The Definitions and Calculation Methods of GNSS Open Service Performance Parameters

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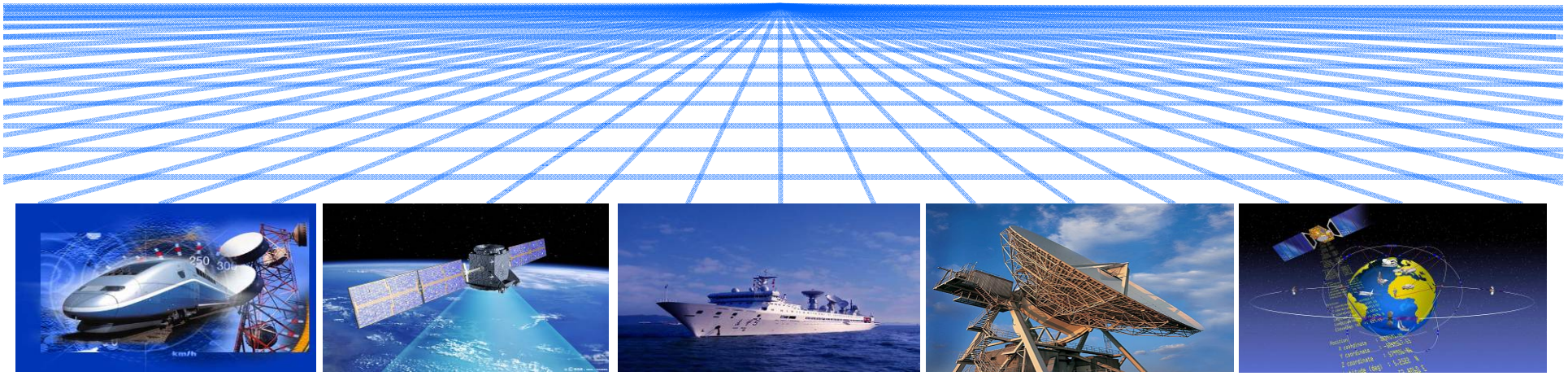


Contents

BACKGROUND

- ICG WG-A recommended that the definitions and calculation methods of the performance parameters should be clarified and discussed in order to facilitate the subsequent work on the template in Sep.2011.
- This work is benefit to promote the interoperability and applications of Multi-GNSS.
- It is also an important work for international GNSS monitoring and assessment activities.

Who need it?

There are two kinds of user.

- GNSS terminal User

Mainly focus on the service volume and service performance.

- GNSS User Equipment manufactory

It is a basic issues for design, developing , and application popularizing.

Definitions and Calculation Methods

Categories of GNSS performance parameters

- **Constellation configuration**
- **Navigation Signal**
- **SIS Performance**
- **Time and Coordinate system**

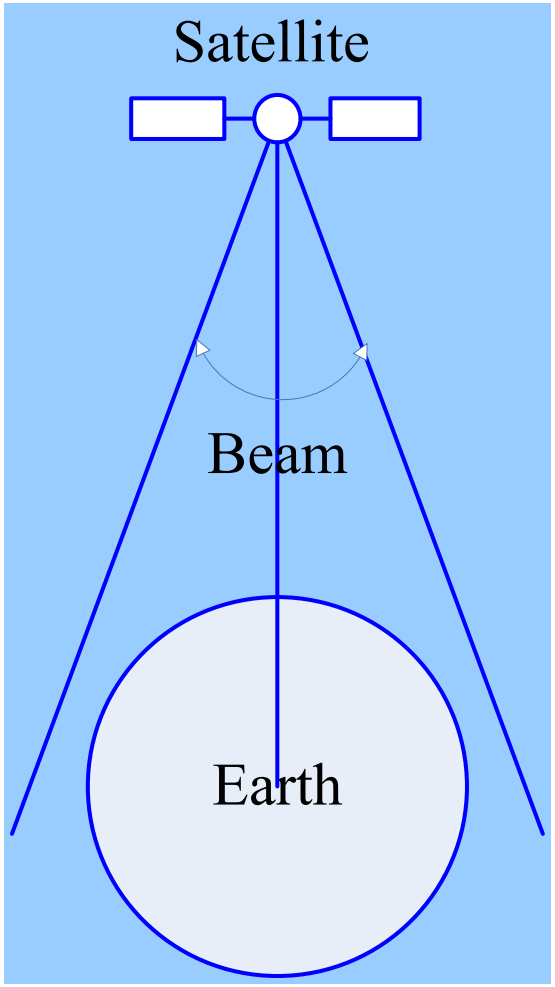
Constellation configuration

- **SVs of Baseline constellation**
  - Total number of the operation constellation
- **Orbital slot Parameters of per-satellite.**
  - Right Ascension of the Ascending Node (RAAN)
  - The Argument of Latitude
  - The corresponding Groundtrack Equatorial Crossing (GEC) values

Navigation Signal

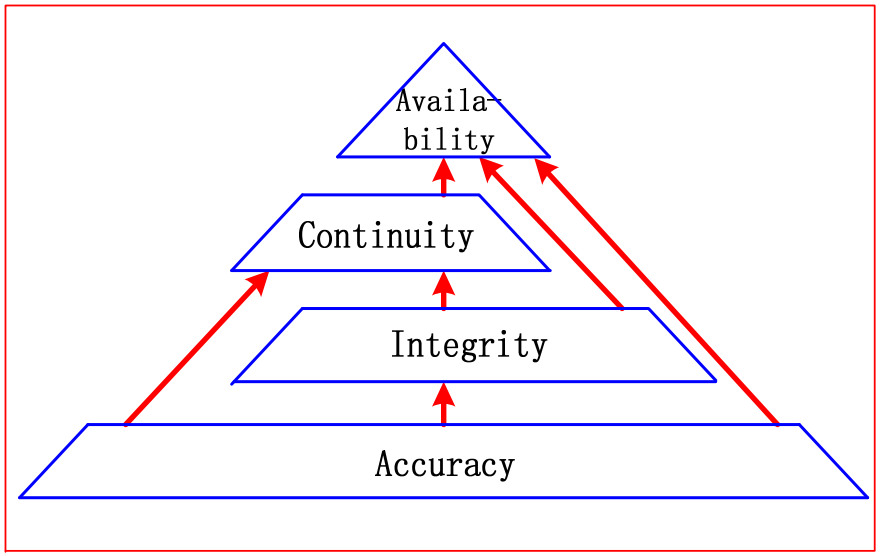
- **Beam angle**
  - To determine the coverage of SIS.

- **Signal power**
  - Minimum and maximum value of signal power in service volume of navigation signal.

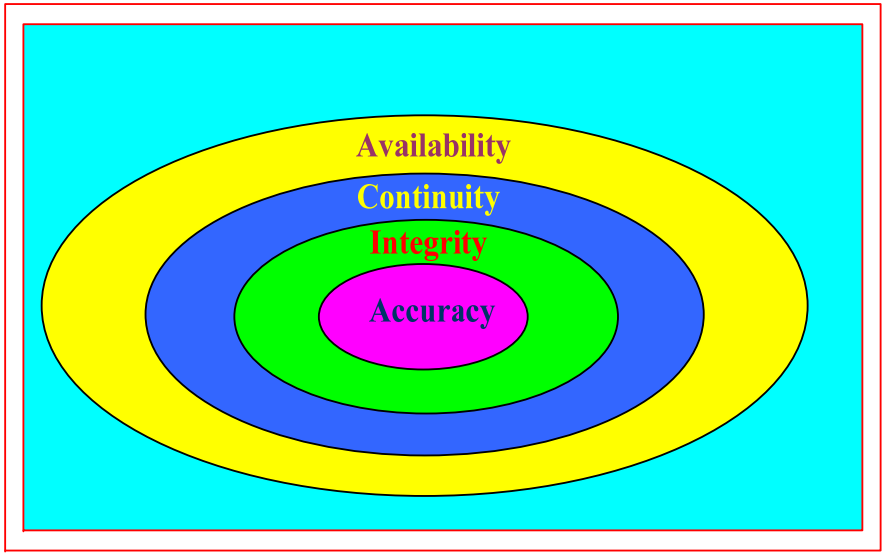


SIS Performance

- Accuracy
- Integrity
- Continuity
- Availability

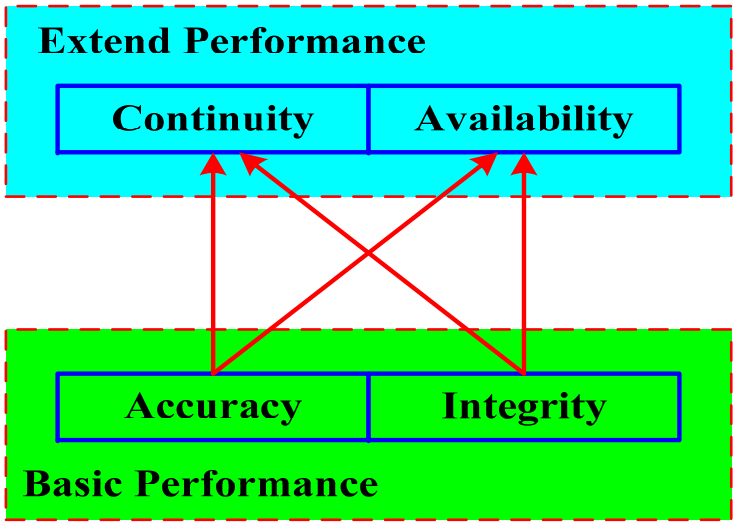


pyramid model



spherical shell model

SIS Performance



Parallel Progression Model(PPM)

- **SIS Accuracy**
  - **SIS Accuracy's Continuity**
  - **SIS Accuracy's Availability**
- **SIS Integrity**
  - **SIS Integrity's Continuity**
  - **SIS Integrity's Availability**

SIS Accuracy

- **SIS URE**
- **User Range Error (pseudorange inaccuracy due to the SIS)**
- **95% Global Average URE during Normal Operations at Any AOD.**
- **The user's line-of-sight error caused by broadcast ephemeris error.**

- **For any healthy SIS.**
- **Neglecting single-frequency ionospheric delay model errors**
- **Including group delay time correction (TGD) errors**
- **…**

SIS Accuracy

- **SIS URRE**
  - **User Range Rate Error (pseudorange velocity inaccuracy due to the SIS)**
  - **95% Global Average URRE during Normal Operations at Any AOD.**
  - **The first-order derivative of URE versus time.**
- **SIS URAE**
  - **User Range Acceleration Error (pseudorange acceleration inaccuracy due to the SIS)**
  - **95% Global Average URAE during Normal Operations at Any AOD.**
  - **The second-order derivative of time versus URE.**

SIS Accuracy

- **SIS Accuracy's Continuity (AC)**
  - **The probability that a health instantaneous SIS URE doesn't exceed the threshold without interruption over a specified time interval.**

Calculation Method：

In a short time △t, if the instantaneous URE of all epoch don't exceed the threshold, this SIS's Accuracy is continuity.

$$\text{Accuracy}_{\text{Continuity}} = \frac{\sum_{i=1}^{i=n} bool\left(URE_{\Delta t_i} \le Theshold\right)}{n}$$

△t depends on user's requirement.

SIS Accuracy

- **SIS Accuracy's Availability(AA)**

- **The probability that a instantaneous URE doesn't exceed the threshold over a specified time interval.**

Calculation Method：

$$\text{Accuracy}_{\text{Availabilaity}} = \frac{\sum_{i=1}^{i=n} bool\left(URE_{\text{i}} \le Theshold\right)}{n}$$

n : Total number of epochs

SIS Integrity

- **The capability to issue timely alerts when the instantaneous SIS cannot meet Threshold indicators.**
- **The SIS integrity is defined to be the trust which can be placed in the correctness of the information provided by the SIS.**

SIS integrity is an advanced performance parameter.

It is important for aviation user especially.

SIS Integrity

Parameters:

- **Probability of a Major Service Failure.**

The probability of a major service failure for the SIS is defined to be the probability that the SIS's instantaneous URE exceeds the URE NTE tolerance without a timely alert being issued.

- **Time to Alert(TTA)**

TTA is defined to be the time from the onset of MSI until an alert (alarm or warning) indication arrives at the receiver's antenna.

- **SIS URE NTE Tolerance**

NTE=Not To Exceed

SIS Integrity

- **SIS Integrity's Continuity (IC)**
  - **The probability that a integrity SIS service continue to be integrity without interruption over a specified time interval.**

Calculation Method：

In a short time △t, if the SIS service of all epoch is integrity , this SIS's integrity is continuity.

$$\text{Integrity}_{\text{Continuity}} = \frac{\sum_{i=1}^{i=n} bool\left(Integrity_{\Delta t_i}\ works\ correctly\right)}{n}$$

SIS Integrity

- **SIS Integrity's Availability(IA)**

- **The probability that a instantaneous Integrity is work correctly over a specified time interval.**

Calculation Method：

$$\text{Integrity}_{\text{Availabilaity}} = \frac{\sum_{i=1}^{i=n} bool\left(Integrity_{\text{i}}\ works\ correctly\right)}{n}$$

n : Total number of epochs

Time and Coordinate system

- **The accuracy of Time systems**
  - **The accuracy of a navigation system's time aligned to UTC。**

- **The accuracy of Coordinate systems**
  - **The matching accuracy of a navigation system's coordinates aligned to ITRS.**

Summary

（1）Research on the definitions and calculation methods of GNSS open service performance parameters is benefit to promote the interoperability and applications of Multi-GNSS.

（2） The GNSS performance parameters on open Service could be described by those items, including constellation configuration, navigation signal, SIS performance , Time and Coordinate system.

（3）we propose that ,the definitions and calculation methods of all parameters should be further discussed one by one .

Thanks for your attention!

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