



International Committee on  
Global Navigation Satellite Systems



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

**ICG IGMA Task Force  
November 6, 2018  
ICG-13 WG-S @Xi'an China**



ICG International Committee on  
Global Navigation Satellite Systems

# Outline

**1. ICG IGMA**

**2. IGMA Joint Trial Project**

**3. IGMA Activities and Progress**

**4. Summary**



**ICG** International Committee on  
Global Navigation Satellite Systems



**IGS** INTERNATIONAL  
GNSS SERVICE

# 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**



**ICG** International Committee on  
Global Navigation Satellite Systems



# 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



ICG International Committee on  
Global Navigation Satellite Systems



# 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.



**ICG** International Committee on  
Global Navigation Satellite Systems



**IGS** INTERNATIONAL  
GNSS SERVICE

# 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
<b>SV status and cutoff angle for assessment</b>	Healthy,5deg	Healthy,5deg	Healthy including Age of Ephemer below 4h, 5deg	Healthy,5deg	Healthy,10deg	
<b>Reference Orbit</b>	NGS (NGS FTP)		GRC	iGMAS(iGMAS Web)	Provider (QZSS Web) (*1)	
<b>Broadcast Orbit (assessment object)</b>	IODEs from US TP reference stations			iGMAS	Ephemeris (Zero age, All age)	
<b>Compare Position</b>	APC	APC	APC	APC	APC	
<b>PCO/PCV for Reference Orbit</b>	IGS		GSC website	iGMAS(iGMAS Web)	Provider (QZSS Web) (*2)	
<b>PCO/PCV (internal use of the provider for Broadcast ephemeris)</b>	Provider(GPS APC)	Provider	Provider	Provider(BDS Web)	Provider (QZSS Web) (*2)	
<b>Coordinate System for Results</b>	Satellite body-fixed(RAC)	RAC	RAC	RAC	RAC	
<b>Attitude</b>			Described on GSC website			
<b>Transformation between Coordinate Systems (used for Reference and Broadcast orbit)</b>						
<b>Sample interval</b>	5-60sec			30-300sec	300sec	
<b>Statistic Method and Step</b>	3 days 95%, Daily worst error	Monthly, Exclude large error		Weekly,95%	Daily,95%	



# ➤ CLOCK

Items	GPS	GLONASS	GALILEO	BDS	QZSS	Recommend
<b>Reference Clock</b>	NGS (NGS FTP)		GRC	iGMAS(iGMAS Web)	Provider (QZSS Web) (*)	
<b>Broadcast Clock</b>	IODEs from US TP reference stations			iGMAS	Clock correction coefficients	
<b>Clock Reference Frequency</b>	L5?			B3(Refer ICD)	L1C/A L2C	
<b>Compare Position</b>	APC	APC	APC	APC	APC	
<b>PCO/PCV for Reference Clock</b>	IGS			iGMAS(iGMAS Web)	Provider (QZSS Web) (*)	
<b>PCO/PCV for Broadcast Clock</b>	Provider	Provider	Provider	Provider(BDS Web)	Provider (QZSS Web) (*)	
<b>DCB/TGD</b>				iGMAS(iGMAS Web)		
<b>Sample interval</b>	5-60sec			30-300sec	300s	
<b>Statistic Method and Step</b>	3 days,95% Daily worst error	Monthly, Exclude large error		Weekly,95% RMS	Daily,95%	

(\*) <http://sys.qzss.go.jp/dod/en/archives/pnt.html>





# ➤ URE

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



# ➤ UTCOE

Items	GPS	GLO	GAL	BDS	QZSS	Recommend
Reference Value	USNO			NTSC	NICT	
Reference Value download	USNO			NTSC	NICT	
Sample interval	daily		daily	daily	daily	
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	N/A(*)	

(\*) QZSS is 4 satellite constellation.



# IGS IGMA WG activities



**ICG** International Committee on  
Global Navigation Satellite Systems



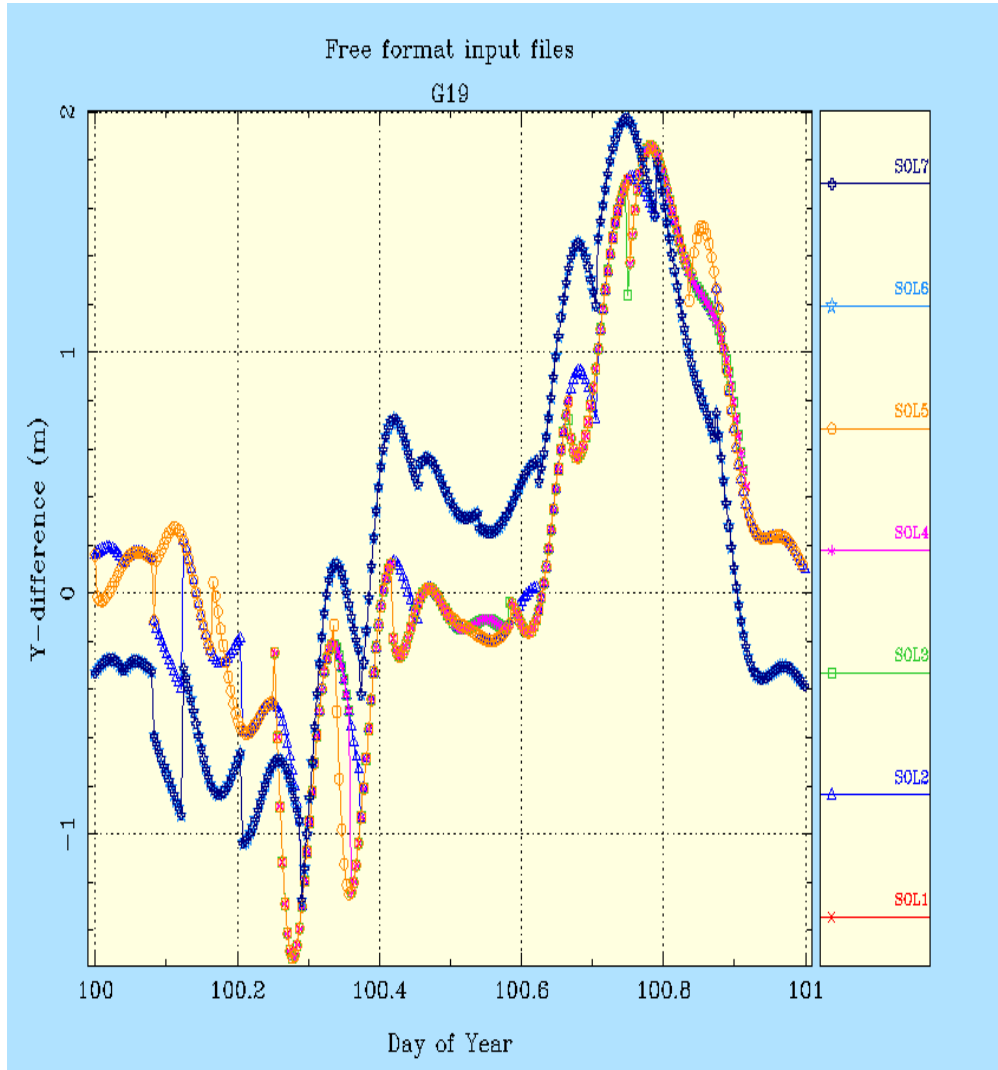
**IGS** INTERNATIONAL  
GNSS SERVICE

# Overview



- Three tests performed
  - “Full” test
    - Single day test (2018 100)
    - Single week test (2018 245-252)
- The first “full” test led to very different results
  - Informative but not very useful
- Single day test much simpler
  - Better agreements but still very significant differences
- Single week test
  - Similar results as single day test but only three groups so far

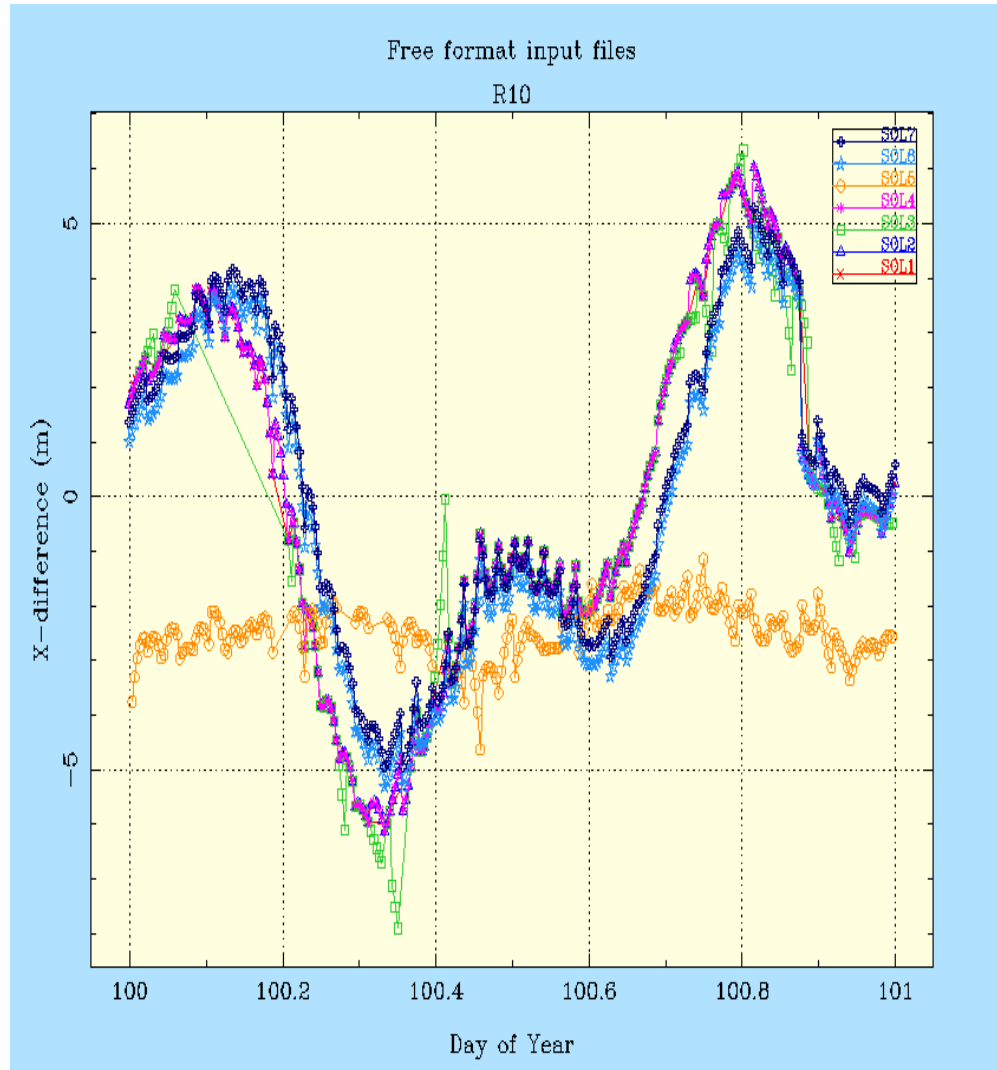




## Notes:

- SOL6 and SOL7 used PCO offsets
- SOL2 and SOL7 identical save for PCO offsets
- Very good agreement in general but some significant differences

# GLONASS Results (ICGC group different, better?)





# Next Steps

1. Speed-up activities!
  2. Improve agreement
    - Remain with centre of mass assumption for broadcast
    - Make sure all differences become well below the 0.1 m level
  3. Obtain information on broadcast reference points
    - Preferably in Antex format
    - Repeat exercise with offsets
      - Satellite attitude also comes into play
- 
- Will fix some dates to achieve the above points (April 2019)
  - We can use the current two test cases

# 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, .
- 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
  - IGMA/PS Workshop 2019 will be held in Boston, U.S. on June 4-6 or June 11-13, 2019



# References

- Andrew Hanson, KPI Methodologies Proposed by US, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Tim Springer, Methodology proposed by the IGS-IGMA, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Xiaolin Jia, Shuli Song, Algorithms and Implementation of GNSS Basic Monitoring and Assessment Parameters, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Marco Porretta, Peter Buist, Gaetano Galluzzo, Methodology proposed by EU, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Satoshi Kogure, Takao Nakagawa, Yoshihiro Iwamoto, Methodology proposed by Japan, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Sergey Kaplev, Methodology for Trial Project Materials, IGMA Workshop, Noordwijk, The Netherlands, May 14-15, 2018.
- Terms of Reference for IGMA-IGS Joint Trial Project – IGMA-TF – June 15, 2016
- [www.igs.org](http://www.igs.org)
- [www.igmas.org](http://www.igmas.org)
- [www.beidou.gov.cn](http://www.beidou.gov.cn)
- [https://gssc.esa.int/navipedia/index.php/Satellite\\_Antenna\\_Phase\\_Centre](https://gssc.esa.int/navipedia/index.php/Satellite_Antenna_Phase_Centre)
- <https://www.gps.gov/cgsic/meetings/2008/kelley.pdf>