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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 1 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".

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.

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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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.

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 requirements herein are intended to address the growing use of complex location systems required for the provision of location-based applications particularly for the mass-market (refer to ETSI TR 103 183 [i.1]).

The present document defines the functional requirements applicable to location systems, based on a summary of types of applications relying on location-related data provided by location systems.

The present document can be considered as the Stage 1 characterization of location systems according to the ITU/3GPP approach [i.2].

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.

Not applicable.

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

[i.3] IS-GPS-200D: "Revision D, Navstar GPS Space Segment/Navigation User Interfaces".

[i.4] IS-GPS-705D: "Navstar GPS Space Segment/User Segment L5 Interfaces".

[i.5] IS-GPS-800D: "Navstar GPS Space Segment/User Segment L1C Interfaces".

[i.6] European GNSS (Galileo) Open Service: "Signal In Space Interface Control Document", Issue 1.1.

[i.7] "Global Navigation Satellite System GLONASS Interface Control Document", Version 5.1.

[i.8] DTFA01-96-C-00025: "Specification for the Wide Area Augmentation System (WAAS)", US Department of Transportation, Federal Aviation Administration.

[i.9] RTCA DO-229D: "Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment", SBAS ICD Annex 1.

[i.10] IS-QZSS: "Quasi Zenith Satellite System Navigation Service Interface Specifications for QZSS", Version 1.0.

[i.11] BDS-SIS-ICD-B1I-1.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal B1I (Version 1.0)".

3 Definitions and abbreviations

3.1 Definitions

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

Accumulated Delta Range (ADR): another term for carrier phase measurement

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

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

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 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 in order to disrupt communications

NOTE: In the present technical context, targeted communication signals are GNSS or telecommunication signals.

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 several of the following time-tagged information elements: target position, target motion indicators (velocity and acceleration), 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

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

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 directly the actual geometrical distance.

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

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 orbito-synchro 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

rover: target or location target, mainly used in the context of Differential GNSS/RTK

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 target data

target: See location target.

terminal: target or location target, mainly used in the context of Assisted GNSS

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 unsafe integrity condition occurs to when an alerting message reaches the user

3.2 Abbreviations

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

3GPP	3rd Generation Partnership Project
ADAS	Advanced Driver Assistance Systems
ADR	Accumulated Delta Range
ADS-B	Automatic Dependent Surveillance – Broadcast
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
CID	Cell-ID OTD
D-GNSS	Differential GNSS
E-CID	Enhanced Cell-ID
EGNOS	European Geostationary Navigation Overlay System
E-OTD	Enhanced Observed Time Different
FKP	Flachen Korrektur Parameter (German)
GAGAN	GPS-Aided Geo-Augmented Navigation
GBLS	GNSS-Based Location Systems
GEO	Geostationary Earth Orbit
GLONASS	Global Navigation Satellite System (Russian based system)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
INS	Inertial Navigation Sensor
IT	Information Technology
ITS	Intelligent Transport Systems
LAD-GNSS	Local Area Differential GNSS
LTE	Long Term Evolution

M&C	Monitoring and Control
MAC	Master Auxiliary Correction
MMI	Man-Machine Interface
MNO	Mobile Network Operator
MSAS	Multi-functional Satellite Augmentation System
NRTK	Network RTK
OBU	On-Board Unit
OSR	Observation State Representation
OTDOA	Observed Time Difference Of Arrival
PAYD	Pay As You Drive
PL	Protection Level
PPP	Precise Point Positioning
PRC	Pseudo-Range Correction
PVT	Position, Velocity and Time
QoS	Quality of Service
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RTCA	Radio Technical Commission for Aeronautics
RTK	Real Time Kinematic
SBAS	Satellite Based Augmentation System
SNR	Signal to Noise Ratio
SSR	Space State Representation
UDRE	User Differential Range Errors
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunications System
UTDOA	Uplink Time Difference of Arrival
VHF	Very High Frequency
VRS	Virtual Reference Station
WAAS	Wide Area Augmentation System
WAD-GNSS	Wide Area Differential GNSS

4 Context description

4.1 Location based applications requirements

4.1.1 Reminder of ETSI TR 103 183 content

ETSI TR 103 183 [i.1] provides a thorough inventory of the location based applications which is used as a reference in the present document. The present clause summarizes the classification work which was conducted in order to identify those applications driving the requirements.

These requirements were organized into two separate categories:

- Basic requirements common to all location-based applications.
- Additional specific requirements, only required by certain applications.

Examples of location based applications are given in table 4-1 (clause 4.2).

4.1.2 Common requirements

Based on ETSI TR 103 183 [i.1], the following requirements were identified as shared by all location-based applications:

- Services remain available over a predefined service area.
- **Management of multiple end users:**
  - The application shall be used by one or multiple end users.

- **Management of the location targets:**
  - The application shall be able to cope with one or **multiple location targets.**
  - The application shall be able to cope with location target(s) distributed **arbitrarily** over a predefined service area.
  - The application shall be able to cope with location target(s) with **a priori unknown location-related data.**
- **Service policy**: the application shall implement mechanisms allowing the enforcement of service policy such as:
  - **Privacy protection policy** to protect the location target user identity (where relevant).
  - **Data protection policy** to control access to information identified as sensitive (through confidentiality, authentication and integrity mechanisms).

4.1.3 Specific requirements

Application classes were established in ETSI TR 103 183 [i.1] by gathering location-based applications having the same differentiating requirement (s). An inventory of these requirements is summarized below in order to list the requirements specific to a subset of applications.

- **Location Based Charging**

  The objective is to charge a user based on the reported position. The main requirements are:
  - **Reliability of check point crossing detection:** there is a risk that the user reported position triggers a charging event when it is actually in a position that should be free of charge.
    This risk is generally required to be very low.
  - **The service availability:** the percentage of cases when the user actual position has to trigger a charging event but the system is not properly informed. The service unavailability can be due to either an erroneous reported position, or to the unavailability of the location information itself.
    This service unavailability is generally required to be low.

NOTE 1: This type of location-related requirement is required for road user charging (road), on-street parking fee pricing (road), waterways and harbours charging (maritime/multimodal), home zone billing, regulated fleets in urban areas, etc.

- **"Pay As You Drive" (PAYD) charging**

  The objective is to charge a user based on the distance travelled (e.g. for pay-per-use insurance). The challenge is quite similar to the previous group, except that the useful information is the distance travelled rather than the position itself.

  The main driver is the **accuracy of the travelled trajectory or distance** in order to optimize the fee collection.

NOTE 2: This type of location-related requirement is required for pay-per-use insurance (road), car rental pricing (road), taxi service pricing (road), freight tolling (road), car-pooling (road), pay-as-you-pollute (road), energy charging (train).

- **Cooperative basic geo-positioning**

  The objective is to recover the position of one or several assets or vehicles, remotely or locally. The main drivers are generally:
  - **The reported position accuracy:** as far as fleet management or personal navigation is concerned, the main objective is to obtain an accurate position estimate.
    The required accuracy highly depends on the application: tens of meters for personal road navigation and vehicle fleet management, meters for pedestrian personal navigation and city sightseeing.