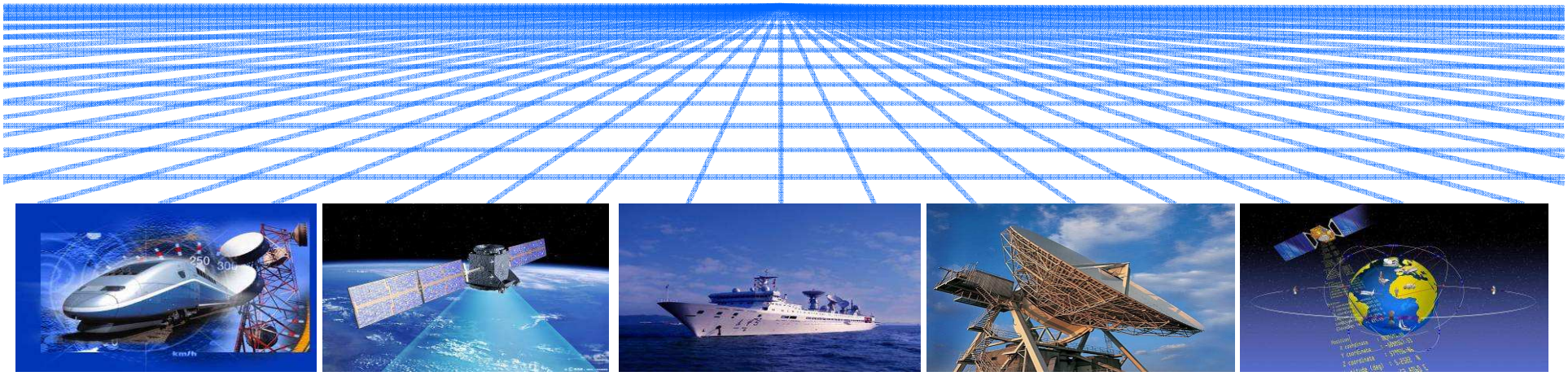
# Studies On GNSS Open Service Performance Standard Template

**Li Jianwen**
**ZZLJW@126.com**
**Zhengzhou Institute of Surveying and Mapping, China**



# *BACKGROUND*

- ICG Principle at ICG-4 (Sep 2009)

*"Every GNSS provider should establish documented civil performance commitments to inform users about minimum levels of service".*

- This work will benefit to promote the interoperability and applications of Multi-GNSS.
- It is also an important work for international GNSS monitoring and assessment activities.
- In November 2012,at ICG-7 , GNSS OS PS Template (draft) was distributed by delegate of USA. suggestions were welcomed.

# *The potential Users of GNSS OS PS*

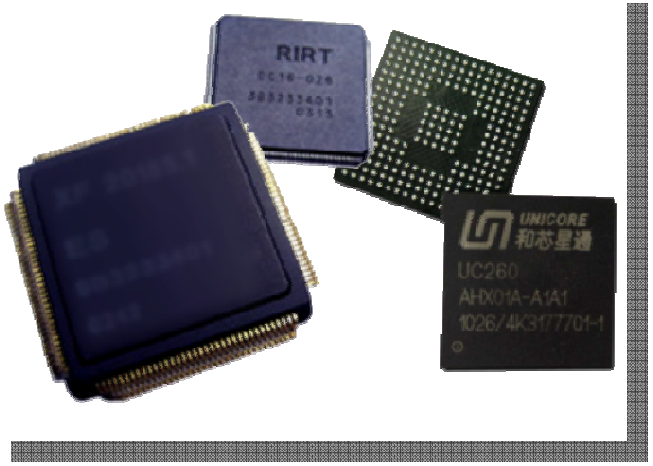
There are two kinds of user.

- GNSS terminal Users

Mainly focus on the service volume and some frequent-used service performance parameters.


- GNSS User Equipment manufacturers

This is a basic issues for design, developing , and application popularizings.



# *Categories of GNSS OS Paremeters*

- GNSS Constellation Definitions
- GNSS OS SIS Coverage
- GNSS OS SIS Accuracy
- GNSS OS SIS Integrity
- GNSS OS SIS Continuity
- GNSS OS SIS Availability
- GNSS OS Position/Time Domain

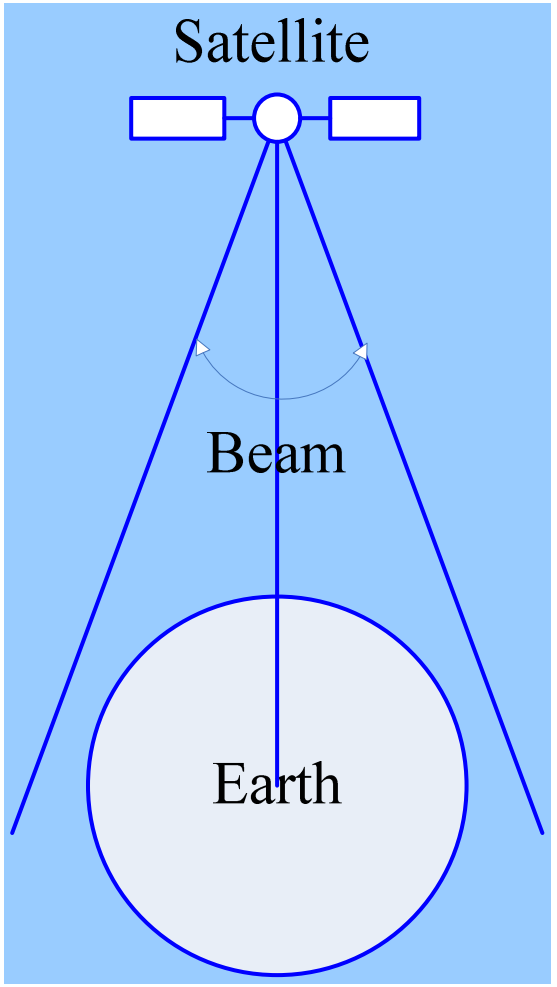
# GNSS Constellation Definitions

- **SVs of the Baseline constellation**
  - Total number of the Satellite Vehicles.
- **Orbital slots Parameters of per-satellite.**
  - Right Ascension of the Ascending Node (RAAN)
  - The Argument of Latitude
  - The corresponding Ground track Equatorial Crossing (GEC) values

# GNSS OS SIS Coverage

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

- **Signal power**
  - Minimum and maximum value in the Terrestrial Service Volume (TSV) and the Space Service Volume



# GNSS OS SIS Accuracy

- **Three aspects of OS SIS accuracy**

➢ User Range Error (URE)

The pseudorange accuracy

➢ User Range Rate Error(URRE)

The time derivative of the URE

➢ User Range Acceleration Error( URAE)

The second time derivative of URE

# OS SIS URE Accuracy Standards

| SIS Accuracy Standard | Conditions and Constraints |
|---|---|
| Single-Frequency PRN Code:<br>• ≤ *[TBD]* m 95% in the service volume URE during Normal Operations over all AODs<br>• ≤ *[TBD]* m 95% in the service volume URE during Normal Operations at Zero AOD<br>• ≤ *[TBD]* m 95% in the service volume URE during Normal Operations at Any AOD<br>• ≤*[TBD]* hours of maximum AOD during Normal Operations | • For any healthy OS SIS<br>• Neglecting single-frequency ionospheric delay model errors<br>• Including group delay time correction ($T_{GD}$) errors<br>• Including inter-signal bias errors |

# OS SIS URRE Accuracy Standards

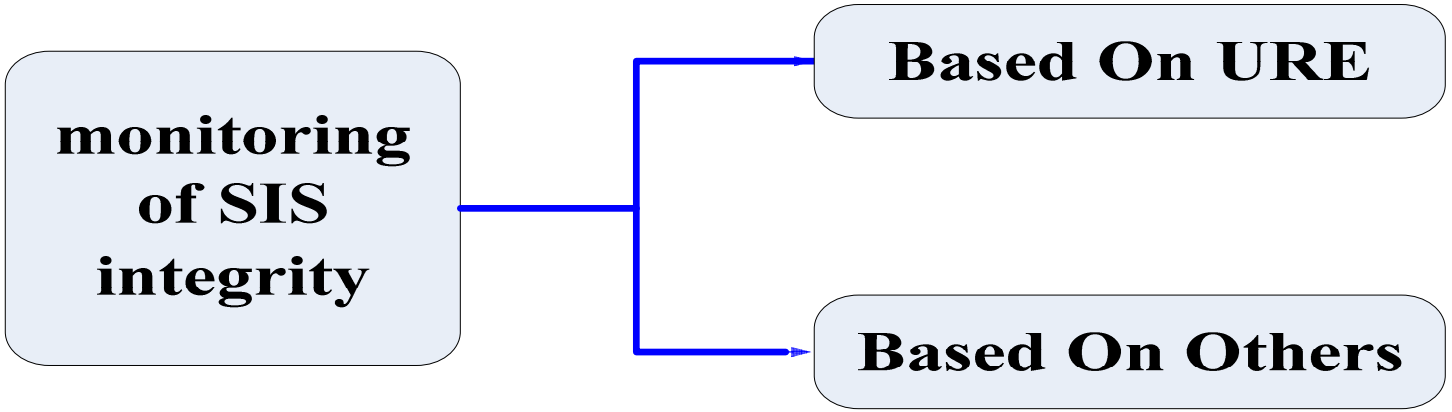
| SIS Accuracy Standard | Conditions and Constraints |
|---|---|
| Single-Frequency PRN Code:<br>• ≤ *[TBD]* m/sec 95% Service Volume URRE over any *[TBR]*second interval during Normal Operations at Any AOD<br>• ≤*[TBD]* hours of maximum AOD during Normal Operations | • For any healthy OS SIS<br>• Neglecting all perceived pseudorange rate errors attributable to pseudorange step changes caused by NAV message data cutovers<br>• Neglecting single-frequency ionospheric delay model errors |

# OS SIS URAE Accuracy Standards

| SIS Accuracy Standard | Conditions and Constraints |
|---|---|
| Single-Frequency PRN Code:<br>• ≤ *[TBD]* m/sec/sec 95% in the service volume URAE over any *[TBR]*second interval during Normal Operations at Any AOD<br>• ≤*[TBD]* hours of maximum AOD during Normal Operations | • For any healthy OS SIS<br>• Neglecting all perceived pseudorange acceleration errors attributable to pseudorange step changes caused by NAV message data cutovers<br>• Neglecting single-frequency ionospheric delay model errors |

# GNSS OS SIS Integrity

- **There are different ways to complete monitoring of SIS integrity in GNSS.**
- **GNSS OS SIS integrity parameters based on URE is not the only method.**



# GNSS OS SIS Integrity

- **Proposed parameters are as below:**

| SIS Integrity Standard | Conditions and Constraints |
|---|---|
| Single-Frequency PRN Code:<br>•PIM, Parameter of Integrity Monitoring<br>• ≤ $1x10^{-[TBD]}$ Probability Over Any Hour of the OS SIS Instantaneous PIM Exceeding the *NTE[TBD]* Tolerance Without a Timely Alert during Normal Operations<br>• Worst case for delayed alert is *[TBD]* hours | • Applies to any healthy OS SIS<br>• Given that the maximum OS SIS instantaneous URE did not exceed the NTE tolerance at the start of the hour<br>• Neglecting single-frequency ionospheric delay model errors |

# GNSS OS SIS Continuity

| SIS Continuity Standard | Conditions and Constraints |
|---|---|
| Unscheduled Failure Interruptions:<br>• ≥ *[TBD]* Probability Over Any Hour of Not Losing the OS SIS Availability from a Slot Due to Unscheduled Interruption<br>• *NTE[TBD] second* tolerance of Unscheduled Failure Interruptions<br>• at least *[TBD]* hours in advance of the interruption information are published. | • Calculated as an average over all slots in the *<NN>*-slot constellation, normalized annually<br>• Given that the OS SIS is available from the slot at the start of the hour |

**OS SIS Continuity Standards – Unscheduled Failure Interruptions**

# GNSS OS SIS Continuity

| Status and Problem Reporting Standard | Conditions and Constraints |
|---|---|
| Scheduled Event Affecting Service<br>• issued to the civil user notification systems *<ICG Monitoring Information Center >* at least *48[TBD]* hours prior to the event | • For any OS SIS<br>• *ICG Monitoring Information Center informs to other organizations.* |
| Unscheduled Outage or Problem Affecting Service<br>• issued to the civil user notification systems *<ICG Monitoring Information Center >* as soon as possible after the event | • For any OS SIS<br>• *ICG Monitoring Information Center informs to other organizations.* |

**Status and Problem Reporting Standards**

# GNSS OS SIS Availability

| SIS Availability Standard | Conditions and Constraints |
|---|---|
| • ≥ *[TBD]* Probability that a Slot in the Baseline Constellation Configuration will be Occupied by a Satellite Broadcasting a Healthy OS SIS | • Calculated as an average over all slots in the Baseline constellation, normalized annually<br>• Applies to satellites broadcasting a healthy OS SIS which also satisfy the other performance standards in this *OS PS* |

**OS SIS Per-Slot Availability Standards**

***Availability.3-1***

# GNSS OS SIS Availability

| Operational Satellite Count Standard | Conditions and Constraints |
|---|---|
| • ≥ *[TBD]* Probability that the Constellation will Have at least *<NN>* Operational Satellites Regardless of Whether Those Operational Satellites are Located in Slots or Not | • Applies to the total number of operational satellites in the constellation (averaged over any day); where any satellite which appears in the transmitted navigation message almanac is defined to be an operational satellite regardless of whether that satellite is currently broadcasting a healthy OS SIS or not and regardless of whether the broadcast OS SIS also satisfies the other performance standards in this *OS PS* or not |

**Operational Satellite Count Standards** ***Availability.3-3***

# GNSS OS Position/Time Domain PS

| PDOP Availability Standard | Conditions and Constraints |
|---|---|
| ≥ *[TBD]*% Service Volume PDOP of 6*[TBD]* or less<br>≥ *[TBD]*% worst site PDOP of 6*[TBD]* or less | • Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval. |

**PDOP Availability Standards**

# GNSS OS Position/Time Domain PS

| Position Service Availability Standard | Conditions and Constraints |
|---|---|
| ≥ *[TBD]*% Horizontal Service Availability, average location<br>≥ *[TBD]*% Vertical Service Availability, average location | • *[TBD]* m horizontal (SIS only) 95% threshold<br>• *[TBD]* m vertical (SIS only) 95% threshold<br>• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval. |
| ≥ *[TBD]*% Horizontal Service Availability, worst-case location<br>≥ *[TBD]*% Vertical Service Availability, worst-case location | • *[TBD]* m horizontal (SIS only) 95% threshold<br>• *[TBD]* m vertical (SIS only) 95% threshold<br>• Defined for a position/time solution meeting the representative user conditions and operating within the service volume over any 24-hour interval. |

**OS Position Service Availability Standards** ***Domain.4-2***

# GNSS OS Position/Time Domain PS

| Position Accuracy Standard | Conditions and Constraints |
|---|---|
| Service Volume Average Position Domain Accuracy<br>• ≤ *[TBD]* m 95% Horizontal Error<br>• ≤ *[TBD]* m 95% Vertical Error | • Defined for a position/time solution meeting the representative user conditions<br>• Standard based on a measurement interval of 24 hours averaged over all points in the service volume. |
| Worst Site Position Domain Accuracy<br>• ≤ *[TBD]* m 95% Horizontal Error<br>• ≤ *[TBD]* m 95% Vertical Error | • Defined for a position/time solution meeting the representative user conditions<br>• Standard based on a measurement interval of 24 hours for any point in the service volume. |

**OS Position Service Accuracy Standards**

# GNSS OS Position/Time Domain PS

| Time Accuracy Standard | Conditions and Constraints |
|---|---|
| Time Transfer Domain Accuracy<br>• ≤ *[TBD]* nsec time transfer error 95% of time (SIS only) | • Defined for a time transfer solution meeting the representative user conditions<br>• Standard based on a measurement interval of 24 hours averaged over all points in the service volume. |
| • ≤ *[TBD]* nsec 95% Service Volume Average UTCOE during Normal Operations at Any *AOD(Hours [TBD])* | • For any healthy OS SIS |

**OS Time Service Availability Standards**

# *Summary*

**（1）The potential Users of GNSS OS PS mainly are popular consumers and it's equipment  manufacturers.**

- **The requirements of those users is quite different form Users of IACO.**

**（2）the work of template for GNSS Service Performance Commitments should be carried forward step by step.**

- **A list of parameters to be included in template should be developed firstly.**
- **Then, methodology for each parameter must be determined .**

**（3）We propose that, a common view set of parameters are determined firstly .**

- **This is the base of the future work,.**
- **The parameters also could be extended in the future .**

# *Recommendation*

- **the work of template for GNSS Service Performance Commitments should be carried forward step by step.** And a list of parameters to be included in template should be developed firstly. Then, methodology for each parameter must be determined .
- **A common view set of parameters should be determined in first-step .**This is the base of the future work and the parameters also can be extended in the future .

# Thanks for your attention!

**Li Jianwen**

Zhengzhou Institute of Surveying and Mapping, China
ZZLJW@126.com