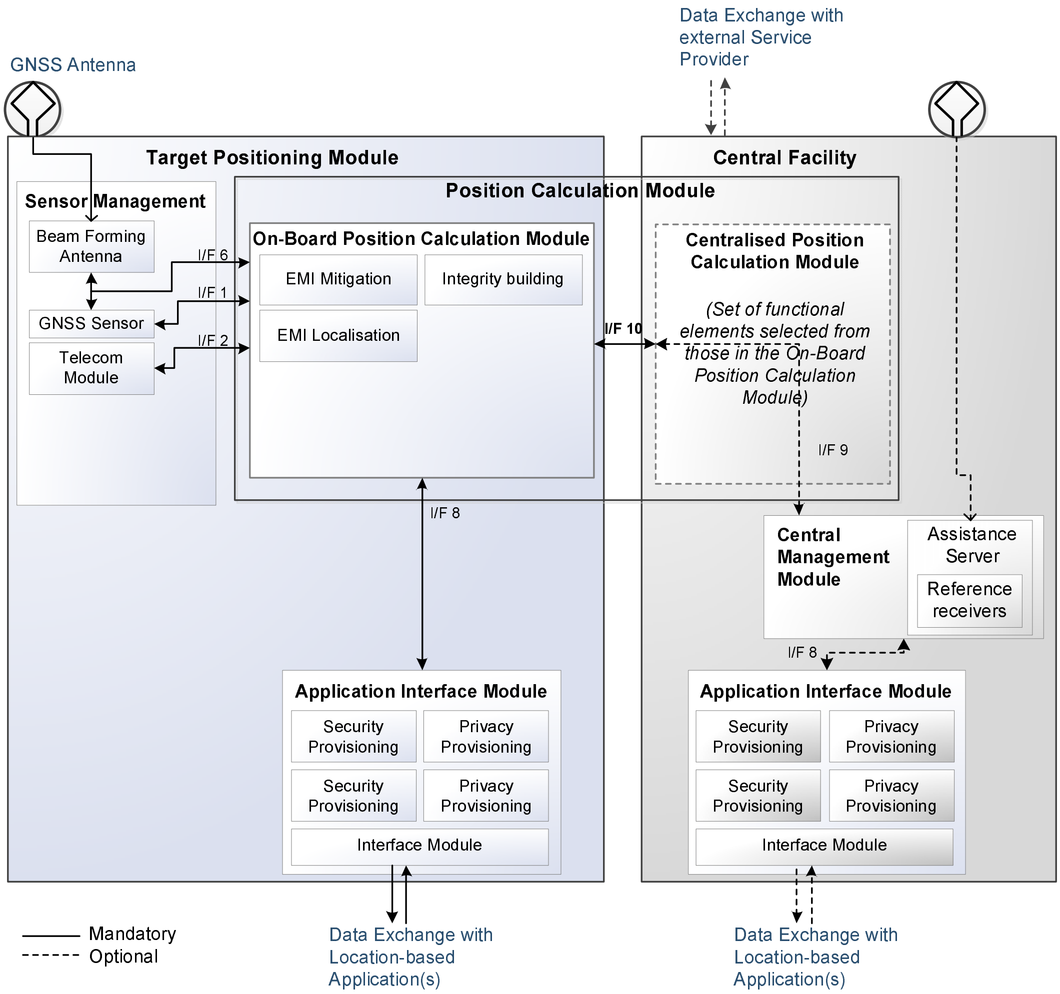

Figure E.6: IP6: GBLS suitable for applications operating in hostile environments, with presence of electro-magnetic interference

E.8 Implementation Profile #7

Typical architecture for a personal navigation device. The GBLS is then limited to a positioning module, embedded on a navigation terminal.

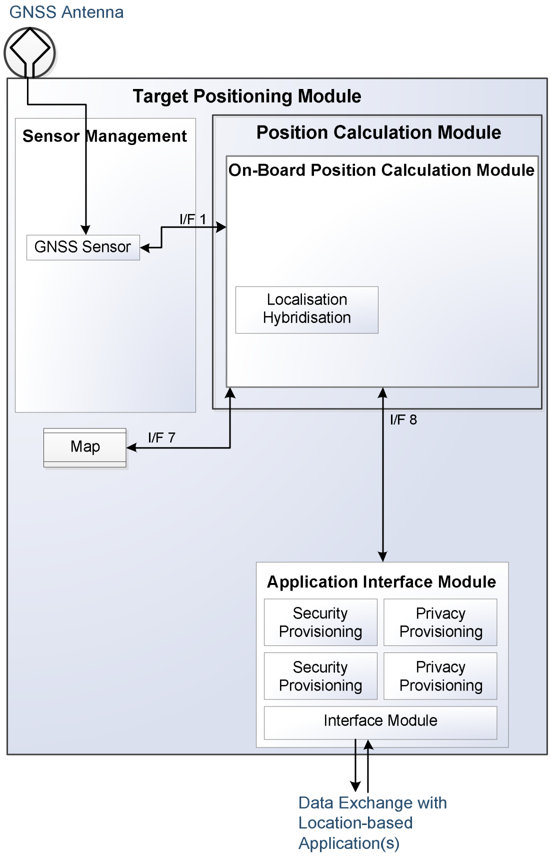

Figure E.7: IP7: GBLS for personal navigation

Annex F (informative): Bibliography

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- ETSI TS 136 355: "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP) (3GPP TS 36.355)".
- OMA-TS-LPPe-V2: "LPP Extensions Specification".
- IEEE 802.15™: "Wireless Personal Area Network".

History

Document history		
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V1.2.1	March 2017	Publication