International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE

Activity report of the IGMA Trial Project

10 December, 2019

Satoshi Kogure, Shuli Song,
Tim Springer(IGS)

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

Topics

1. Background Info.
2. IGMA joint Trial Project (TP) Activities and Progress
   A) Provider
   B) IGS
3. Actions and Next Steps

1. Background Info

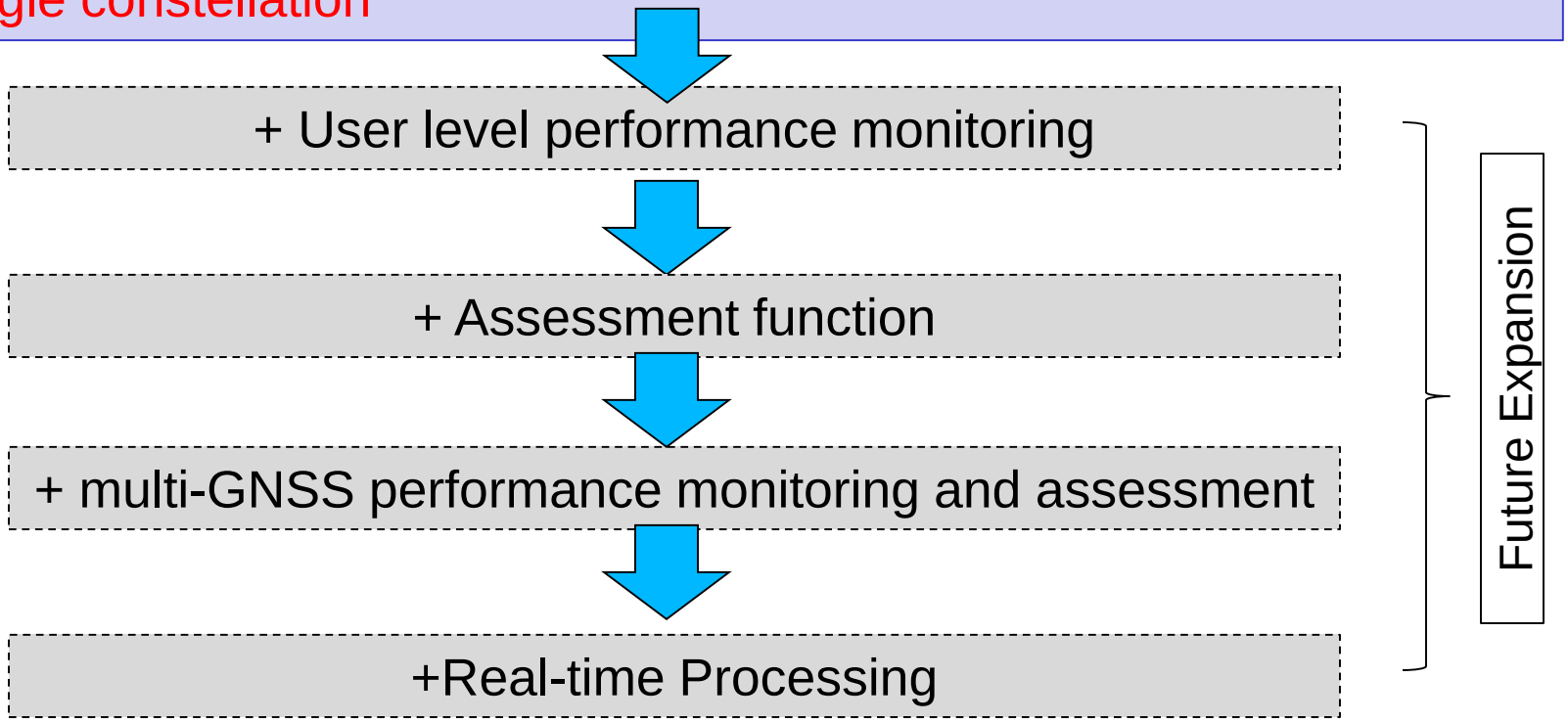
- ICG-IGS Joint Trial Project was proposed in ICG-10 to assist with public confidence in GNSS service provision and interoperability
- Objective of the joint Trial Project:
  - To implement a monitoring system for all participating GNSS
    - Monitoring a limited number of parameters
      - Broadcast Ephemeris Accuracy (orbit 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

1. Background Info

Phased Approach was adopted

Initial phase of the Trial Project

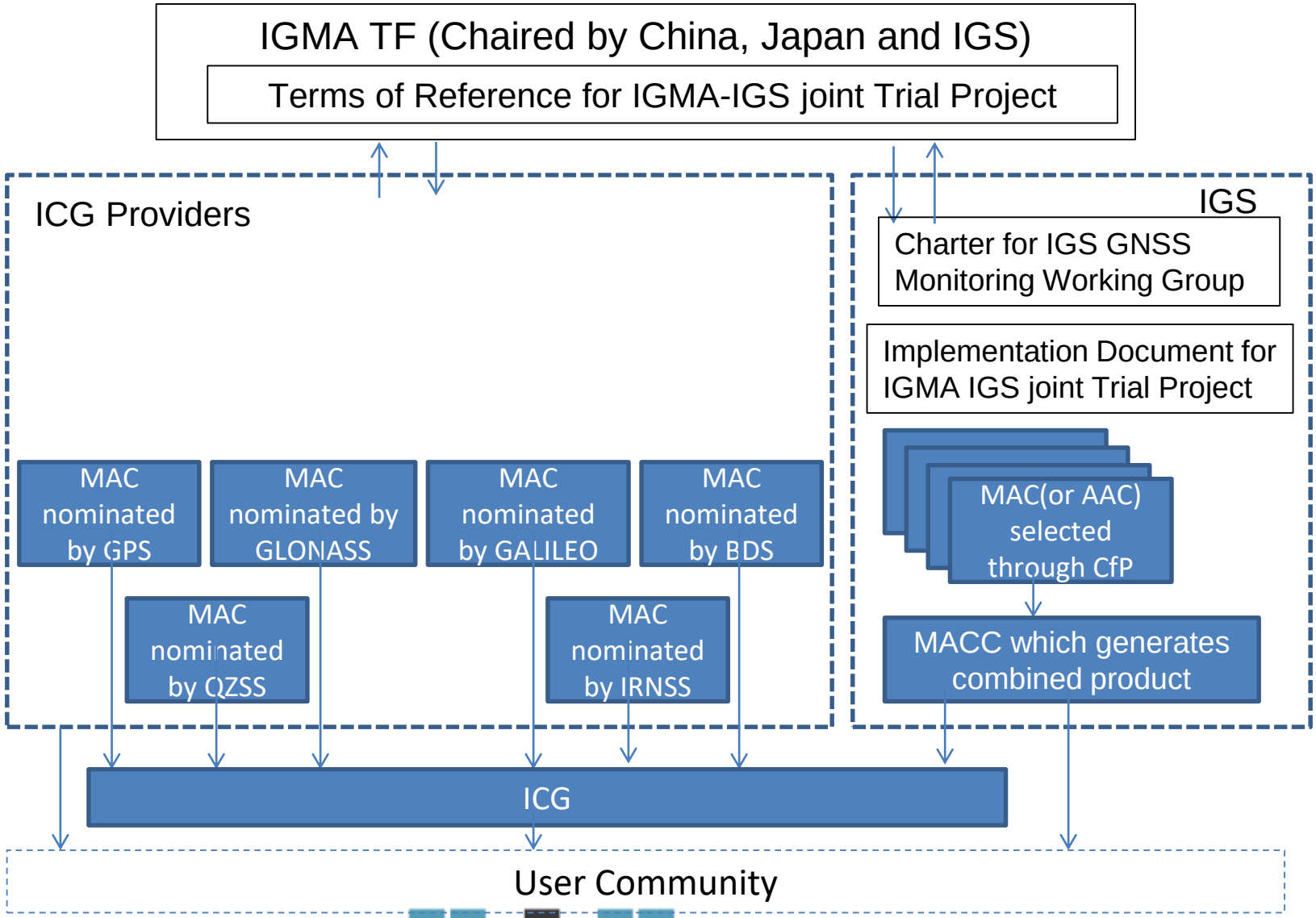
- Post Processing
- System level performance monitoring with limited parameters for each single constellation



ICG International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE

1. Background Info



ICG International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE

2a IGMA TP Activities and Progress (Providers)

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

2a IGMA TP Activities and Progress (Providers)

Activities in 2019

- Initial Trial Project (TP) is being implemented in collaboration with IGS, in still preliminary stage.
- Continuous monthly teleconferences were conducted jointly with Performance Standards Dream Team.
- Workshop 2019 was held in Vienna, on June 12 and 13, 2019.

  (See next slides)
- TF meeting was held on December 8, 2019

- Four limited parameters were selected and initial calculation results among providers were reviewed.
- Findings suggested a need for common calculation methodologies to achieve consistent comparison of results.

2a IGMA TP Activities and Progress (Providers)

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

ICG International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE

2a IGMA TP Activities and Progress (Providers)

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

2a IGMA TP Activities and Progress (Providers)

- 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,5deg	Healthy,5deg	Healthy	Healthy,10deg	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 TGVF-GESS and GRC network (Healthy SIS and Age of Ephemeris below 4h as per [11])	Combination from IGMAS stations	Ephemeris (All age)	IGS combined 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.

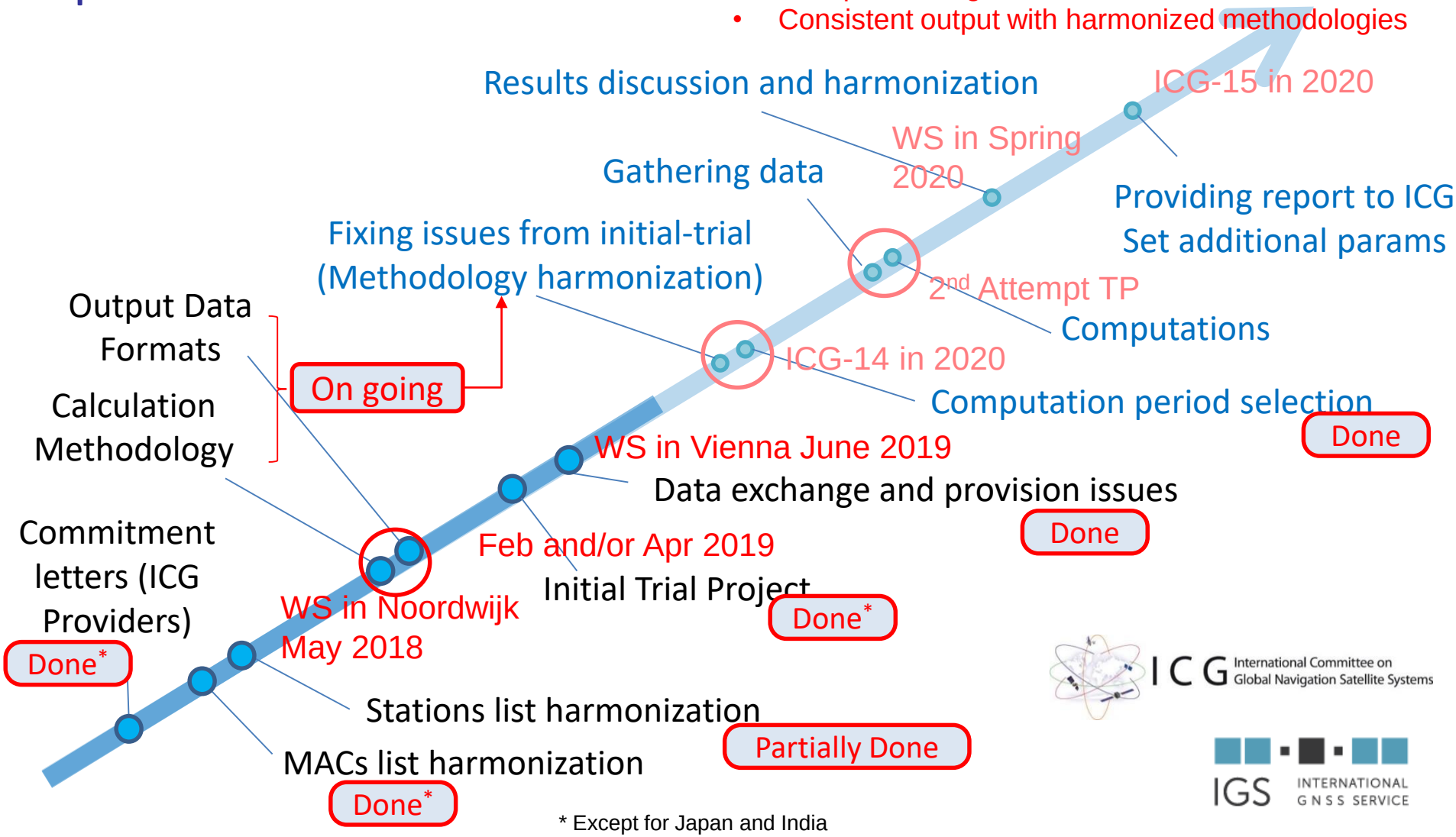
2a IGMA TP Activities and Progress (Providers)

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

ICG International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE

2b IGMA TP Activities and Progress (IGS)

IGMA-IGS Joint Trial Project

Tim Springer

IGS INTERNATIONAL GNSS SERVICE

IGS-IGMA joint trial project

- In 2017 12 groups responded to the call for participation
- A smaller subset has been active in this project:
  - DLR, ESOC, GMV, GOP, ICGC, SHAO, UNESP, WHU

- Main Activities
  - Participate in the monthly ICG-IGMA teleconferences
    - IGS Central Bureau and IGS-IGMA ACC
  - Initial orbit and clock comparisons
    - Participation by the above mentioned groups
    - Interpretation of broadcast harder then expected
    - But finally convergence was reached for position
      - Still need to converge on the clocks
  - Participated in the 2019 Joint ICG Performance Standards and IGMA Task Force Workshop in Vienna

Monitoring Experiments

- Initial test week in 2017 resulted in vastly different results
- Performed a simple 1 day test end of 2018 comparing the orbits in X, Y, and Z. Also led to significantly different results
- Did an even simpler test (2019) with just one single broadcast ephemerides for one satellite per constellation
  - Achieved mm level agreement
- H1 2019 performed a 1 day test in orbital parameters including clock and SISRE and a 3 month comparison (February to April 2019)
  - Good agreement achieved for orbit
  - Significant differences in the clock approaches
    - Need description from the different groups
    - Need common agreement on how the clock will be done

IGS

April 30, 2019 test day

- Based on past work the X, Y, Z orbit differences have converged reasonably well
- Time for next step to compute RAC differences and clock differences
  - Selected a very recent test day (April 30, 2019)
  - But also request a “full” analysis for ICG-IGMA meeting covering February to April 2019
  - For simplicity the 1-day test ignored the reference point differences
- Results from four groups were received

IGS

Main Findings

- Small differences for most systems based on selection of different ephemerides
  - But in general very good agreement now
- No harmonized procedure for system clock alignment was established yet
  - Thus clock agreement not so good
  - Consequently SISURE not in agreement either
- The same four groups provided results for the full 3 month period for all GNSS systems (GPS, GLONASS, Galileo, BeiDou, QZSS
    - Results demonstrate the agreement between the IGS groups

IGS

Conclusions of Experiment

- Need to converge on handling of broadcast ephemerides
  - Reception time, age and validity of ephemeris
- IGS work plan
  - Orbit differences are converging
    - Main issue is selecting the "correct" ephemeris
  - Start converting orbit and clocks to common location and compare
    - need a proper IGS-IGMA antex file
  - Develop/agree and implement clock comparison strategy
  - UTCOE to follow after orbit and clock comparison is resolved
    - Can we make use of the IGS time scale for this?
  - PDOP and SISURE to follow?

IGS

Current Status

- Presented very good results from the 3 month experiment at the 2019 ICG IGMA workshop
- Several issues have been identified by the Group in the ICG-IGMA workshop in Vienna in June 2019
  - Work in progress
- The IGS contribution was greatly valued by the different system operators
  - Considered to be truly independent and high quality

IGS

Next Steps

- Need info on Broadcast "reference points"
- Also clarity and uniformity needed regarding validity intervals of the broadcast ephemerides
  - Small differences are clearly present
- Clear description needed regarding clock monitoring
  - Unclear what the different groups are doing
  - Unclear what inputs (IGS products!?) are required for that
    - Only clear for one group!
- Need multi-GNSS IGS products, especially also biases for the clock monitoring

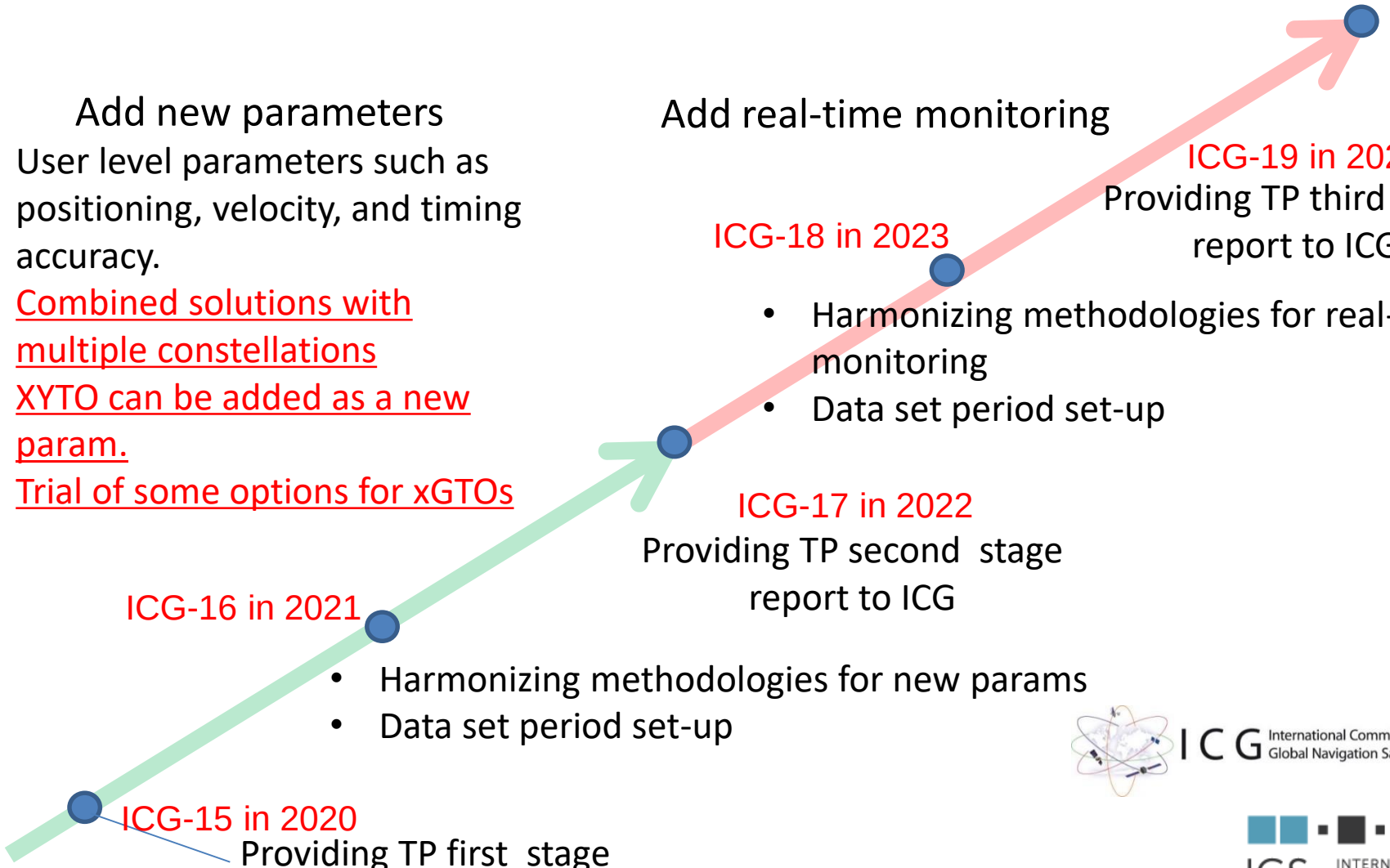
3 Actions and Next Steps

- 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?

IGMA TP Roadmap Beyond 2020

Long term goal:

- Proof of real-time performance monitoring and evaluation result dissemination



Add new parameters

- User level parameters such as positioning, velocity, and timing accuracy.
- Combined solutions with multiple constellations
- XYTO can be added as a new param.
- Trial of some options for xGTOs

ICG-15 in 2020

Providing TP first stage report to ICG

ICG-16 in 2021

- Harmonizing methodologies for new params
- Data set period set-up

ICG-17 in 2022

Providing TP second stage report to ICG

ICG-18 in 2023

- Harmonizing methodologies for real-time monitoring
- Data set period set-up

Add real-time monitoring

ICG-19 in 2024

Providing TP third stage report to ICG

ICG International Committee on Global Navigation Satellite Systems

IGS INTERNATIONAL GNSS SERVICE