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TECHNICAL SPECIFICATION

Satellite Earth Stations and Systems (SES);
GNSS based location systems;
Part 1: Functional requirements

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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
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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

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].

ETSI TS 103 246 parts 2 [i.14], 3 [i.15], 4 [i.16] and 5 [i.17] addresse 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 parts 2 [i.14], 3 [i.15], 4 [i.16] and 5 [i.17] 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. The requirements 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]).

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

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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-200K: "Navstar GPS Space Segment/Navigation User Segment Interfaces".

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

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

[i.6] "European GNSS (Galileo) Open Service: Signal In Space Interface Control Document", Issue 1.3.

[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-229E: "Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment", SBAS ICD Annex 1.

[i.10] IS-QZSS-PNT-003: "Quasi-Zenith Satellite System Interface Specification Satellite Positioning, Navigation and Timing Service", Revision 003.

[i.11] BDS-SIS-ICD-B1I-3.0: "BeiDou Navigation Satellite System Signal In Space Interface Control Document; Open Service Signal B1I (Version 3.0)".

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

[i.13] ISRO-IRNSS-ICD-SPS-1.1: "Signal In Space ICD For Standard Positioning Service Version 1.1".

[i.14] ETSI TS 103 246-2: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 2: Reference Architecture".

[i.15] ETSI TS 103 246-3: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 3: Performance requirements".

[i.16] ETSI TS 103 246-4: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 4: Requirements for location data exchange protocols".

[i.17] ETSI TS 103 246-5: "Satellite Earth Stations and Systems (SES); GNSS based location systems; Part 5: Performance Test Specification".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

Accumulated Delta (or Doppler) Range (ADR): pseudorange-rate measurement using the carrier which measures the instantaneous phase of the signal (modulo 1 cycle) plus some arbitrary number of integer cycles

NOTE: Once the receiver is tracking the satellite, the integer number of cycles correctly accumulates the change in range seen by the receiver. Also see carrier phase measurement.

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

authentication: process/protocol to provide authenticity

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

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

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 pseudo range 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, 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

data integrity: assurance that the consistency of data is guaranteed

integrity (equivalent to "location integrity" in GBLS context): 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.

pseudo range: 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 pseudo range 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

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 (pseudo ranges, 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 Symbols

Void.

3.3 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 (or Doppler) Range
ADS-B	Automatic Dependent Surveillance – Broadcast
A-SMGCS	Advanced Surface Movement Guidance and Control System
ATC	Air Traffic Control
CID	Cell-ID
D-GNSS	Differential GNSS
E-CID	Enhanced Cell-ID
EGNOS	European Geostationary Navigation Overlay System
E-OTD	Enhanced Observed Time Difference
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
IRNSS	Indian Regional Navigational Satellite System
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
WLAN	Wireless Local Area Network

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 (see 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 data 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.

  - The **service availability:** position availability might not be as important as for other application (see location based charging applications), but for example it is a clear challenge in case of car positioning in urban area where high masking or shadowing, tunnels, signal multipath effects etc. all clearly can produce degraded availability.

NOTE 3: This type of location-related requirement is required for fleet/asset/resource management, personal navigation (pedestrian, road, multi-modal, airport vehicle management by A-SMGCS), traffic travel info, city sightseeing, etc.

- **Non-cooperative geo-positioning**

  This class of application encompasses applications for which one or several stakeholders (target itself, target user, external actor) have an interest in fooling the application enabler by intentionally altering the location target position.

  The driver for this application class is the ability to **detect fraud,** by determining the authenticity of the location-related data.

NOTE 4: This type of location-related requirement is required for some cases of fleet management (car rental), location of stolen car (road), electronic tagging device for prisoners (multi-modal).

- **Reliable geo-positioning**

  The common requirement for this class of application is to obtain a reliable position estimate for security, safety or legal reasons. Such applications are often referred to as "liability-critical applications".

The main driver here is the reliability of the applicable figure of merit, which is dependent on the ability to **monitor the positioning performance** with a (usually) high confidence level. The required performance metrics are typically the target position error (horizontal or vertical), trajectory error (along track, cross track) or time synchronization error.

Each application has its own tolerance regarding positioning performance. Thus, a properly monitored performance exceeding the application tolerance causes service unavailability. Therefore, the **reported position accuracy** is also an important driver.

NOTE 5: Both "non-cooperative geo-positioning" and "reliable geo-positioning" above rely on an assessment of the confidence associated with the target position-related data. They are however treated separately:

- "Non-cooperative geo-positioning" class only faces intentional position alteration aiming at luring the location based application. Any position uncertainty due to non-intentional origins (GNSS signal interference, multipath) is not covered.
- "Reliable geo-positioning" class however covers all sources of position alteration, in order to bring confidence in both position authenticity and accuracy.

NOTE 6: This type of location-related requirement is required for livestock transport tracking and tracing, dangerous and hazardous cargo tracking and tracing, special (high value, sensitive, dual-use) goods traffic tracking, perishable goods/food tracking and tracing. Reliable geo-positioning is also a specific requirement for airport vehicle management systems.

- **(Reliable) Vehicle movement sensing**

  Some applications require, in addition to the terminal position and/or trajectory, information related to its movement: speed, acceleration, heading, gyration, etc.

  The main driver is the **accuracy of the motion sensor indicators** (e.g. monitor the speed of a vehicle**)**.

  In addition, the ability to **monitor the positioning performance** (here positioning refers to movement sensing) with a (usually) high confidence level may also be required (e.g. for legal speed enforcement).

NOTE 7: This type of location-related requirement is required for:

- Liability critical applications: legal speed enforcement (road), accident reconstruction (road), vehicle control assistance (ADAS) + collision warning (road), cold movement detector (train), traffic management systems (train).
- Non-liability critical applications: eco-driving and carbon emissions foot- printing (road), traffic congestion reporting (road), airport vehicle management systems (A-SMGCS).

4.2 Generic location-based application use case

Table 4-1 lists the description of the different cases of location-based applications, all extracted from the inventory made in ETSI TR 103 183 [i.1] and summarized in clause 4.1. The case of airport vehicle management has been added.

Table 4-1: Example of location-based applications

Application	End user	Location Target(s)	Location system	Application(s)	Added value service
Road charging	State/ Ministries of transport	Road Users Vehicles	Fleet of On-Board Units, equipped with positioning module and communication means, distributed over the targeted road users.	Billing server collecting OBU/vehicles positions and deriving billing information.	Possibility to apply road charges with limited infrastructure (i.e. off motorways).
Vehicle or pedestrian navigation	Vehicle driver or pedestrian	Vehicle or pedestrian	Positioning module (using GNSS, inertial and odometer measurements).	Navigation application, embedded with the positioning module in a navigation terminal, providing guidance information to driver/pedestrian.	Ability to provide to user its position, surrounding points of interest and travel directions.
Airport vehicles management	Airport ground handling operators or Airport ground traffic ATC controllers or Vehicle driver	Airport vehicles and specific ground assets	Fleet of vehicles and specific assets with OBU implementing positioning module and communication means (this can be an ADS-B transceiver).	A-SMGCS with positioning-guidance-and control application for ATC controllers and vehicles drivers. Airport server and fleet management systems operated by airport handling operators.	Reliable, accurate positioning and identification of vehicles and assets with movement parameters (heading, speed).
Precision farming	Farmers	Farming vehicles	Local or network RTK solution, composed of at least a reference station and one or several positioning modules installed on the targets.	Harvest scheduling, or farming vehicles automation.	Farming logistics optimization, or 24/7 unmanned harvesting.
Ride sharing	Car sharing aficionados	Shared cars	Fleet of On-Board Units, equipped with positioning module and communications means, distributed over participating cars.	Centralized Car sharing application collecting OBU positions and building appropriate scheduling.	Simple and efficient car sharing.
Transaction synchronization	Trading company	Synchronization module	GNSS sensors replicating GNSS time for synchronization across wide areas.	Stock exchange trading, using replicated GNSS time as the source of synchronization.	Accurate synchronization of trade orders.
House-arrest monitoring	Penitentiary authorities	Prisoner under house-arrest	Monitoring wristlet, reporting position when prisoner steps out of constrained area.	Central server collecting alarms reported by wristlets.	Geo-fencing. House-arrest remote monitoring.
Cellular Communication infrastructure monitoring	Mobile Network Operator	Potential sources of interference	Monitoring centre aggregating information from GNSS receivers positioned on the network base stations.	Visualization in MNO operation room.	Improvement of network performance through identification of interference sources.
Race monitoring and safety system	Race competitor and Race coordinator	Race vehicles (car, trucks and motorcycles)	Fleet of terminals, equipped with positioning module and communication means, distributed over the race vehicles and Central location server, achieving terminal M&C.	MMI offered to race competitors (distress call trigger) and Application offered to race coordinator in headquarters, for monitoring purposes.	Competitor position quasi real-time monitoring, distress call enabler.

4.3 GNSS-based location systems

The present document provides the functional requirements applicable to GNSS-Based Location Systems (GBLS).

GBLS are defined as Location Systems using GNSS as a primary source of positioning. Hence, a GBLS shall support at least one of the GNSS methods listed in clause A.1.

Optionally, it may support one or several of the following common positioning methods:

- assisted GNSS, further described in clause A.2;
- differential GNSS, further described in clause A.3;
- proximity sensing, further described in clause A.4.1;
- multilateration, further described in clause A.4.2;
- triangulation, further described in clause A.4.3;
- multi-sensor positioning through GNSS hybridization, further described in clause A.5.

As presented in figure 4-1, the GBLS is in charge of generating the location-related data upon which the application or added value service is built.

The GBLS may support a wide range of application end-user profiles: in-field users, headquarter users, supervisors, etc. in fixed or mobile usage conditions.

The picture does not preclude any communication network architecture supporting the different logical interfaces identified.

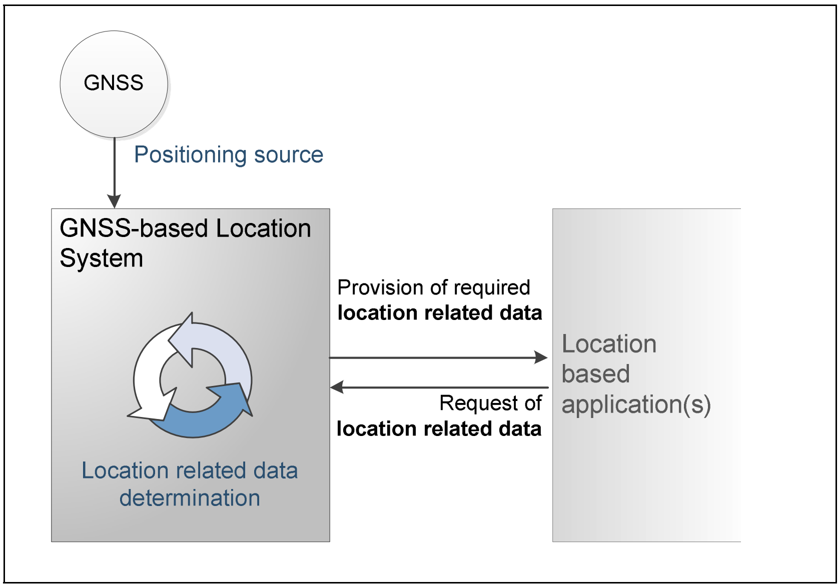

Figure 4-1

5 Functional requirements for GNSS-based Location system

5.1 Functional requirements outline

Clauses 5.2 and 5.3 provide the functional requirements applicable to the GBLS. These requirements are derived from location based application requirements inventoried in clause 4.1.

An outline of the derivation strategy is given within this clause, and summarized in annex B (mapping between location based applications requirements (common and specific) and GBLS functional requirements).

NOTE: This derivation strategy, also called functional analysis, is given for information only, since it is outside the scope of the GBLS Technical Specifications.

Functional requirements are organized as follows:

- A set of mandatory requirements, which provide the specification any GBLS shall comply with, regardless of the type of application served. These requirements are derived from the location based applications common requirements given in clause 4.1.1.

- A set of requirements for optional features, required for some of the targeted application classes. These requirements are derived from the location based applications "specific requirements" given in clause 4.1.2.

For each requirement, an introduction is given to identify the requirement origin.

The requirement itself is then worded and highlighted using the present formatting.

5.2 Mandatory requirements

5.2.1 Positioning techniques

The following mandatory requirements are applicable to any GBLS.

In order to support the location based application requirement over a wide variety of potential service areas (in terms of characteristics such as size, location, obstacle density), it is mandatory that GBLS uses a GNSS positioning technique as the main source of location-related data. It indeed offers the best technical trade-off matching the service area coverage requirement.

The GBLS shall provide location-related data containing at least the location-target geographical position, expressed in an explicit coordinate reference system, and the timestamp this position was sampled at, expressed in an explicit reference timescale.

The GBLS shall determine the location-related data of the location target(s) through the use of at least one of the GNSS methods listed in clause A.1.

5.2.2 Location-related data delivery

The following mandatory requirements are applicable to any GBLS.

In order to support the application requirement to deliver services to end-users, it is expected that the GBLS is not only able to deliver the location-related data through a dedicated interface to an external entity (i.e. the application module), but also that the location-related data delivery can be monitored and controlled by this external entity.

The GBLS shall implement an external interface conveying location-related data, and allowing the monitoring and control of the data provisioning.

Furthermore, in case where the application serves multiple end users, the supporting GBLS is expected to be able to process the incoming positioning requests based on a priority criteria. This is required in order to cope with the situation where several end users require the sending of simultaneous positioning requests to the GBLS.

The GBLS shall be able to handle the incoming positioning requests based on priority criteria.

5.2.3 Location system policies

The following mandatory requirements are applicable to any GBLS.

For the majority of applications, location targets are owned by location targets users, whose private information, including identity and location-related data, needs to be protected. GBLS, as the component generating and delivering the location-related data is therefore expected to implement appropriate protection mechanisms. These mechanisms shall ensure that target location-related data is delivered to an external entity only upon location target user authorization. Several such mechanisms exist: management of a user privacy profile in GBLS, request for authorization from the user to authorize positioning operation (manual or conditional authorization).

The GBLS shall implement a privacy protection policy for the location target user, in order to ensure that location-related data delivery takes place only upon authorization.

In order to properly support multiple location based applications, GBLS shall be able to interface with multiple application modules. Therefore, when receiving positioning operation requests from application modules, the GBLS is required to implement a service authorization policy, so as to discriminate between authorized and unauthorized application modules.

The GBLS shall implement a service authorization policy in order to identify the application modules authorized to send it positioning requests.

Protection of sensitive information (e.g. information with legal value, market value, defence value) at the application level needs to be also implemented in the GBLS as some of information contained in the GBLS (such as location-related data, location target identity) can be identified as sensitive information. As such, it needs to be protected against unwanted disclosure or alteration.

The GBLS shall implement security policy enabling the protection of sensitive information against unwanted disclosure or alteration.

5.3 Requirements for optional features

5.3.1 Positioning techniques

The following optional features may be applicable to GBLS.

Some of the specific requirements identified in clause 4.1.2, require the combining of GNSS measurements as a primary source of positioning with additional measurements provided by additional sensors, as a way to improve the positioning accuracy. As a consequence, the possibility of embedding in the GBLS additional sources of navigation, and implementing measurement fusion techniques, are proposed as an option.

The GBLS may use multiple sensors in order to collect additional measurements as a complement to the GNSS measurement source. In addition, it may implement hybridization techniques in order to enable the generation of consolidated location-related data.

Another means to improve the quality of the target positioning is the use of assistance data for use with the GNSS measurements. These GNSS augmentation methods are further described in clause A.2 and in clause A.3.

The GBLS may use augmentation methods such as Assisted GNSS and Differential GNSS positioning methods to deliver improved location-related data.

5.3.2 Location-related data content

Some of the applications require location target movement information, in addition to their position. This information is mainly target speed and acceleration, heading, angular speed and angular acceleration. Some of this information can be reconstructed at application module level, based on the position alone. However, in the case that more accuracy is required, GBLS may be required to determine and output these data, using sensor measurements.

The GBLS may provide location-related data containing, in addition to the location-target geographical position and associated timestamp, one or more of the following: location target speed, acceleration, heading, angular speed and angular acceleration.

In some applications, the type of service delivered requires the ability to monitor the positioning performance. This flows down to the GBLS as the requirement to be able to determine quality of service indicators. Different QoS indicators may be required depending on how demanding the application is:

- Estimation of the position accuracy (horizontal or vertical). This indicator statistically characterizes the positioning error distribution, such as error standard deviation or percentile values.
- Horizontal or vertical protection level associated with a confidence level. This indicator is an upper bound of the actual positioning error distribution, and the reliability of this upper bound (i.e. risk of being exceeded by the actual positioning error) shall meet the required confidence level expressed as a probability (i.e. this risk shall be lower than the confidence level).
- GNSS-based position authenticity flag. This indicates whether or not the location-related data for a location target has been derived from authentic GNSS satellite signals. In other words, it indicates if the information provided is a genuine position, or if it is likely to have been calculated using non-authentic signals (also known as spoofing signals).

NOTE: Depending on the type of application, the GBLS can implement different strategies to compute a location solution: use only authenticated satellites or a mixture of authenticated and not-authenticated satellites. The usage of satellites, whose authentication check has failed, is highly discouraged.

The GBLS may provide location-related data containing, in addition to the location-target geographical position and associated timestamp, one or several of the following quality of service indicators:

- **location target position accuracy (horizontal or vertical);**
- **location target position availability;**
- **location target position continuity;**
- **location target position integrity including protection levels (horizontal or vertical) and authenticity.**

5.3.3 Location-related data delivery

The availability of a location service is a requirement for some applications. As a major contributor to the service provision, GBLS itself may therefore be required to be able to provide location-related data in a specified percentage of time (also called availability). This ability mainly depends on three GBLS parameters:

- System availability, which is the percentage of time the GBLS itself (hardware and software components) is available, i.e. operational. It takes into account usual system "Reliability, Availability and Maintainability" considerations.
- GBLS response latency, which is the time elapsed between the reception of the positioning request from the application module and the provision of the associated answer. This latency is driven by the time taken to conduct positioning operations, including location target position determination through sensor measurements, and in case of a distributed system the performance of the communication channel.
- GBLS service area coverage, which represents the area the location target can travel across and still be positioned. This depends on the type of positioning techniques used, the type of environment across the service area, and in the case of a distributed system the performance of the communication channel.

The GBLS may be required to meet a pre-defined availability and continuity performance of its hardware and software components.

The GBLS may be required to meet a pre-defined latency in the location-related data reporting to the application module.

The GBLS may be required to provide position-related data when the location target(s) travel(s) a pre-defined service area.

5.4 GBLS Functional requirements summary

Figure 5-1 gives a summary of the GBLS functional requirements identified above.

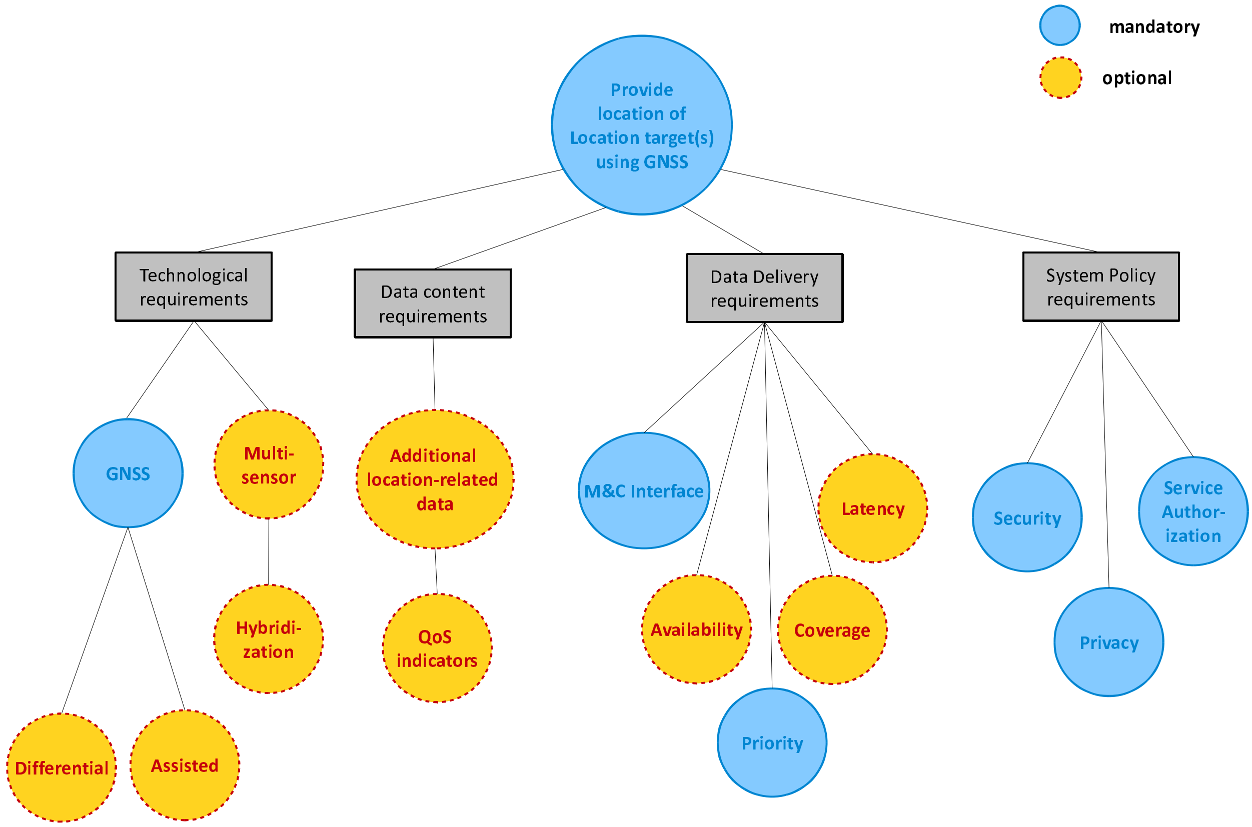

Figure 5-1: Functional requirements for GNSS-Based Location Systems

Annex A (informative): Common positioning techniques

A.1 GNSS methods

Global Navigation Satellite System (GNSS) is the standard generic term for satellite navigation systems that provide geo-spatial positioning with large coverage.

Some of them are global (worldwide) and autonomous.

All are designed as radio navigation services, in which the satellites simultaneously broadcast radiofrequency signal(s) featuring enough characteristics in their modulation that any receiver, on receiving the transmission, is autonomously enabled to generate time-consistent ranging information from the satellites, as well as the position of each satellite. This enables the receiver to determinate its exact location.

The following autonomous worldwide GNSSs are supported in the present document:

- GPS and its modernization (see IS-GPS-200 [i.3], IS-GPS-705 [i.4], and IS-GPS-800 [i.5]);
- Galileo (see [i.6]);
- GLONASS (see [i.7]);
- BeiDou (see BDS-SIS-ICD-B1I [i.11] and BDS-SIS-ICD-B1C [i.12]).

Additional autonomous systems, but covering only a regional area of service are also supported by the present document.

- Quasi-Zenith Satellite System (QZSS) (see [i.10]);
- Indian Regional Navigational Satellite System (IRNSS) (see [i.13]);

Each global GNSS can be used individually or in combination with others. When used in combination, the advantages can be:

- extra satellites can improve availability (of satellites at a particular location), in particular in areas where satellite signals can be obscured, such as in urban canyons;
- extra satellites and signals can improve reliability, i.e. with extra measurements the data redundancy is increased, which helps identify any measurement outlier problems;
- extra satellites and signals can improve accuracy due to improved measurement geometry and improved ranging signals from modernized satellites.

In addition there are regional non-autonomous GNSSs, designed as augmentation systems, aimed at enhancing the performance of global GNSSs with respect to availability, accuracy and integrity. Among them, the following regional GNSSs are supported in the present document:

- Satellite Based Augmentation Systems (SBAS), including WAAS (DTFA01-96-C-00025 [i.8]), EGNOS (RTCA DO-229D [i.9]), MSAS, and GAGAN.

A.2 Assisted-GNSS methods

In order to increase the performance of a GBLS, additional so-called assistance data can be provided to the GNSS receiver that will assist its performance. These performance improvements can:

- Reduce the GNSS receiver start-up and acquisition times. The satellite search window can be limited and the measurement times are sped up significantly as a result.

- Increase the GNSS receiver sensitivity. When the GNSS sensor operates in unfavourable SNR condition, provision of assistance data can compensate for the imperfect demodulation of the GNSS satellite signals.
- Allow the GNSS receiver to consume less power compared to a stand-alone GNSS receiver. This is due to the rapid start-up times as the GNSS receiver can now be in idle-mode when it is not needed.

The Assisted GNSS methods rely on some form of communication between the GNSS receiver embedded in the GBLS, and a so-called assistance server. This server is connected to a continuously operating GNSS reference receiver network, which has wide-area and clear sky visibility of the GNSS constellation.

The assistance data sent to the terminal can be broadly classified into:

- **data assisting the measurements:** e.g. reference time, visible satellite list, satellite signal Doppler, code phase, Doppler and code phase search windows;
- **data providing means for position calculation:** e.g. reference time, reference position, satellite ephemeris, clock corrections.

The assistance data content may vary depending on the terminal capability (terminal-assisted or terminal-based mode).

A.3 Differential GNSS methods

A.3.1 General

Differential GNSS methods aim at improving GNSS performances (notably the positioning accuracy), by reducing some systematic measurement errors in a GNSS receiver, that are commonly observed by one or more receivers in vicinity at a well-known position.

All differential GNSS techniques rely on the sharing of data extracted from the simultaneous tracking and observation of the GNSS signals by both the target receiver and by one or more reference receivers(s), through a communication link (typically UHF, VHF, satellite L-Band, cellular phone) or by wired communication (Internet).

The differential data generation in the reference station side and the use of this information to determine the target position should be consistent both side of the communication link in order to effectively fix the measurement errors.

Two categories of Differential GNSS are defined, according to the service area of the particular type of Differential GNSS:

- Local Area Differential GNSS (LAD-GNSS): when only a single reference station is used, the positioning accuracy improvement is met only in a local area around the reference station's location.
- Wide Area Differential GNSS (WAD-GNSS): when using a networks of reference stations distributed over a wide area, the positioning accuracy improvement can be effective over a region or even a continent. EGNOS, WAAS, SBAS are examples of public, free of charge Wide Area Differential GNSS services provided over continental areas.

Along time, Differential GNSS techniques have matured from the simplest LAD-GNSS using broadcast data-link that transmit pseudo range corrections up to multiple sophisticated network architectures based either on broadcast or on bidirectional data-link enabling to compute models of the systematic errors to be applied both on pseudo range and on carrier phase measurement on wide areas of service.

In the following clauses, various differential GNSS techniques are presented detailing the different functions that are required in the ground reference facilities on the one hand, and in the target positioning module on the other hand.

A.3.2 D-GNSS

D-GNSS provides typically an accuracy of 1 meter or slightly better on short range area.

The D-GNSS method comprises:

- The generation and transmission of Pseudo Range Correction (PRC) values by one reference GNSS receiver, which precisely knows its own location.
- Optionally, and in particular when a D-GNSS service provider wants to provide its service for critical user operations, several reference GNSS receivers are collocated and networked. This ensures redundancy of measurements for reliability and a consistency check in order to detect satellites presenting integrity issues, thus allowing the sending of a "do not use" flag for the detected faulty satellites. This functionality also allows for the evaluation of quality estimators for the correction (UDRE), and for monitoring the integrity of data broadcast by the reference station, by using one of its own receivers as a target.

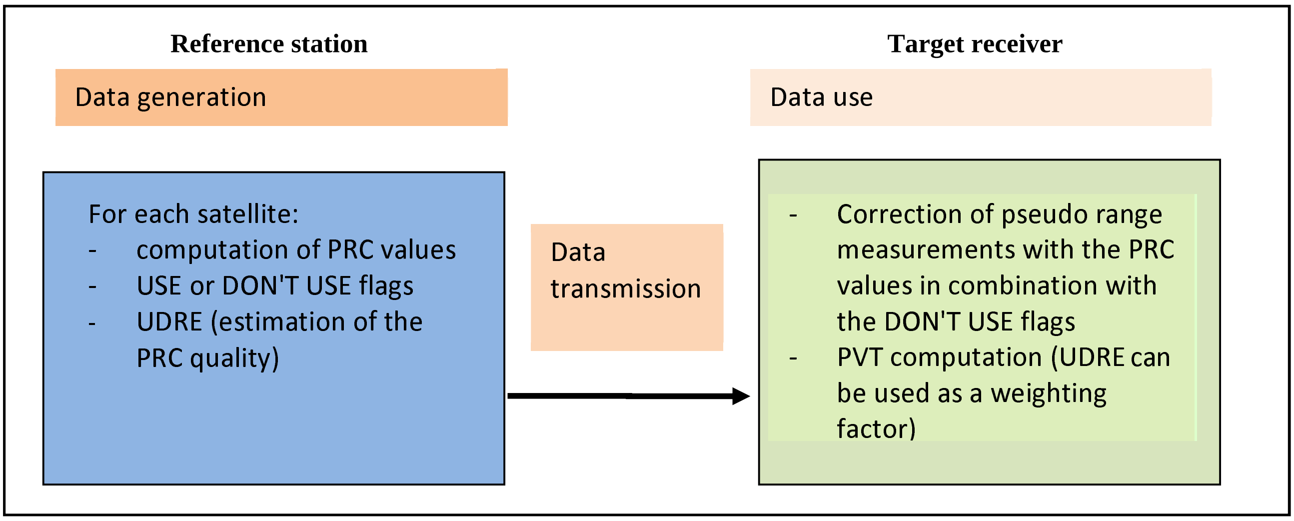

Figure A.1: D-GNSS specific functions

With this technique, which uses a single known location for the reference station, it is impossible to separate the different components of the systematic errors, and the station generates a **unique aggregate correction** per satellite, which includes in a same number all the errors, namely the ionospheric delay, the tropospheric delay, and the orbital bias residual error.

Since the different systematic errors start to become spatially uncorrelated when two GNSS receivers are further apart than about 10 km, this technique can only be used as a Local Area Differential GNSS (LAD-GNSS) in a service area of a few kilometres around the reference station.

The pseudo range measurements are sensitive to the receiver thermal noise and to the multipath. Therefore, the GNSS antenna for the reference station has to be carefully installed to avoid any potential multipath environment.

D-GNSS principles can be applied separately to any GNSS and to any of the GNSS signals (L1, L2, L5, etc.).

A.3.3 RTK

Real Time Kinematics (RTK) is a differential GNSS technique which provides positioning performance of decimetre accuracy or even better in the vicinity of a reference station.

The technique is based on the use of carrier phase measurements (ADR) and the transmission of these raw measurements from a reference station instead of just the corrections. The location of the reference station needs to be accurately known in order for the rover to compute an accurate geodetic position, however the method can also be used for estimating just a very accurate relative position from the reference station.

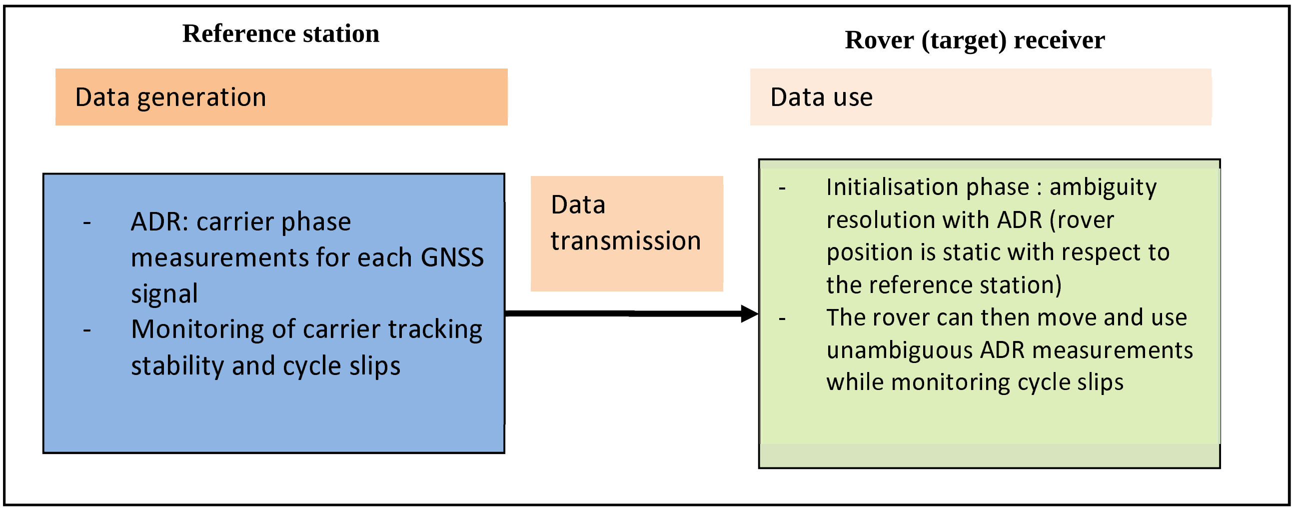

Figure A.2: RTK specific functions

The rover position determination uses a process called "ambiguity resolution" based on the double difference of the carrier phase measurements. This technique is very accurate (to centimetre level) and gives very repeatable results once the integer ambiguity is resolved. However this ambiguity resolution cannot be performed in the presence of large residual errors from the correction of systematic errors. Therefore, this technique is applicable only for a short range around the reference station.

The process of ambiguity resolution can take a long time (up to half an hour) if the rover has only a single frequency receiver, however it can be speeded up if dual frequency receivers are used and is quasi-instantaneous with a tri-frequency receiver. In addition, the ambiguity number is stable only while the carrier phase tracking is easy and stable, but needs to be recomputed for each satellite for which a loss of lock in carrier tracking is observed (either in the reference station or in the rover). This really limits the use of this technique to open environments for GNSS signals.

RTK is a local GNSS augmentation technique since the RTK reference station can only cover a service area up to about 10 km, depending on environmental effects such as interference, ionospheric stability and the quality of the telecoms link. The bandwidth required on this telecoms data-link is normally higher than for D-GNSS.

As discussed above, RTK performance is greatly improved by using dual constellation receivers and dual- or tri-frequencies, however this increases the cost of deployment.

A.3.4 NRTK

Networked RTK (NRTK) has been developed to overcome the perceived problem with RTK of the small size of the service area covered by an RTK reference station, especially considering its cost.

At least three technical solutions have been developed for NRTK where a number of RTK reference stations are placed inside clusters and networks operated by a commercial service provider.

Each solution uses a central facility which acts as a central data collection point for the carrier phase measurements from the reference stations belonging to the network. The central facility performs an estimation of the ambiguity resolution for each reference station and the estimation of the systematic GNSS errors and then the necessary data is transmitted to the users.

With NRTK, the systematic GNSS errors are parameterized in the state space domain. This is done by identifying any and all physical causes of systematic errors in the GNSS error budget and allocating to each error component a parametric model in terms of space and time correlation, with both deterministic and stochastic components. Then, the estimation process (using a Kalman filter for example), fed by each observation coming from the continuously operated reference stations over time, estimates a real time value for each parameter of the error models.

This approach has led to two main methods of providing the information about the GNSS errors to the user:

- The OSR or Observation State Representation method, mainly used for LAD-GNSS, provides the user with a global value of error for each satellite, to be directly applied as a correction to the satellite measurement.

  The OSR method provides the value of the sum of all the modelled errors, corrected for the location of the user or its local vicinity.

- The SSR or Space State Representation method, which is more appropriate for WAD-GNSS, provides the user with the values of the parameters of the various errors according the modelling process and the user then applies the values to the parameterized model to compute the corrections to be applied to its measurements according to its own location.

There are three different NRTK techniques using these two OSR or SSR methods:

- **VRS** for Virtual Reference Station. This technique is based on a two way communication link over which the NRTK service provider receives an approximate location transmitted by the rover and then computes and transmits the OSR data as it would be generated by a reference station close to the rover.

- **FKP** for (in German) "Flachen Korrectur Parameters". This technique broadcasts from the network the carrier phase measurements of the reference stations operating in the network and the SSR corrections for the mixed orbit-tropospheric errors, the ionospheric errors and a low-order surface model for extrapolation of these errors around the reference stations.

- **MAC** for Master Auxiliary Correction. This technique also generates an SSR model separating the dispersive (ionospheric) and non-dispersive (geometric and tropospheric) errors, obtained after having levelled the number of ambiguities of all the reference stations belonging to a subnetwork. It then broadcasts to the users the OSR information for a subnetwork:

  - Measurements of a Master reference station.

  - For each auxiliary station: the corrections to be applied between the master and the auxiliary reference station separated into dispersive and non-dispersive error data.

  - The network topology of the reference stations is also described and transmitted.

  In this case, the user can apply either direct corrections or extrapolated correction data according to its location in the subnetwork. Roaming from one subnetwork to another is facilitated when a reference station(s) is used in two or more subnetworks by the levelling of ambiguities. The MAC NRTK technique brings flexibility into the distribution of processes between the network service provider and the user, at the price of needing the user's receiver to perform more complex computation.

A.3.5 PPP

Precise Point Positioning (PPP) is an extension of NRTK using the SSR representation. This technique relies on the use of the carrier phase measurements and requires the broadcast by ground server and beacons, at quite low data rate, of an accurate set of corrections of the navigation messages broadcast by the GNSS satellites.

For PPP, the network of reference stations transmitting their carrier phase measurements is distributed worldwide, and a detailed SSR is used to transmit the data to the users with a model of the refined GNSS errors.

Consequently, PPP generates, in a similar way to the ground segment of the GNSS system itself, and in quasi real time, detailed orbit and clock parameters, a global atmospheric model and a detailed model of the hardware satellite biases. In some cases these are more detailed than those generated by the GNSS ground segment as PPP can take benefit from more continuously operated reference stations round the world, and it is not as constrained by its communication link compared to the broadcast of navigation messages in the GNSS signals, since the PPP data link is not a ranging link.

If a mobile receiver is able to receive this information broadcast by one of the PPP service providers and to apply the PPP concept inside its positioning algorithm, its accuracy in geodetic positioning can be improved down to the sub-meter or even sub-decimetre level with a dual frequency receiver. The main problem with this technique is the relatively long initialization time to get this ultimate accuracy.

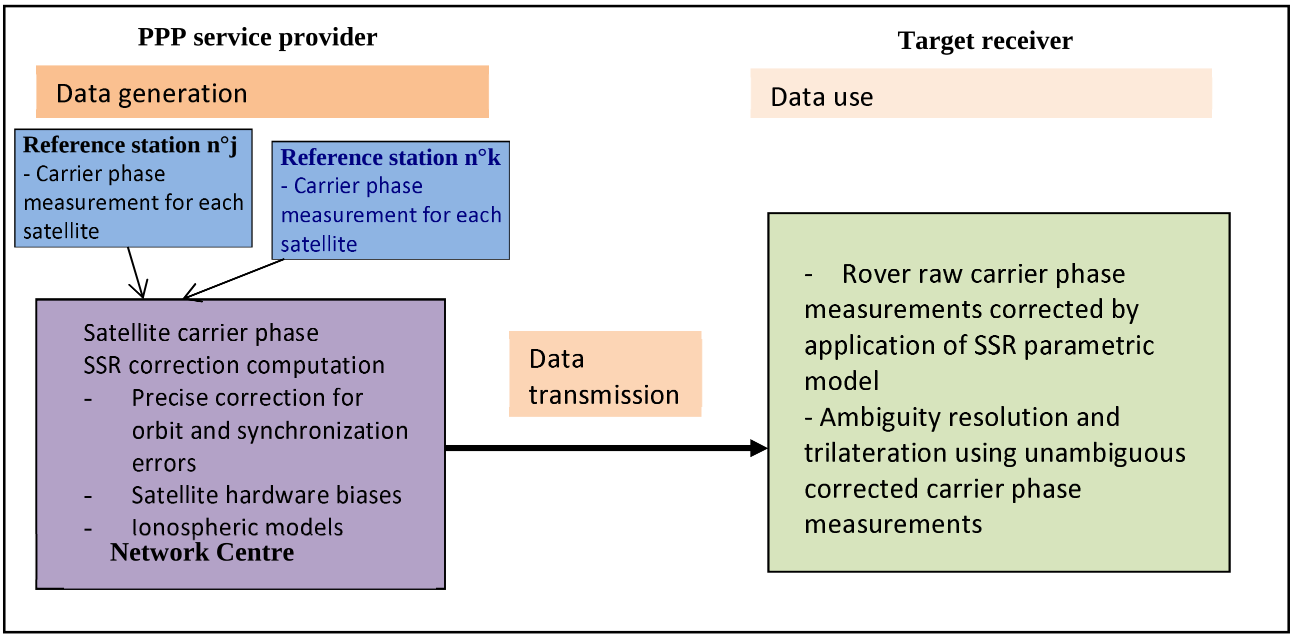

Figure A.3: PPP data representation

A.4 Mixing GNSS and telecommunication positioning techniques

A.4.1 Proximity sensing

The determination of the position of a mobile target can be achieved by identifying that it is in the vicinity of a reference point whose position is well known.

The case of cellular telecommunication networks offers one case where this method can be used. A cellular network is a wireless network distributed over land areas in the form of cells, each served by at least one fixed-location transceiver, known as a base station. These base stations are potential reference points. Identifying the transceiver to which a terminal is connected allows its position to be identified as being inside the associated cell.

This technique is also applicable in the case of WLAN/Wi-Fi® networks, Bluetooth® devices (beacons) and other similar technologies and systems.

Regardless of which technique is used the term "base station" is used to identify the source of the signal with which the proximity sensing is executed, and whose position provides the location estimate. In the same way, the "cell" is the area covered a base station.

This technique requires that the position of the base station is somehow known by the positioning module.

It represents a simple way to determine the position of a compatible positioning module, but suffers from poor accuracy. Indeed, accuracy of the obtained location depends on the size of the cells, hence of the density of base stations.

A typical example of such technique is Cell-ID (CID) for UMTS and LTE cellular networks.

A.4.2 Multilateration

Enhancements of the previous method are possible if range or range difference measurements between the mobile target and several base stations are achievable.

Several such techniques exist:

- Circular multilateration; range measurements are performed with at least 3 separate base stations. Each range measurement locates the terminal on a sphere or circle centred on the base station (including uncertainty due to measurement); the intersection of the spheres or circles provides a position estimate.
  Ranging measurements can be obtained using various techniques with various accuracies: for example measurement of the received signal strength or of the propagation time.

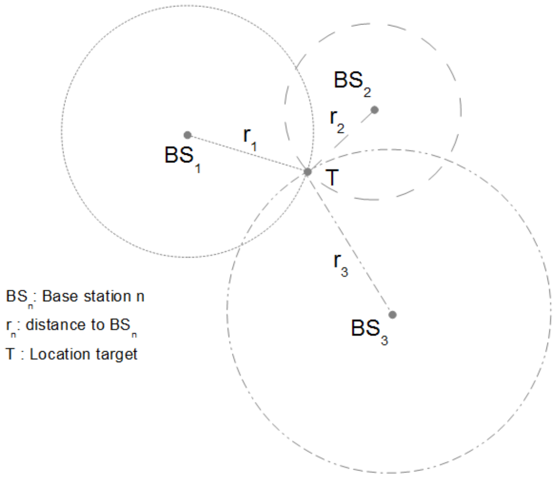

Figure A.4: Circular multilateration method

Typical example of circular multilateration is the enhanced cell-ID method (E-CID) used for LTE networks.

Note that the GNSS technique is a circular multilateration technique, using a dedicated system whose primary purpose is positioning and therefore whose signalling sources are finely synchronized.

Hyperbolic multilateration; this method relies on measurement of the range differences between the terminal and surrounding base stations; each range difference measurement, executed for a pair of base station, locates the terminal on a hyperbola with its focal points on the 2 base stations; the intersection of the hyperbolas provides a position estimate.

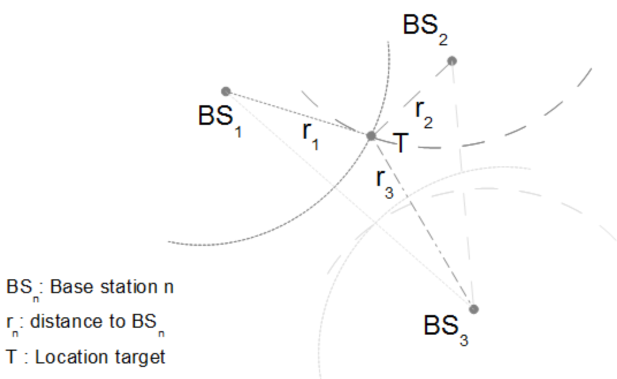

Figure A.5: Hyperbolic multilateration method

Note that since multilateration requires measurements executed on several base stations, the position of the neighbouring transceivers needs to be known.

Downlink multilateration techniques mentioned above are techniques built upon existing cellular networks whose primary objective is telecommunication. These techniques therefore mainly rely on the use of existing mechanisms, signals and measurements to determine the terminal position.

Typical examples of hyperbolic multilateration are Enhanced Observed Time Difference (E-OTD) used for GSM network, Observed Time Difference of Arrival (OTDOA) for UMTS and LTE networks. For both techniques, measurements are obtained at terminal (mobile station) level.

An additional hyperbolic multilateration method relies on uplink measurements. This is the case of Uplink Time Difference of Arrival (UTDOA) method used in GSM networks. Such methods are network-based, so that no measurement is made at the terminal level, only position information would be available at terminal level.

A.4.3 Triangulation

Multilateration brings more accuracy by using ranging measurements between the mobile target and reference points. Triangulation brings more accuracy by using angle of visibility of a mobile target from various observation points.

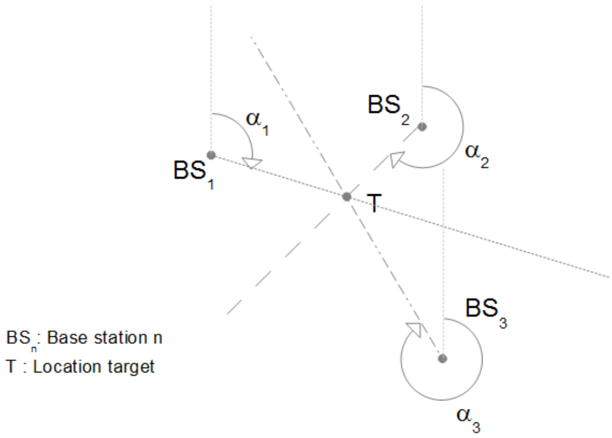

Figure A.6: Triangulation method

A.5 Multi-sensor positioning through GNSS or Assisted/Differential GNSS hybridization

The hybridization of GNSS sensors with other navigation systems allows for the computation of a final data (position, speed, heading) from intermediate data provided by these systems. The idea behind this is to develop a hybrid system that id therefore more robust in operational conditions (interference and multipath, loss of GNSS signal, etc.), and more available.

The type of intermediate data to be processed depends on the hybridization methods used, and the type of navigation systems considered.

Several levels of hybridization exist:

- In the first level, each navigation source, including the GNSS sensor, provides the information of position and velocity of the mobile target. A final position is then computed from the various available positions (average, weighted average, etc.). This is called "loose" coupling.

- An enhanced level of hybridization can be reached if ranging measurements are provided by the various navigation sources, thus providing estimates of distances between the mobile target and a number of reference points. The final position is then computed by feeding these measurements into a single navigation algorithm. This is called "tight" coupling.

- Finally, if it is possible to have access to the heart of the GNSS sensor processing and more particularly to the tracking loops, "ultra-tight" level of integration can be implemented. In that case, information collected from the other navigation sources is used to improve the GNSS measurement quality and thus obtain an enhanced navigation solution.

The navigation sources listed below provide data injectable into a hybridization algorithm:

- Inertial Navigation Sensor (INS): data from accelerometers and gyrometers can be used to improve the positioning performance.
- Odometer and tachometer: these devices, typical used in the automotive domain, provide valuable information on the mobile target movement; in addition, when installed on the 2 front (or rear) wheels of a car they provide information on car gyration.
- Cellular network modem: such sensors can provide various location-related information, from estimated location (accuracy depending on the method), down to base station ranging measurements.

NOTE: Hybridization can provide reliable authentication mechanisms: for instance, inertial systems can be used to implement innovation checks that can detect and exclude outlier GNSS measurements/positions (see [i.9]). This mechanism can be applied to both position integrity verification and authenticity verification.

Annex B (informative): GBLS High level functional analysis

Tables B.1 and B.2 indicate the mapping between:

- the location based application requirements, either common or specific as defined in clause 4.1; and
- the GBLS functional requirements which were derived from these requirements, either mandatory or optional as defined in clauses 5.1 and 5.2.

Table B.1: Common application requirements mapping to mandatory GBLS requirements

		GBLS Functional requirements						
		Use of GNSS	M&C Interface	Priority	Security	Privacy	Service Authorization	Target identification
Application Requirements	Multiple end users		x	x			x	
	Multiple location targets			x				x
	Privacy protection policy					x		
	Data protection policy				x			
	A priori unknown location-related data	x						
	Availability over wide area	x						

Table B.2: Specific application requirements mapping to optional GBLS requirements

		GBLS Functional requirements						
		Multi-sensor	Hybridization	Additional location data (Assisted/ Differential)	QoS indicator	Availability	Coverage	Latency
Application Requirements	Reliability of check point crossing detection	x	x		x			
	Service availability			x		x	x	x
	Accuracy of the travelled trajectory or distance	x	x	x				
	Accuracy of the reported position	x	x	x				
	Fraud Detection	x			x			
	Positioning Performance Monitoring	x			x			
	Accuracy of the motion sensor indicators (speed, acceleration, heading, etc.)	x	x	x	x			

History

Document history		
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V1.3.1	October 2020	Publication