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Satellite Earth Stations and Systems (SES);
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Part 2: Reference Architecture

Reference

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Foreword

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

The present document is part 2 of a multi-part deliverable 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

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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.

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

1 Scope

The present document defines the architecture applicable to location systems. This is a "functional" architecture, meaning that the system is defined in terms of discrete functional elements connected to other internal or external functional elements via associated "logical" interfaces. These functional elements and interfaces are derived from service requirements.

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

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

ETSI TS 103 246 part 1 [10], part 3 [i.6], part 4 [i.2] and part 5 [i.3] 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 [10], part 3 [i.6], part 4 [i.2] and part 5 [i.3] propose a list of functional and performance requirements and related test procedures. For each performance requirement, different classes are defined allowing the benchmark of different GNSS Based Location Systems (GBLS) addressing the same applications.

2 References

2.1 Normative references

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

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

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

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

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

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

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

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

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

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

[7] IS-QZSS-PNT-003: "Quasi-Zenith Satellite System Interface Specification Satellite Positioning, Navigation and Timing Service", revision 003.

[8] ISRO-IRNSS-SIS-ICD-SPS-1.1: "Signal In Space ICD For Standard Positioning Service Version 1.1".

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

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

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

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

[13] US Department of Transportation, Federal Aviation Administration: "Global Positioning System Wide Area Augmentation System (WAAS) Performance Standard", 1st Edition, 31 October 2008.

NOTE: Available at http://www.gps.gov/technical/ps/2008-WAAS-performance-standard.pdf.

[14] RTCA DO-229: "Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment".

[15] 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.

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

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

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

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

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

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

[i.6] ETSI TS 103 246-3: "Satellite Earth Stations and Systems (SES); GNSS based location systems Part 3: Performance requirements".

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

application module: entity in charge of retrieving from a location system the location-related data associated with one or more location targets and processing it in order to deliver to the application user the location based service it has been designed for

NOTE: The application module can be located inside or outside the terminal.

architecture: abstract representation of a communication system

NOTE: Three complementary types of architecture are defined:

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

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 that a location system is able to provide the required location-related data

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

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 refer to conventional differential GNSS.

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

fraud: any kind of activity of a location-based application stakeholder aiming at jeopardizing the application objective

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

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 built to deliver a warning (or alert) of any to users within a given period of time (time-to-alert).
Related to the Integrity concept, a Loss of Integrity event occurs when an unsafe condition occurs (i.e. a positioning error higher that the protection level) without annunciation for a time longer than the time-to-alert limit.

Integrity Monitor (IM): only applicable to conventional D-GNSS. A component of the D-GNSS Reference Station which is responsible for validating the integrity of the correction computation and broadcast signals

NOTE: When this IM component detects anomalies, it reports these conditions to the Reference Station component.

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

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

latency: measure 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-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 one or more of the following time-tagged information elements: target position, target motion indicators (velocity and acceleration), and quality of service indicators (estimates of the position accuracy, reliability or authenticity)

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

location system central facility: centralized logical entity, inside a location system, that gathers the location information and manages the communication of the location-related data to the application module, which is the location system external client

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

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

positioning module: logical entity inside a location target responsible for providing, as a minimum, the relevant measurements for locating the target

NOTE: In some cases, the positioning module will also determine the location of the target and provide the location related data to the application module. In other cases, it will provide raw measurements to the location system central facility (enabling it to determine the location target location-related data). In all case, it includes the group of sensors required to execute these tasks. This group can include navigation sensors (GNSS, terrestrial beacons, Inertial, Odometers, etc.)

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

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

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

NOTE: The prefix "pseudo" highlights the fact that the propagation delay accessible to the receiver encompasses contributions (such as receiver local clock offset with respect to satellite time) which do not allow it to determine the actual geometrical distance.

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

NOTE 1: The estimated range generally uses the computed satellite clock bias correction and may use the estimated receiver clock bias correction.

NOTE 2: The Pseudo Range Correction represents an estimate of the total GNSS systematic error observed on one satellite line-of-sight, comprising ionospheric delay, tropospheric delay and orbital bias residual error. It can be directly used in a local area around the reference station to cancel most of the systematic errors.

quality of service: set of indicators that can accompany the location target's position/motion information and is intended to reflect the quality of the information provided by the location system

NOTE: QoS indicators can include an accuracy estimate, a protection level statistic, the integrity risk, an authentication flag.

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

NOTE: It can be isolated, and in this case will be integrated in the GBLS, or can be part of a network which itself can be a part of the GBLS or can be part of the network of an external differential GNSS service provider.

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

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

terminal-assisted: mode in which the terminal performs only the GNSS measurements (pseudoranges, pseudo Doppler, etc.) and sends these measurements to a remote central facility where the position calculation takes place

NOTE: This calculation may possibly use additional measurements or data from other sources (GNSS server assistance, differential GNSS services or non GNSS sensors etc.).

terminal-based: mode in which the terminal performs the GNSS measurements and calculates its own location

NOTE: This calculation may possibly use additional measurements or data from other sources (GNSS server assistance, differential GNSS services or non GNSS sensors etc.)

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

Time-To-First-Fix (TTFF): time taken by the receiver to produce the first position and time fix whose accuracy is lower than a defined accuracy limit, starting from the moment the receiver is switched on

3.2 Symbols

Void.

3.3 Abbreviations

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

3GPP	3rd Generation Partnership Project
A-GNSS	Assisted GNSS
AOA	Angle Of Arrival
CF	Central Facility
CID	Cell IDentifier
CMM	Central Management Module
CPCM	Centralized Position Calculation Module
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
D-GNSS	Differential GNSS
EDAS	EGNOS Data Access Service
EGNOS	European Geostationary Navigation Overlay System

EMA	EMI Mitigation Algorithm
EMI	Electro-Magnetic Interference
FKP	Flächen Korrektur Parameter (German)
GAGAN	GPS-Aided Geo-Augmented Navigation
GBAS	Ground Based Augmentation Systems
GBLS	GNSS-Based Location System
GEO	Geostationary Earth Orbit
GLONASS	Global Navigation Satellite System (Russian based system)
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile communications
IBA	Integrity Building Algorithm
IM	Integrity Monitor
IMU	Inertial Measurement Unit
INS	Inertial Navigation Sensor
IRNSS	Indian Regional Navigation Satellite System
ITS	Intelligent Transport Systems
KSM	Key Storage and Management
LAAS	Local Area Augmentation System
LAD-GNSS	Local Area D-GNSS
LBS	Location-Based Services
LHA	Location Hybridization Algorithm
LTE	Long Term Evolution
M&C	Monitoring and Control
MAC	Master Auxiliary Corrections
MD	Map Database
MSAS	Multi-functional Satellite Augmentation System
NMA	Navigation Message Authentication
NRTK	Network RTK
NTRIP	Networked Transport of RTCM via Internet Protocol
OBPCM	On-Board Position Calculation Module
OSNMA	Open Service Navigation Message Authentication
OTD	Observed Time Difference
OTDOA	Observed Time Difference Of Arrival
PL	Protection Level
PM	Positioning Module
PPP	Precise Point Positioning
PVT	Position, Velocity and Time
QoS	Quality of Service
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RSIM	Reference Station Integrity Monitor
RSS	Received Signal Strength
RTC	Real Time Clock
RTCA	Radio Technical Commission for Aeronautics
RTCM	Radio Technical Commission for Maritime Services
RTK	Real Time Kinematic
SBAS	Satellite Based Augmentation System
SDCM	System for Differential Corrections and Monitoring
SNR	Signal-to-Noise Ratio
SSR	Space State Representation
TDOA	Time Difference Of Arrival
TOA	Time Of Arrival
TS	Technical Specification
TTFAF	Time-To-First-Authenticated-Fix
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
VHF	Very High Frequency
VRS	Virtual Reference Station
WAAS	Wide Area Augmentation System
WAD-GNSS	Wide Area D-GNSS