

Status and Progress on ICG IGMA Task Force and Joint Trial Project with IGS

ICG IGMA Task Force

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ICG International Committee on
Global Navigation Satellite Systems



1. International Committee on GNSS(ICG)

- ICG was **established** in 2005 under the umbrella of the United Nations.
- ICG **strives** to encourage and facilitate **compatibility, interoperability and transparency** between **all the satellite navigation systems**, to promote and protect the use of their open service applications and thereby benefit the global community.
- ICG is open to States **Members** of the **United Nations, international organizations** or **international entities** that are responsible for GNSS and their augmentations.
- ICG current **workplan** included **Systems, Signals and Services; Enhancement of GNSS Performance, New Services and Capabilities; Information Dissemination and Capacity Building, and Reference Frames, Timing and Applications.**



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1. ICG IGMA

- A **Providers' Forum** was established in 2007 in ICG with the aim to promote greater compatibility and interoperability among current and future GNSS providers.
- **ICG Providers' Forum Work Plan** proposed to **widely monitor the performance of their open signals and provide timely updates to users.** The Working Group will support this activity by translating open service performance standards into parameters for multi-GNSS monitoring.
- **IGMA Task Force(TF) was established** at ICG-6 meeting in Tokyo, **2011.** (At that time it was called the IGMA Sub Group).



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1. ICG IGMA

- **Task of the IGMA TF:**
 - **Determine Service Parameters to Monitor**, Determine what gaps exist in current and planned monitoring and assessment
 - **Consider organizing workshop** on IGMA parameters, services and methodologies
 - **Recommend what should be monitored** by:
 - Individual GNSS monitoring/control segments; Shared sites of 2 or more GNSS through bilateral agreements; Global monitoring of Multi-GNSS parameters
 - **Propose an Organizational Approach** that:
 - Avoids Duplication; Coordinates and integrates the related activities for identifying parameters; Considers the role of the current/planned IGS and Defines the Relationship of the proposed organization to ICG.
 - **Explore methods to disseminate monitoring and assessment results**, considering specific proposals from system providers



2. IGMA ICG-IGS joint Trial Project

ICG-IGS joint Trial Project was proposed in ICG-10 to assist with public confidence in GNSS service provision and interoperability.

➤ Objectives of joint Trial Project:

- **To implement a monitoring system for all participating GNSS**
 - Monitoring a **limited number of parameters**
 - Broadcast Ephemeris Accuracy (Orbits and Clocks)
 - SIS User Range Error , SIS UTC Offset Error and PDOP
 - Using **existing monitoring infrastructures**
 - To start simple and reach early success, then build to include more parameters and improved processing
 - Developing a set of requirements for monitoring system(s) in subsequence phases of the project
- **To demonstrate user benefits of**
 - Consolidated monitoring system products and Combined use of multi-constellations
- **To promote trust in GNSS via an ICG endorsed monitoring system**



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2. IGMA ICG-IGS joint Trial Project

➤ Basic Idea of the Trial Project

Phased Approach was adopted

Initial phase of the Trial Project

- Post Processing
- System level performance monitoring with limited parameters for each single constellation

+ User level performance monitoring

+Real-time Processing

+ Assessment function

+ multi-GNSS performance monitoring and assessment

Future Expansion



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3. IGMA Activities and Progress

- ICG Rec 10A/D 4.1 on Nov. 5 2015 at ICG-10
- **Terms for Reference** established, CfPs were issued
- IGS Governing Board meeting on Dec. 10, 2016
 - IGS decision to join the TP
- Performance Monitoring **Workshop** and TF meeting on May 22, 2017 in Shanghai
- IGS-ICG joint Trial Project meeting as a **splinter meeting** in IGS Workshop 2017 on July 4, 2017 in Paris
 - IGS Pilot Project was initiated, preliminary trial were carried out
- TF meeting during WG-S intersessional meeting on July 6, 2017 in Paris
- **TF meetings on Dec. 4, 2017 during ICG-12 and**
- **9 monthly tele-conferences in 2018**
- **ICG IGMA and Performance Standard Workshop @GRC on May 14-15, 2018**



3. IGMA Activities and Progress

Providers' Nomination Status SUMMARY

| Country | Signed CL | Category | Organization Name |
|---------|-----------|--------------------|--|
| Russia | X | MAC | PNT Center in TSNIMASH |
| | | Monitoring site(2) | Klyuchi, Korolyov |
| | | Data Center | PNT Center in TSNIMASH |
| U.S. | X | MAC | DOT/Volpe Center |
| | | Monitoring site(6) | Boston, Honolulu, Los Angeles, Miami, Juneau, and Merida |
| | | Data Center | USCG |
| EU | X | MAC | GSA/Galileo Reference Centre |
| | | Monitoring site | To be provided |
| | | Data Center | To be provided |
| China | X | MAC | RISM/NTSC |
| | | Monitoring site(3) | Shanghai, Lhasa, and Urumqi |
| | | Data Center | TARC/CSNO |
| Japan | | To be provided | To be provided |

3. IGMA Activities and Progress

IGMA Workshop in 2018,2017,2015



ICG IGMA&PS Workshop 2019 @US

ICG IGMA&PS Workshop 2020 @RS



IGMA and Performance Standard WS 2018

- Date: May 14-15, 2018
 - Venue: [Galileo Reference Centre \(GRC\)](#), Noordwijk, The Netherlands
 - Participants: GPS, GLONASS, Galileo, BDS and QZSS, IGS representatives around 30 attendees
 - Agenda;
 1. [Methodologies for agreed 4 params in TP ToR](#)
 2. [Data format](#)
 3. Continuity Definition
 4. Service Definition Document
 5. IGMA TF meeting
 6. PS “Dream Team” meeting
- IGMA Part
- PS Part
- Closed session



Discussion on Methodologies

5 Providers and IGS presented their calculation methods. Findings through discussion were followings;

- **Orbit and Clock error.**
 - APC Offset with satellite attitude
 - Reference orb and clock
 - NAV message and SV health status
 - XYZ or RAC
- **URE**
 - Using projected range error based on precise orbit rather than monitored observation.
 - Only US proposed monitored observation
 - Further discussion will be continued at a monthly teleconferences



Discussion on Methodologies

- **UTC Offset Error**

- Limited access to national standard time and system time
- Only provider can calculate and provide result
- Ensemble time for multi-GNSS could be used for comparison among GNSS, and this is a topic of the workshop in Vienna in June.

- **PDOP**

- There were discussions of grid size (global), time increment, and the need to apply satellite health.

- **Time intervals, common statistics**

- Discussion on using common periods to permit comparisons. Candidates for statistical averaging periods are 3 day, 1 day, 30 days.
- RMS, 95%, 99%....



Discussion on Data Format

Two types of data format for exchanging and archiving calculated parameters are being proposed.

- **Text format, XML format**
- Importance of backward compatibility as well as flexibility to future change of the calculation method and increment of parameters was recognized
- No consensus on consolidated format at this time, TF agreed to **need further discussion after the discussion on calculation methodologies** were finished.



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Preliminary Summary of Methodologies Discussion

The characteristics associated with each parameter are given in the tables following. For some items, agreements were reached by all participating parties. Certain items remain to be worked out.

➤ Contributions of each MAC(Monitoring Analysis Center)

| Items | US | RS | EU | China | Japan | |
|------------|-----|---------------------------|--|--|---------------------------------|--|
| Num.of Sys | GPS | GPS, GL O, GAL, BDS | GPS, GLO, GAL, BDS | GPS, GLO, GAL, BDS | GPS, GLO, GAL, BDS , QZSS | |
| Orbit | YES | YES | YES | YES | | |
| Clock | YES | YES | YES | YES | | |
| URE | YES | YES | YES | YES | YES | |
| UTC OE | YES | YES | YES | YES | YES | |
| Method | | | According to each constellation's definition | According to each constellation's definition | | |

| Items | GPS | GLONASS | GALILEO | BDS | QZSS | Recommend |
|---|-------------------------------------|------------------------------|---|-------------------|------|-----------|
| SV status and cutoff angle for assessment | Healthy,5deg | Healthy,5deg | Healthy including Age of Ephemer below 4h, 5deg | Healthy,5deg | n/a | |
| Reference Orbit | NGS (NGS FTP) | | GRC | iGMAS(iGMAS Web) | n/a | |
| Broadcast Orbit (assessment object) | IODEs from US TP reference stations | | | iGMAS | n/a | |
| Compare Position | APC | APC | APC | APC | n/a | |
| PCO/PCV for Reference Orbit | IGS | | GSC website | iGMAS(iGMAS Web) | n/a | |
| PCO/PCV (internal use of the provider for Broadcast ephemeris) | Provider(GPS APC) | Provider | Provider | Provider(BDS Web) | n/a | |
| Coordinate System for Results | Satellite body-fixed(RAC) | RAC | RAC | RAC | n/a | |
| Attitude | | | Described on GSC website | | n/a | |
| Transformation between Coordinate Systems (used for Reference and Broadcast orbit) | | | | | n/a | |
| Sample interval | 5-60sec | | | 30-300sec | n/a | |
| Statistic Method and Step | 3 days 95%, Daily worst error | Monthly, Exclude large error | | Weekly,95% | n/a | |

➤ CLOCK

| Items | GPS | GLONASS | GALILEO | BDS | QZSS | Recommend |
|------------------------------------|-------------------------------------|---------------------------------|----------|-------------------|------|-----------|
| Reference Clock | NGS (NGS FTP) | | GRC | iGMAS(iGMAS Web) | n/a | |
| Broadcast Clock | IODEs from US TP reference stations | | | iGMAS | n/a | |
| Clock Reference Frequency | L5? | | | B3(Refer ICD) | n/a | |
| Compare Position | APC | APC | APC | APC | n/a | |
| PCO/PCV for Reference Clock | IGS | | | iGMAS(iGMAS Web) | n/a | |
| PCO/PCV for Broadcast Clock | Provider | Provider | Provider | Provider(BDS Web) | n/a | |
| DCB/TGD | | | | iGMAS(iGMAS Web) | n/a | |
| Sample interval | 5-60sec | | | 30-300sec | n/a | |
| Statistic Method and Step | 3 days,95% Daily worst error | Monthly, Exclude large error | | Weekly,95% RMS | n/a | |
| | | | | | | |



➤ URE

| Items | GPS | GLONASS | GALILEO | BDS | QZSS | Recommend |
|------------------------------------|---|--------------|---|--------------|---------------|-----------|
| SV | Healthy,5deg | Healthy,5deg | Healthy including Age of Ephemer 4h.,5deg below | Healthy,5deg | Healthy,10deg | |
| Projection | YES | | yes | YES | YES | |
| Observations | YES | | | YES | | |
| Sample interval | 5-60sec | | 300sec | 30-300sec | | |
| Statistic Method and Step | 3 days 95%, Time-tagged event on condition SISURE > 4.42 x URA | Monthly, 95% | Monthly,95% | Weekly,95% | Daily,95% | |
| Statistic of each satellite | YES | | yes | YES | | |
| Constellation Statistic | | YES | YES | YES | | |



➤ UTCOE

| Items | GPS | GLO | GAL | BDS | QZSS | Recommend |
|---------------------------|----------------------|-----|------------|------------|--------|-----------|
| Reference Value | USNO | | | NTSC | NICT | |
| Reference Value download | USNO | | | NTSC | | |
| Sample interval | daily | | daily | daily | weekly | |
| Statistic Method and Step | Yearly ,No statistic | | Yearly 95% | Yearly 95% | | |
| | | | | | | |



➤ PDOP

| Items | GPS | GLO | GAL | BDS | QZSS | Recommend |
|-----------------------|---------|---------|-------------------|-------------------|------|-----------|
| SV | healthy | healthy | healthy | healthy | n/a | |
| Cutoff Angle | 5deg | 5deg | 5deg | 5deg | n/a | |
| Spatial Coverage | S74-N74 | | Global | | n/a | |
| Space/Time Resolution | altered | | fixed | altered | n/a | |
| Statics | | | Average and Worst | Average and Worst | | |



4 Summary

- Several workshops and tens monthly tel-meetings have been carried out within IGMA TF to discuss the methodology and format.
- Members begin to implement the Trial Project and share and discuss results.
- The IGS IGMA WG performed three test campaigns, results will be presented in the splinter meeting today at 16:30.
- Need further discussion
 - The methods for assessing the accuracies of the Orbit & Clock, URE, UTCOE and PDOP have been discussed. For some items, agreements were reached by all participating parties. Certain items remain to be worked out.
 - Each parameter will be discussed further and to make common definition
- Next short-term goal:
 - Share and compare results from Trial Project



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