ETSI TS 103 246-3 V1.3.1 (2020-10)

Satellite Earth Stations and Systems (SES);
GNSS based location systems;
Part 3: Performance requirements

Reference

RTS/SES-00453

Keywords

GNSS, location, navigation, performance, receiver, satellite, system

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:
http://www.etsi.org/standards-search

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx

If you find errors in the present document, please send your comment to one of the following services:
https://portal.etsi.org/People/CommiteeSupportStaff.aspx

Copyright Notification

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

Foreword

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

The present document is part 3 of a multi-part deliverable covering 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".

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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

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

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

ETSI TS 103 246 part 1 [7], part 2 [8], part 4 [i.24] and part 5 [i.25] 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 [7], part 2 [8], part 4 [i.24] and part 5 [i.25] 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 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.

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

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

[1] "European GNSS (Galileo) Open Service: Signal In Space Interface Control Document" Issue 1.3.

[2] IS-GPS-200K: "Navstar GPS Space Segment/Navigation User Segment Interfaces".

[3] IS-GPS-705F: "Navstar GPS Space Segment/User Segment L5 Interfaces".

[4] IS-GPS-800F: "Navstar GPS Space Segment/User Segment L1C Interfaces".

[5] "Global Navigation Satellite System GLONASS Interface Control Document", edition 5.1, 2008.

[6] BDS-SIS-ICD-B1I-3.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document; Open Service Signal B1I (Version 3.0)".

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

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

[9] Void.

[10] Void.

[11] Void.

[12] BDS-SIS-ICD-B1C-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document; Open Service Signal B1C (Version 1.0)".

2.2 Informative references

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

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

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

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

[i.2] IEEE 802.11™: "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.3] IEEE 802.15™: "Wireless Personal Area Network".

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

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

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

[i.12] Void.

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

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

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

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

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

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

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

[i.20] Void.

[i.21] IALA Guideline No 1112 on Performance and Monitoring of DGNSS Services in the Frequency Band 283.5 - 325 kHZ - Edition 1, May 2015.

[i.22] T. E. Humphreys: "Detection Strategy for Cryptographic GNSS Anti-Spoofing", IEEE Trans. Aerosp. Electron. Syst., vol. 49, no. 2, pp. 1073-1090, April 2013.

[i.23] I. Fernández-Hernández and G. Seco-Granados: "Galileo NMA Signal Unpredictability and AntiReplay Protection", in ICL-GNSS 2016, 2016.

[i.24] ETSI TS 103 246-4: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 4: Requirements for location data exchange protocols".

[i.25] ETSI TS 103 246-5: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 5: Performance Test Specification".

[i.26] RTCM 10401.2: "Standard for Differential Navstar GPS Reference Stations and Integrity Monitors (RSIM)".

[i.27] RTCM 10403.2: "Differential GNSS (Global Navigation Satellite Systems) Service".

[i.28] RTCM 10402.3: "Recommended Standards for Differential GNSS (Global Navigation Satellite Systems) Service".

[i.29] IMO Resolution A.1046(27) adopted on 20 November 2011: "Worldwide Radionavigation System".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

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

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

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 or time-related data

carrier phase measurement: measure of the range between the satellite and receiver expressed in units of cycles of the carrier frequency

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.

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

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

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

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

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

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

latency: measure of the time elapsed between the event triggering the determination of the location-related data for a location target and the availability of the location-related data at the user interface

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);
- 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 on whose position the location system builds the location-related data

NOTE: This entity may be mobile or stationary.

Observed Time Difference Of Arrival (OTDOA): time interval observed between the reception of downlink signals from two different cells (in a cellular telecoms system)

NOTE: If a signal from cell 1 is received at the moment t_1, and a signal from cell 2 is received at the moment t_2, the OTDOA is $t_2 - t_1$.

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

position: 3-dimensional position or location

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

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

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

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

NOTE: The protection level is provided by the location system, and with the integrity risk, is one of the two sub-features of the integrity system.

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

NOTE 1: In the RTK context, the target is called the "rover", as opposed to the stationary reference station(s). RTK makes use of the carrier phase measurements, both in the reference station and in the rover, and this technique allows the ambiguities affecting these accurate measurements to be resolved.

NOTE 2: If the reference station is at an accurately known location, the rover can compute its accurate geodetic (or absolute) location. Alternatively, if the reference station's geodetic location is only roughly known, RTK can still provide high accuracy, but only on a relative and not absolute basis.

reference receiver: receiver placed at a known and surveyed position used for differential GNSS technique

NOTE: A reference receiver is an essential component of a reference station.

reference station: station placed at a known and surveyed position aiming at determining and sharing the systematic errors of at least one GNSS constellation

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

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

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

User Differential Range Error (UDRE): 1-sigma estimate of the pseudorange correction range error

3.2 Symbols

P_{FA} Probability of False Alarm
P_D Probability of Detection