

ICG Working Group on Systems Signals and Services (WG-S) ICG-14 Meeting

Interoperability and Service Provision Subgroup Report

***Bangalore, India
10-12 December 2019***



INTEROPERABILITY & SERVICE STANDARDS

Co-chairs

Xiaochun LU, China

Jeff AUERBACH, U.S.



Interoperability & Service Provision Subgroup

Jeff Auerbach, U.S. - Co-lead

China

Shuli SONG

Juan DU

Jun SHEN

Jianwen LI

Japan

Satoshi Kogure

Masaharu Kugi

U.S.

Robyn Anderson

John Lavrakas

Andrew Hansen

Xiaochun LU, China - Co-lead

European Union

Hillar Tork

Peter Buist

Werner Enderle

Joerg Hahn

Russia

Igor Larin

Tatyana Mirgorodskaya

Alex Bolkunov

Igor Silvestrov

Tatiana Primakina

Andrey Druzhin

Sergey Silin

India

N M Desai

R. Ramasubramanian





International Committee on
Global Navigation Satellite Systems

OPEN SERVICE INFORMATION SHARING



ICG International Committee on
Global Navigation Satellite Systems

Work Plan - Open Service Performance Standards

- Consistent with the principle of transparency in the provision of open services, ***each individual Provider will strive to publish and disseminate all signal and system information necessary to allow manufacturers to design and develop GNSS receivers.***
- The Subgroup will ***develop a template to promote common terminology and definitions in individual GNSS Open Service Signal Specifications*** as published in Interface Standards and Interface Control Documents.
- The Subgroup will ***also develop a template that each individual GNSS provider may consider using in their publication of signal and system information***, the policies of provision, and the minimum levels of performance offered for open services used on the Earth and in outer space (Open Service Performance Standards).



Sub-Group Members focused on Performance Standards – Dream Team

- Alexey Bolkunov (co-lead), Sergey Kaplev, Igor Silvestrov - Russian Federation
- John Lavrakas (co - lead), Andrew Hansen, Karl Kovach - United States
- Hillar Tork, Peter Buist, Rafael Lucas-Rodriguez, Daniel Blonski - European Union
- Satoshi Kogure, Masaharu Kugi, Daiju Ichinose – Japan
- Li Jianwen, Du Juan - China

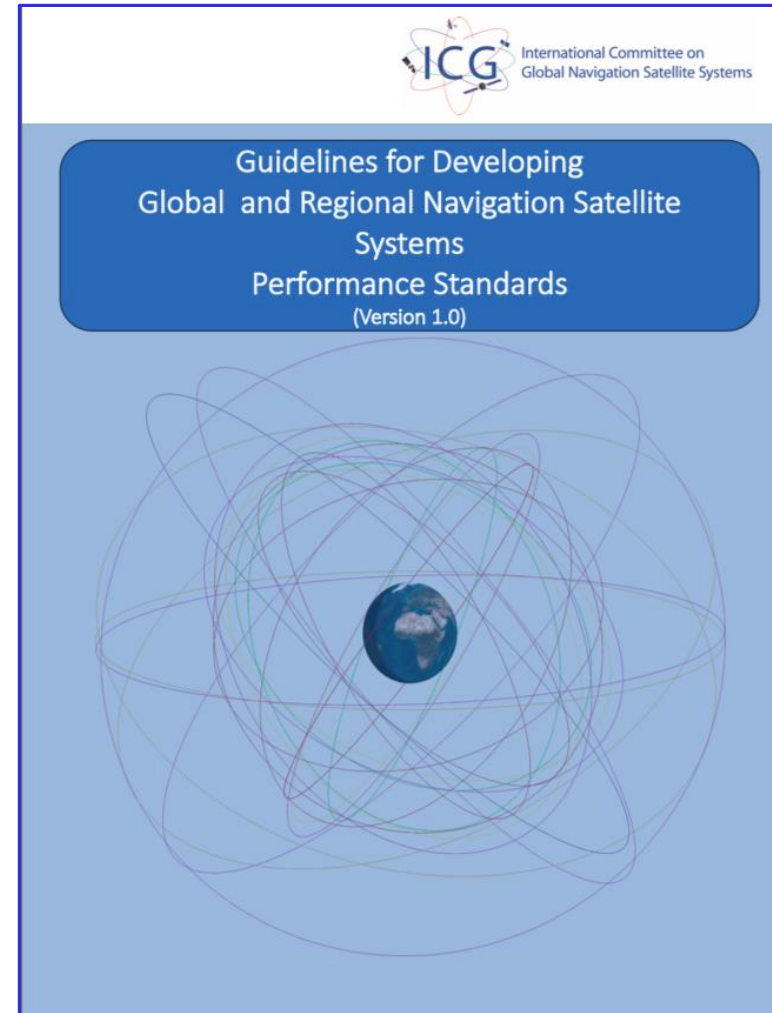


Status of GNSS ICDs and Open Service Performance Standards

	GPS	GLONASS	BDS	Galileo	NavIC	QZSS
Interface Control Documents/ Specifications	✓	✓	✓	✓	✓	✓
	IS GPS 200-H, 705D, 800D	ICD 5.1 for L1&L2 FDMA (2008) ICD 1.0 for L1, L2&L3 CDMA (2017)	ICD 2.1 Open Service signals B1C & B2a (test version)	ICD 1.3	ICD 1.0	IS-QZSS-PNT-001 IS-QZSS-L1S-001 IS-QZSS-L6-001 IS-QZSS-TV-001 (*4 of 5 Svs.)
Open Service Performance Standards	✓	Draft for L1&L2 service is in approval stage	✓	Galileo OS Service Definition Document v1.0 Dec 2016		✓
	SPS PS 4 th edition (L1-only)	English Draft Provided to WG	OS PS 1.0			PS-QZSS-001
Web Access	GPS.gov	GLONASS-IAC.RU	en.beidou.gov.cn/	gsc-europa.eu	irnss.isro.gov.in/	qzss.go.jp/en/technical/ps-is-qzss/ps-is-qzss.html

Activities and Progress

- Performance Standard Guidelines – **published on ICG website**
 - www.unoosa.org/oosa/en/ourwork/icg/working-groups/s/PSindex.html
- Develop definitions – **in progress**
- Develop calculation methodologies - **ongoing**
- Collaboration with IGMA – **Holding monthly joint meetings; held joint workshop with IGMA in June 2019**



Performance Standards Workshop, Vienna

- “Open” Meeting on June 12
- Attended by China, Europe, Japan, Russia, and United States
- Performance Standards Definitions
 - Update was proposed to PS Guidelines to make the standards for Slot Availability “Key” in place of Range Availability
- Next steps –
 - Complete Definitions
 - Consider updates to PS Guidelines
 - Share hints & tips; harmonize calculation methods
 - Russia to host workshop in Spring 2020

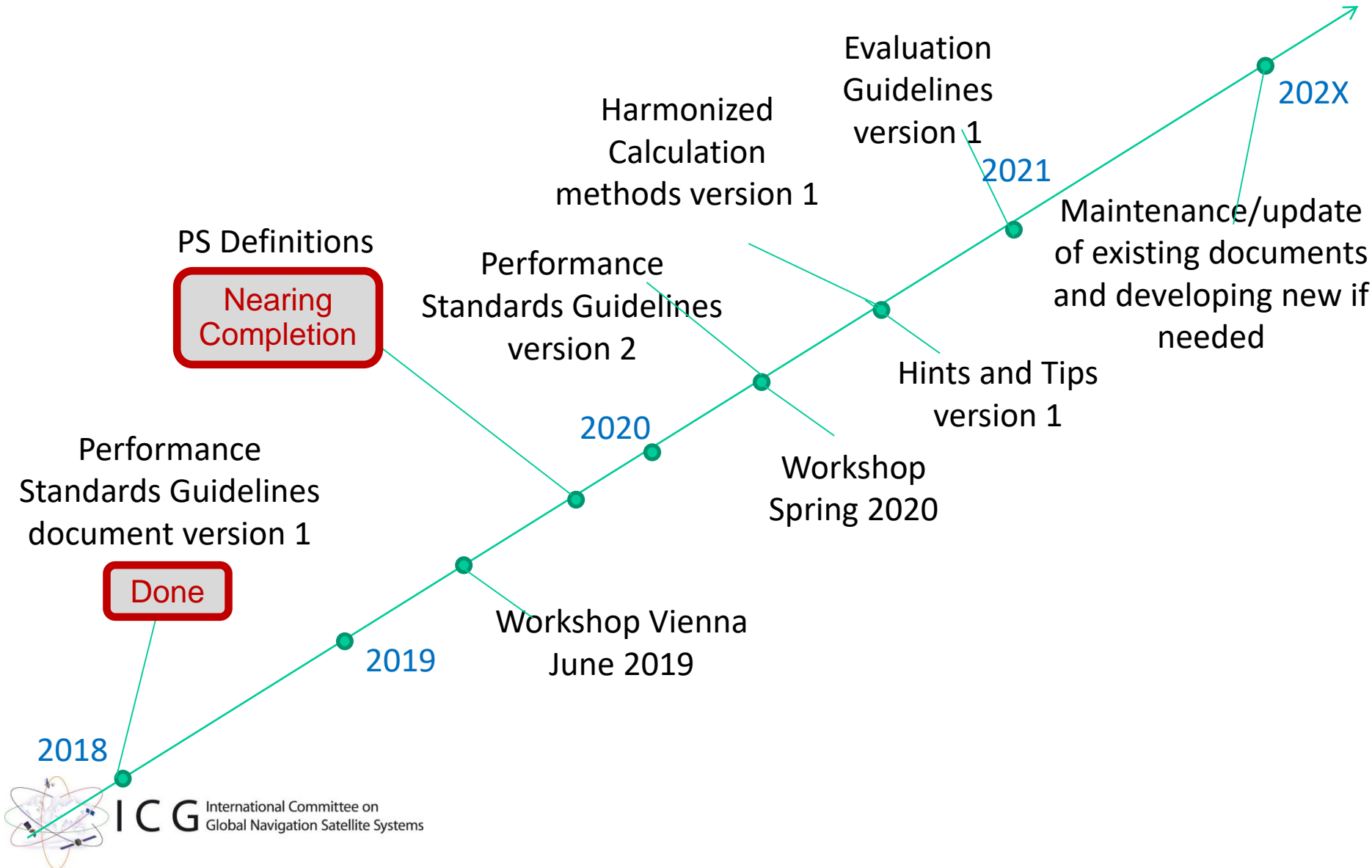


Roadmap & Scorecard – GNSS Performance Standards

Item	Status	Comments
Draft Calculation Methods applicable with DDST-2012	Complete	Draft Calculations Methods Document prepared and provided in 2014
Develop minimum common set	Complete	Begun Dec 2016; Finalized Sep 2017
Issue Performance Standard Guideline Document (“Guidelines for Developing Performance Standards”)	Complete	Recommendation for WG-S and ICG-13
Each GNSS/RNSS provide definitions for terms	Complete	Discussed on monthly teleconference calls (MTC)
Finalize harmonized set of definitions	In progress	Ongoing; complete early 2020
Prepare revision to PS Guidelines (V2)	In progress	Add definitions as appendix
Each GNSS/RNSS identify calculation methods used in PSs and SDDs	In progress	Ongoing. Discussed in MTCs
Hints and Tips on PSs and SDDs (or their new revisions) development and parameters estimation and evaluation	Under discussion	To be discussed in MTCs
Calculation methods Guidelines	Under discussion	To be discussed in MTCs
Further tasks and challenges, including maintaining of issued documents	Under discussion	To be discussed in MTCs



Performance Standards Dream Team Roadmap



Next steps

- DT to hold workshop in Spring 2020, hosted by Russian Federation.
- Continue to hold monthly meetings
 - Complete definitions
 - Prepare Performance Standards Guidelines version 2
 - Discuss and resolve questions on calculation methods



PERFORMANCE MONITORING



IGMA Task Force

- Co-Chairs:
 - Satoshi Kogure, CAO, Japan
 - SONG, Shuli, SHAO, China
 - Allison Craddock, Tim Springer, IGS
- Members:
 - Igor Silvestrov, Alexey Bolkunov, Russia
 - LI Jianwen, China
 - Yoshihiro Iwamoto, Japan
 - Karen Van Dyke, John W. Lavrakas, Andrew J. Hansen, United States
 - Hillar Tork, Peter Buist, Erik Schoenemann, European Union

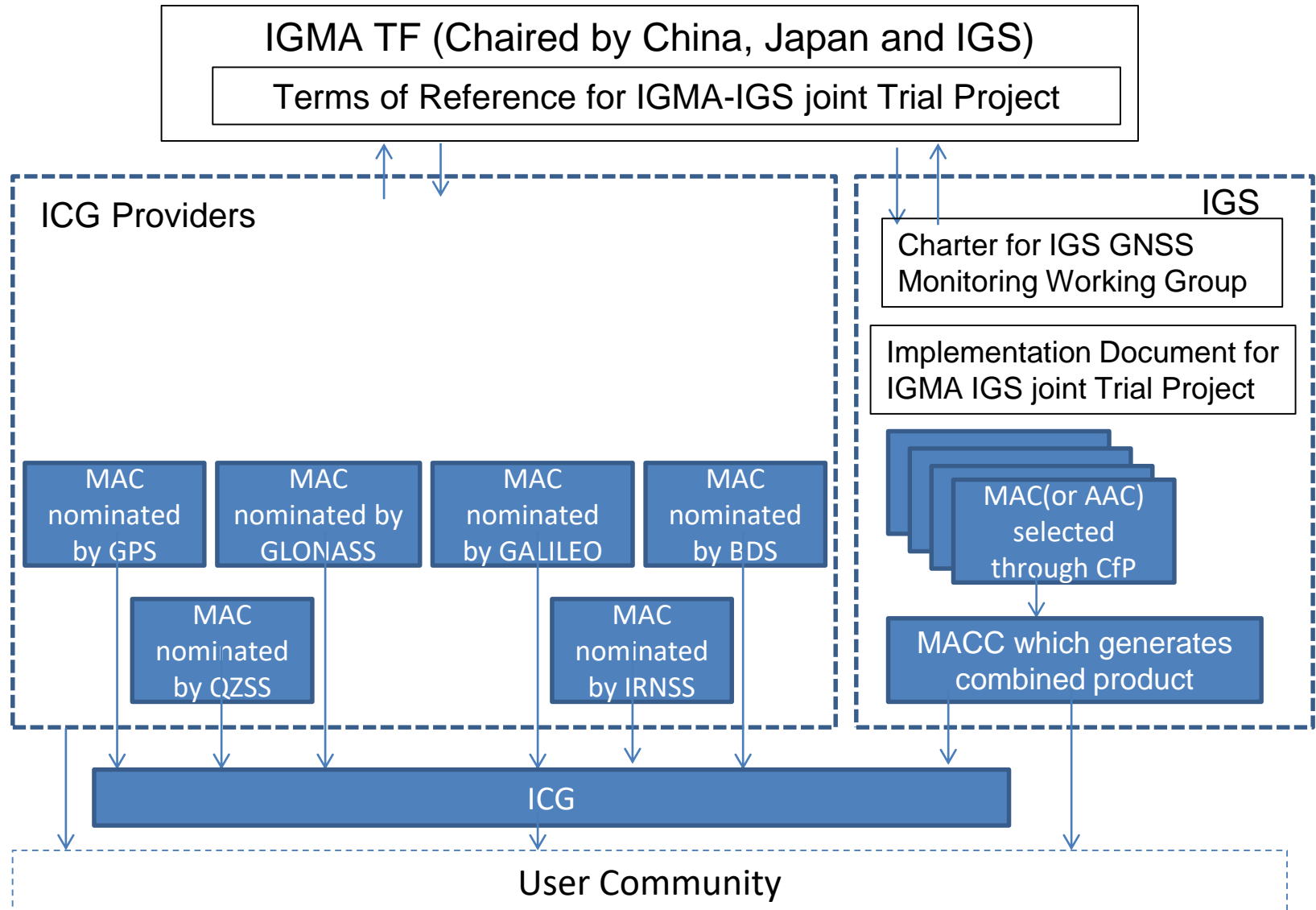


Work Plan – Service Performance Monitoring

- ***The Providers Forum has agreed*** to consider the development and discussion of proposals ***to widely monitor the performance of their open signals*** and provide timely updates to users regarding critical performance characteristics such as timing accuracy, positioning accuracy and service availability
- ***The Working Group***, through the Interoperability and Service Standards Subgroup, ***will support this activity by translating open service performance standards into parameters for multi-GNSS monitoring.*** Recommendations on the necessary monitoring infrastructure and organizational approaches may be made to Providers and international organizations in coordination with other ICG working groups as necessary and appropriate



Background Info



Existing Civil Service Monitoring Information Sources

Name	Country	URL
Information Analysis Center	Russia	http://glonass-iac.ru/en/
US Coast Guard Navigation Center William J. Hughes Technical Center WAAS Test Team	U.S.	http://www.gps.gov/
European GNSS Service Centre	EU	http://www.gsc-europa.eu/
CSNO TARC	China	http://www.csno_tarc.com
QZ-vision	Japan	http://sys.qzss.go.jp/dod/en/
	India	
IGS portal	IGS	http://igs.org/



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 Angels, 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
India		N/A	N/A



IGMA Workshop 2019 (1/2)

Jointly conducted workshop with Performance Standards Dream team

■ “Open” meeting on June 12

- Attended by China, Europe, IGS, Japan, Russia, and United States
- IGMA Joint Trial Project

- Presentations by China, Europe, IGS, Japan, Russia, and United States
- Described methodologies used in their trial project monitoring system
- Provided trial project status



IGMA Workshop 2019 (2/2)

- “Closed” meeting on June 13 for Task Force members
 - Trial Project Results
 - Results of orbit/clock errors, user range error, PDOP, and UTC offset error
 - Presentations by China, Europe, IGS, Russia, and United States
 - The document “**Summary on Methodology of GNSS Monitoring and Assessment for ICG IGMA-IGS JTP**” was discussed and the column identified as “Recommend” was completed, which provides the final harmonized statement for each of the parameters. (See next slide)
 - Next steps –
 - Update IGMA Trial Project Methodologies document
 - Standardize grid selections and definition of UTC Offset error; meet again to compare results
 - Russia to host workshop in Spring 2020



IGMA Progress

- Summary on Methodology of GNSS Monitoring and Assessment for ICG IGMA-IGS JTP is being finalized.
 - Calculation methodologies for four parameters by each providers are tabulated describing input, reference data, time interval, statistics and so on.
 - Common methodology, or recommended way for the next calculation was discussed and is converging

1. Orbit

Items	GPS	GLONASS	GALILEO	BDS	QZSS	IGS	Recommend
SV	Healthy	Healthy, 3deg	Healthy, 3deg	Healthy	Healthy, 3deg	Healthy	Healthy
Reference Orbit	NGS (NGS FTP)	IAC	GRC	IGMAS (IGMAS Web)	Provider (QZSS Web)	IGS combined	Each Service Provider (SP) provide the ref orbit for their own system. In SP3 format. Initially this is on a trial basis.
Broadcast Orbit	IODEs from US TP reference stations	IAC	Combination TGFF-GESS and GRC network (Healthy SIS and Age of Ephemeris below 4h as per [11])	Combination from IGMAS stations	Ephemeris (All age)	IGS combined the broadcast RINEX navigation file.	Each SP provide the broadcast ephemeris for their own system, aligned with the reference orbits and in RINEX format. Initially this is on a trial basis.
Compare Position	APC	APC	APC	APC	APC	Broadcast APC	APC

- Common grid point for DOP/URE calculation was agreed.
- Step by step procedure will be added to avoid ambiguity

- Data format will be analyzed after output data for the next run has been collected.

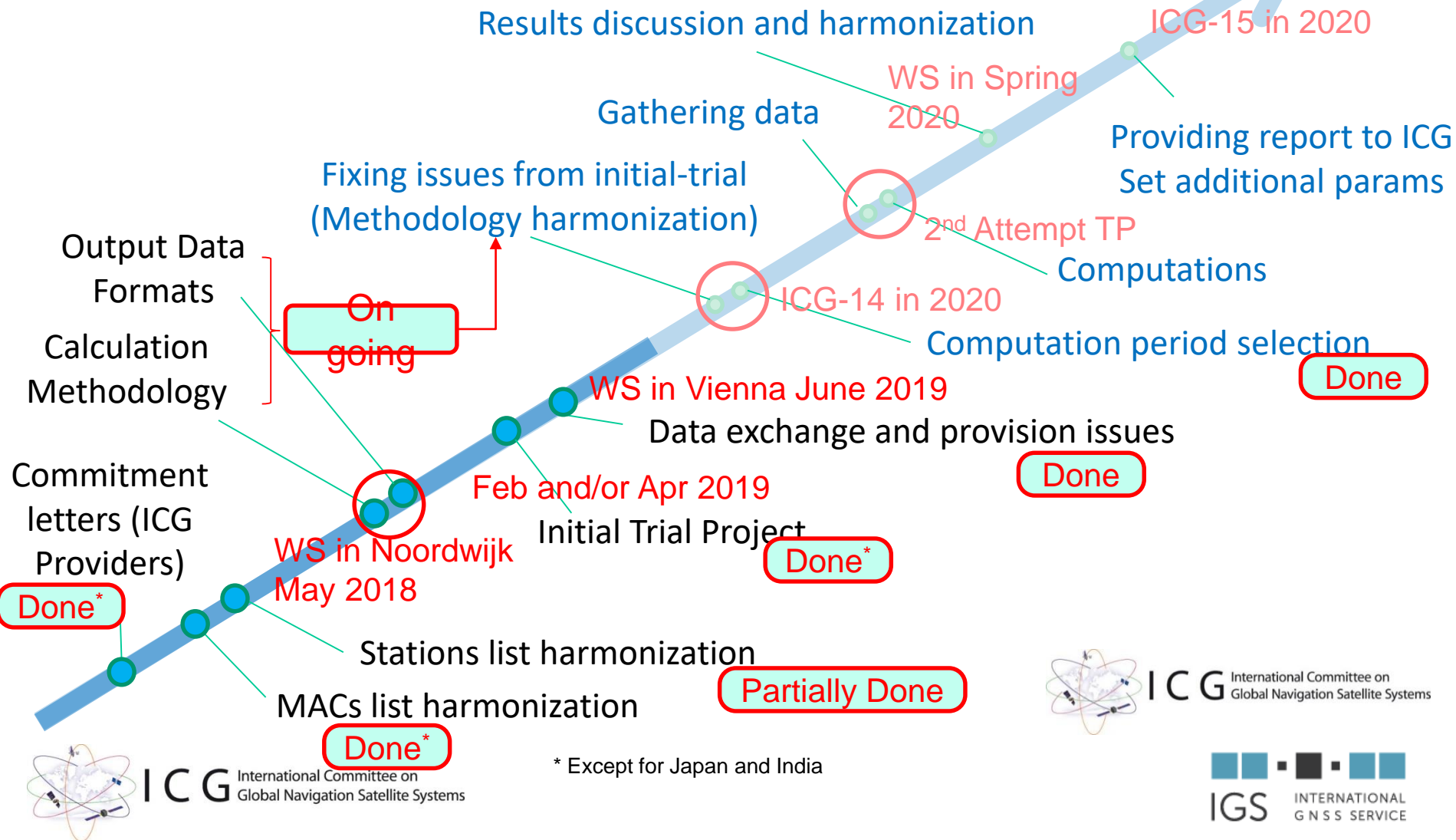


IGMA TP Roadmap

Updated after June 2019

Short term goal: Proof of IGMA concept

- Four params (system level) for each single constellation
- Post processing
- Consistent output with harmonized methodologies



* Except for Japan and India

Actions and Next Steps

- IGMA Workshop 2020
 - Russian federation will organize, location and venue will be confirmed (Vienna in June 2020 is most likely option)
- Common calculation methodology
 - Step by step calculation process would be described in the current working document and set up common procedure
- 2nd Calculation run by providers and comparing results
 - Use same data collected at the previous trial, calculate with agreed methodology before the workshop 2020
- Discuss future milestone, roadmap beyond 2020
 - Which additional parameters and from when?



Timing Interoperability



Work Plan - Interoperability

- As with the ***principle of compatibility, the principle of interoperability and its definition was adopted at the first Providers Forum meeting and updated at the third meeting.*** Consistent with this principle and its definition, the working group, through a subgroup co-chaired by the United States and China, will consider the perspective of various user applications and equipment manufacturers, and will:
 - ***Continue efforts to interact with industry experts and user community representatives in order to solicit input*** on improving the overall open service provided by global and regional navigation satellite systems in a manner that allows for effective multi-GNSS use at the user level;
 - ***Maintain a focus on the open service signal development*** and broadcast plans of the system providers; and,
 - In cooperation with Working Group D, ***consider the role of system time and geodetic reference frames in enabling interoperable multi-GNSS service***



WG-S/WG-D Timing Workshop – June 2019

1. Background and Previous Actions – *Interoperability Subgroup Co-Chairs*
2. GLONASS Time and GNSS Time Interoperability – *Russia*
3. Interoperability through accurate prediction of [GNSS time – UTC] – *BIPM*
4. Different ways of estimating the GGTO, and their impact on the position accuracy – *Royal Observatory of Belgium*
5. The new results of GNSS Time Offsets Monitoring and the Opinion about MGET and xGTO – *China*
6. Progress on Multi-GNSS Timing Offsets: XGTO, MGET – *ESA*
7. Considerations on GNSS Timescale Offsets – *BIPM*



Timing Interoperability Tasks to Subgroup From WG-S Intersessional Meeting

1. Reach consensus on conclusions and actions from June 2019 workshop
2. Discuss the conclusions from ESA presented at the intersessional meeting
3. Propose next steps to WG-S at ICG-14
 - Conduct another workshop or seek alternative approaches to investigate time interoperability?
 - Other actions?



ICG WG-S and WG-D Timing Workshop 14 June 2019

Conclusions and Actions



2019 GNSS Timing Workshop – Conclusions

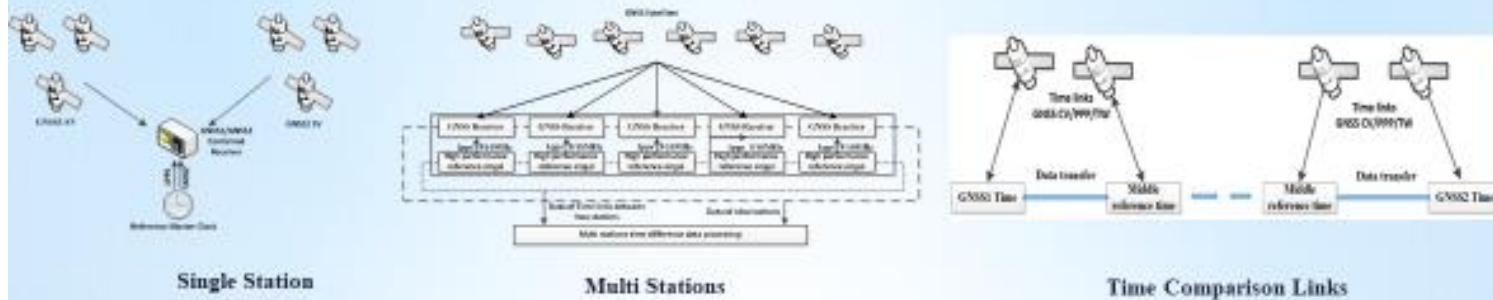
- **CONCLUSION:** The single station time offset monitoring technique, as presented by China at the Workshop, is currently being implemented by all GNSS providers



China Presentation - Timing Workshop (1)

1. BDS Time Offsets Monitoring

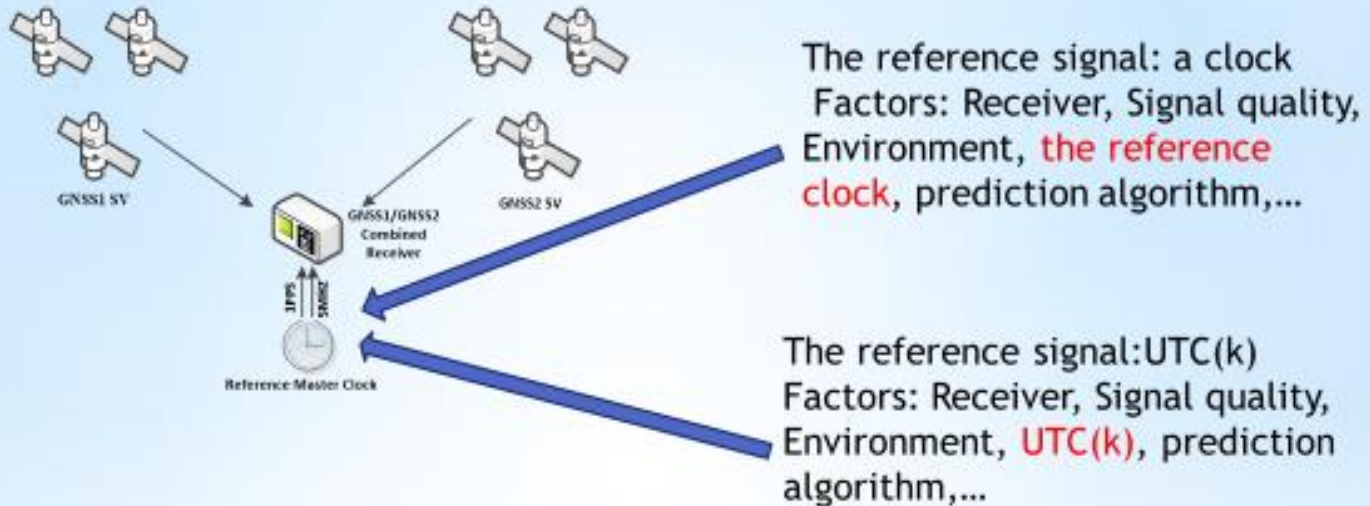
Three methods For GNSS Time Offsets Monitoring



Items	Single station	Multi Stations	Time links
Equipment	Multi mode GNSS Receiver In Time Lab.& GNSS MCS	Multi mode GNSS Receiver In different time laboratory	Time comparison between each GNSS MCS
Data processing	Real time calculation	Data selection, fusion, Post processing	Data interchange, Post processing
Time limit	Real time	Latency 1day or more	Due to time comparison links
Accuracy	~10ns	5-10ns	~5ns

China Presentation - Timing Workshop (2)

1.1. Single Station method and GNSS time offsets differential station



Relative time offsets between two GNSS time

Absolute time offsets between GNSS Time and UTC(k),
UTC(k) is used as a differential station.



2019 GNSS Timing Workshop – Conclusions

- **CONCLUSION:** No consensus among ICG for establishing a task force to examine the XGTO and MGET proposals using live signals, as proposed by ESA



2019 GNSS Timing Workshop – Actions

- **ACTION:** Estimation of the GNSS time offset is best accomplished by estimation within the individual user receiver. Providers should try to ensure that GNSS receiver manufacturers understand this and only use the broadcast GGTO values when internal receiver estimation is not available. Where appropriate include guidance in user ICD, performance specifications, best practices guides, etc...
- **ACTION:** The IGMA Task Force will consider including time offset monitoring under the ICG/IGS Trial Project
- **ACTION:** IGS will provide a briefing at ICG-14 on what the IGS Timing Subgroup is and what it produces and provide future updates as necessary



Next Steps

Need to address the following questions:

1. Should we continue to discuss timing interoperability?
2. If the answer to question 1 is yes, another workshop should be considered to:
 - Further consider the ESA and BIPM presentations made during ICG-14
 - Consider the input of manufacturers/users on the use of GNSS time offsets
 - Determine whether consensus can be reached on any recommendation for time offsets



PPP INTEROPERABILITY



PPP Interoperability

- Interoperability and Service Provision Subgroup Meeting, June 2019 in Vienna
 - Discussion about PPP interoperability as a topic of future discussion within the Subgroup
 - Agreement that this is a topic of interest to Subgroup members
- PPP Workshop, June 2019 in Fiji
 - Chaired by WG-D with participation from WG-S and WG-B
 - Attendees included representatives from: Australia, China, Japan, EU, Russian Federation, U.S., FIG and IGS
 - Focused on understanding proposed designs from service providers and discussing next steps



(1st) Special Technical Session on PPP

- A special technical session on “Standards and interoperability of precise point positioning services” was organized and moderated by the representatives of the ICG working groups S, B and D @ UN ICG Workshop on the Applications of GNSS, Suva Fiji, 24-28 June 2019.
- The purpose of the session was to increase awareness of the systems-provided precise point positioning (PPP) services, the user benefits and opportunities to support positioning , time and navigation (PNT) applications in developing countries; and to encourage standardization and interoperability of the system provided PPP services.
- The meeting was conducted in two sessions: one public PPP³⁷ session as part of the UN ICG/ Fiji Workshop on Applications of GNSS; and one closed session for ICG members.



- **During the open session**, the plans for providing PPP services from several providers have been presented:
 - **RUS** presented about the intended High Precision Service with a terrestrial test as of 2020 for limited users and a full service covering Russia as of 2030. This High Precision Service will be broadcast by GLONASS/SDCM on L3 signal.
 - **JPN** presented about QZSS CLAS and QZSS PPP services to be broadcasted on L6 signal. JPN also presented an update on the Compact SSR format.
 - **EU** presented on status of the Galileo System and the plans for the Galileo High Accuracy Service with an initial HAS capability as of 2020/21. The Galileo HAS will be a global service enabling PPP and it will be free to Galileo users.
 - **CHN** provided a description of the BDS system and some high level insights on the BDS PPP service. In addition the presentation was mainly addressing the application of the PPP technique for time transfer.
 - **AUS** presented on the results on the Australian SBAS PPP testbed activities and provided an outlook for the future PPP service.
 - Natural Resources Canada (NRCan) presented on the **IGS WG on PPP-AR** and the ongoing activities to develop a combined IGS products using contributions from various analysis centre to allow users to perform PPP-AR.
 - **WG-D** provided an introduction to PPP and identified a set of key-points for interoperability of PPP services. Furthermore, a draft recommendation for ICG-14 has been presented.
 - All presentations, highlighted the importance of harmonization of key-aspects of PPP services. A set of open questions in several presentations led to initial reflections from the audience on the need for common terminology and transparency, this has been used as input to the closed discussions.
- The public presentations are available here:

<http://www.unoosa.org/oosa/en/ourwork/psa/schedule/2019/2019-un-fiji-workshop-on-the-applications-of-gnss.html>



- **Closed session.** The meeting attendees included representatives from Australia, China, Japan, EU, Russian Federation, USA, FIG and IGS.
- Meeting minutes were circulated to meeting participants.
- Consolidated Actions:
 - **Action #1** – consider involving/discussing with the SBAS Interoperability Working Group and the ICAO Navigation Systems Panel moving forward. **[To do]**
 - **Action #2** – concentrate on establishing the foundational documents, and baseline language to develop a common language on the basic parameters, etc. as noted in Item 3 - Publish and disseminate PPP signal and system information. **[To do]**
 - **Action #3** – consider discussing a task force within the interoperability subgroup. **[Completed]**
 - **Action #4** – WG-S will attempt to make progress on formulating a draft recommendation for discussion and approval at their intersessional meeting in September 2019. **[Completed]**
 - **Action #5** – in preparation for the WG-S intersessional, the group will develop questions to stimulate discussion in WG-S intersessional meeting in September and also to highlight the importance to develop such foundational documents to PPP services. It is also recommended that Providers should consider the questions and prepare a response for the WG-S intersessional meeting. **[Completed]**

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DRAFT ICG-14 Recommendation 14S-2

- The ICG should establish a Task Force within the WG-S Interoperability Subgroup, with participation from WGs B and D. The Task Force will draft a work plan focused on the objective of improving the interoperability of Precise Point Positioning (PPP) services
- Specifically the Task Force will:
 - Consider involving/discussing with the SBAS Interoperability Working Group and the ICAO Navigation Systems Panel moving forward
 - Concentrate on establishing the foundational documents, and baseline language to develop a common language on the basic parameters, etc. – WG-D Proposal: *Publish and disseminate PPP signal and system information*
 - Seek answers from Service Providers (governmental and commercial) to the questions formulated at the 1st PPP Workshop and follow-on issues identified by the Task Force



Related Action for WGs S, B, and D

- Nominate Candidates to Co-Chair the Task Force
 - Complete: Australia, EU and Japan
- Task Force to identify specific members
- Consider 2nd workshop in 2020 on PPP Interoperability
 - Proposal from Australia to host a workshop in Sydney in February 2020



Other Topics to Consider under Interoperability



Interoperability Subgroup Topics for Future Consideration

- Signal Authentication
- Service Interruption from System Anomalies

