International Committee on GNSS

Recent Developments

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UNOOSA

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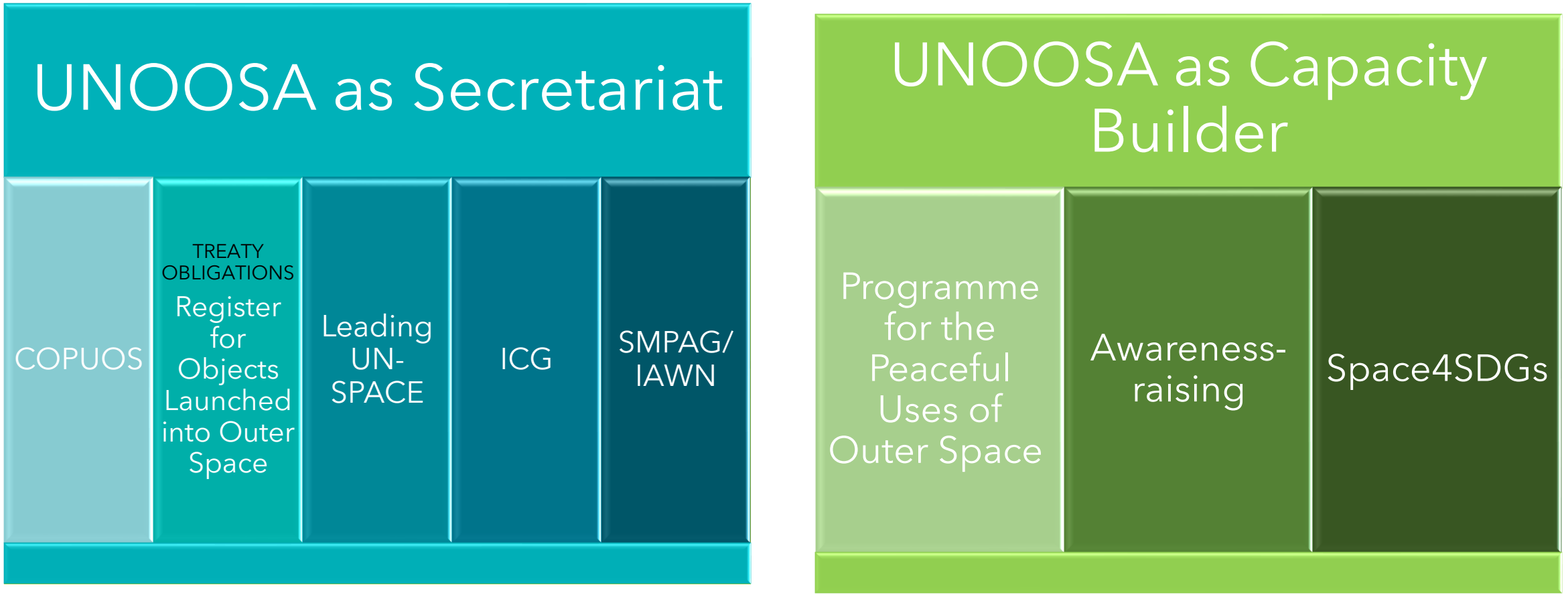

UNOOSA: *Efficient international and neutral convening-platform for Member States, Industry, Academia and Experts*

SMPAG: Space Mission Planning Advisory/IAWN: International Asteroid Warning Network

Int'l Committee on GNSS

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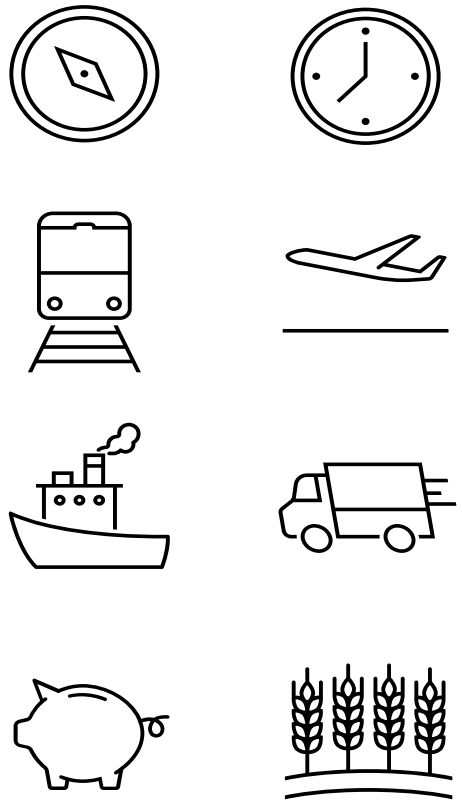
Key responsibilities:

Executive Secretariat
Int'l Committee on GNSS (ICG) (37)
• ***Est. 2005*** - *meets* annually
• Voluntary cooperation, coordination, promoting utilization ***of multiple GNSS signals***
4 Working Groups
• Systems, Signals, Services; Enhancement of GNSS Performance, New Services and Capabilities; ***Information Dissemination & Capacity-building;*** Reference Frames, Timing and Applications
Provider's Forum
• ***Compatibility & interoperability***

Capacity Development
GNSS
• ***Workshops***: annually
• Education Curriculum
Space Weather
• ***Workshops***: annually



Exec. Secretariat to Int'l Committee on GNSS

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ICG Membership

System Providers: Global and Regional Constellations

China (BDS, 27+3IGSO+5GEO), Russian Federation (GLONASS, 24+), United States (GPS, 24+), European Union (Galileo, 24+), India (NavIC, 7), Japan (QZSS, 7)

Services and Applications *(15)*

Algeria, Australia, Italy, Malaysia, New Zealand, Republic of Korea, ***Türkiye*** and United Arab Emirates

Augmentation Systems

India, Japan, *Nigeria*, Russian Federation, United States and European Space Agency

Assoc. Members + Observers: *IGO, NGO, UN entities (22)*

17th meeting of ICG

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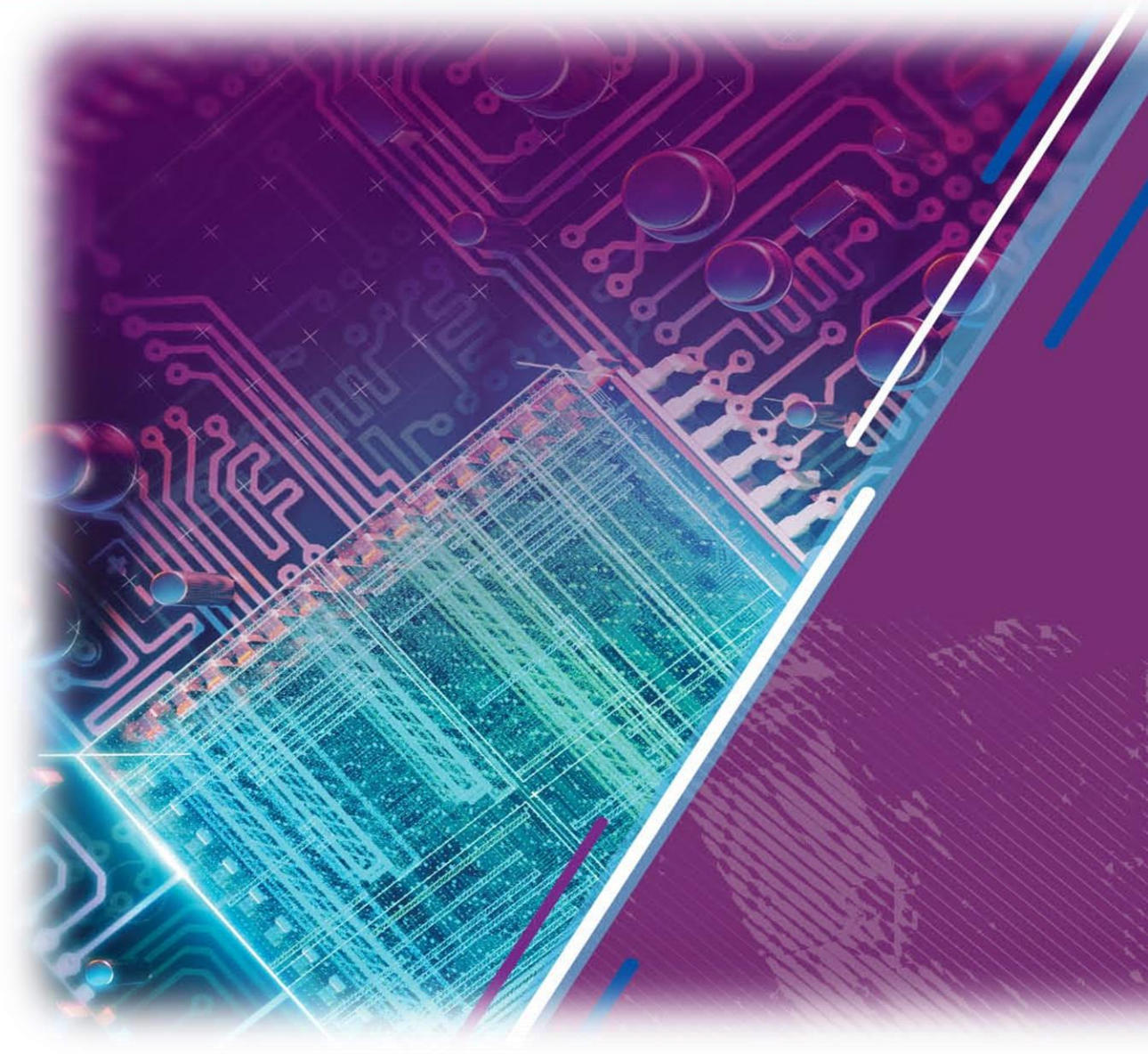

Hosted by the
European Union
in collaboration with the
Spanish Presidency of the EU

15 – 20 October 2023, Madrid

ICG: Working Groups

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- **Systems, Signals and Services** (*United States & Russian Federation*): Compatibility and spectrum protection; interoperability and service standards; system-of-system operations

- **Enhancement of GNSS Performance, New Services and Capabilities** (*India, China & ESA*): Future & novel integrity solutions; implementation of interoperable GNSS Space Service Volume (SSV) examination of performance of atmospheric models, *establish dialogue with space weather*/RS communities and its evolution;

- **Information Dissemination and Capacity Building** (*UNOOSA*): Focused on education and training programmes, promoting GNSS for scientific exploration (incl., *space weather and its effects on GNSS*)

- **Reference Frames, Timing and Applications** (*IAG, IGS & FIG*): Focused on monitoring and reference station networks

ICG: Working Group S Recommendations

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Survey into GNSS Time Offset for Receiver Manufacturers

To implement a dialogue with multi-GNSS receiver manufacturers it's necessary to conduct a survey on time offset accuracy requirements for multi-GNSS receivers. However, it is difficult to engage a lot of manufacturers globally to attend a workshop on timing interoperability because of complicated logistics and schedule as well as cost. Therefore, it's suggested that GNSS providers carry out a survey domestically in a large scale and submit a report to the ICG based on survey results, to push forward the improvement of GNSS time interoperability.

- ❑ GNSS providers are encouraged to reach out to domestic receiver manufacturers (industry) to get feedback on multi-GNSS time interoperability requirements through a common list of questions and criteria developed by WG.
- ❑ Timing experts, in coordination with WGs B and D should organize a meeting/workshop to discuss the results of the receiver manufacturers' feedback.
- ❑ Investigation of national processes for notification of interference testing

ICG: Working Group S Recommendations

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Approval of the Int. GNSS Monitoring and Assessment (IGMA) Joint Trial Project ToR

- IGMA Joint Trial Project with IGS (proposed 2015)
  - IGMA TF and IGS initiate a joint trial project: to demonstrate a global GNSS Monitoring and Assessment capability
  - IGMA TF focusing on establishing harmonized, common calculation methodologies regarding selected 4 system level parameters: orbit and clock error, signal-in-space ranging error, Position Dilution of Precision (PDOP) and UTC Offset Error and adopted a post-processing approach
  - Technical details in the ToR are to be updated as the calculation methodologies discussion proceeded plus some inconsistencies in ToR

- *ICG adopt new revisions to the ToR for the IGMA Joint Trial Project (Aug 2023). If IGS would have comments on the ToR revision, they should be notified to the ICG. In case no substantial changes are proposed to it, the adoption at ICG-18 by ICG would be effective.*

ICG: Working Group S Recommendations

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Incorporation of Emerging Low Earth Orbit (LEO) PNT Providers into ICG

The plans for LEO PNT systems need to be better understood. The Workshop organized by WG-S in June 2023 attempted to gather information about the systems, but it has become apparent that further engagement and coordination is needed to ensure compatibility and interoperability with the existing GNSS providers.

- ICG members should consider inviting domestic LEO PNT system providers (governmental and non-government) to participate in the ICG activities and its relevant WG meetings. This participation could be in various forms, including requesting ICG Observer Status if interested.

- *LEO-PNT Workshop, 26 – 27 June 2024, Vienna*

ICG: Working Group B Recommendation

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Joint ICG - Interagency Operations Advisory Group (IOAG) organization of multilateral workshop on cislunar PNT

To maximize interoperability, compatibility and availability of lunar PNT signals, a multilateral communication of cislunar PNT plans and developments—early and often—is needed.

- The ICG encourages the organization of a joint ICG-IOAG multilateral cislunar PNT workshop that shall:
  - serve as a mechanism to better understand the scope and depth of lunar PNT systems being developed
  - propose recommendations that may be taken up by lunar PNT developers, and
  - facilitate refinement of interoperable, compatible, and available lunar PNT systems of the future.
- The workshop co-leaders ICG/IOAG shall also seek the collaboration of other international bodies such as the ISECG, CCSDS, and SFCG to strengthen the international coordination and standardization of lunar PNT systems.
- This recommendation represents a specific action from the more general recommendation approved at ICG-16 (ICG/REC/2022) entitled "Coordination of GNSS and Lunar PNT systems for lunar operations."

ICG: Working Group B Recommendation

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ICG-16:* *Coordination of GNSS and Lunar PNT systems for lunar operations

- The ICG encourages international GNSS providers and lunar PNT developers to work together via the appropriate multilateral fora, such as IOAG, to ensure the future attainment of an interoperable, compatible, and available PNT system of systems that can support the world's ever-expanding human and robotic space operations around and on the surface of the moon.
- The collaborative efforts of ICG, including the GNSS Space Service Volume initiative, should serve as a model for this promising international exploration initiative.
- ICG will analyze planned lunar PNT systems and their interactions with GNSS and propose recommendations that may be taken up by GNSS providers and lunar PNT developers

- *Working Groups B, D and S Lunar PNT Session, 25 – 26 June 2024, Vienna*

  https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/b.html

- **Workshop on Cislunar Positioning, Navigation, and Timing (PNT), 11 – 13 February 2025, Vienna**

Enhancement of GNSS Performance, New Services and Capabilities (WG B)

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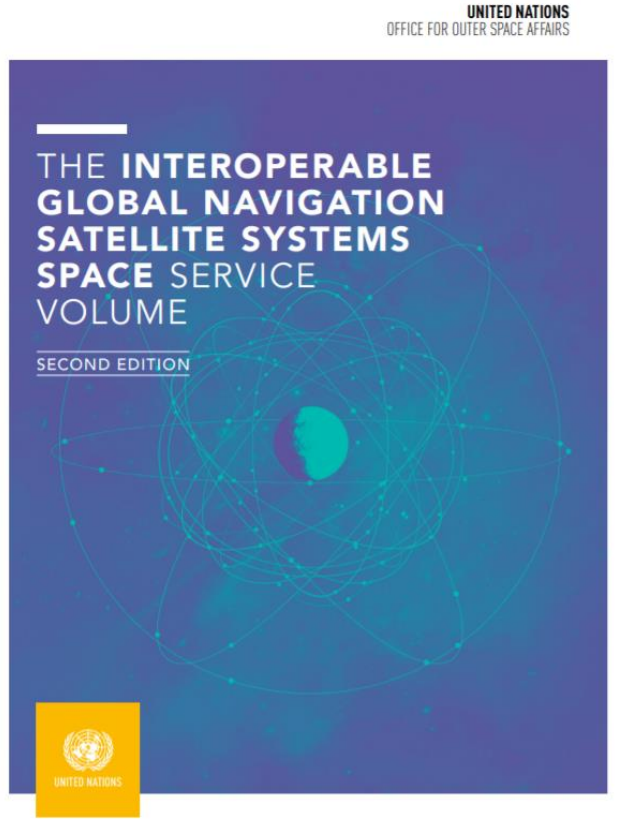
Encourages GNSS providers and lunar PNT developers to work together in order to

- Ensure the future attainment of an ***interoperable, compatible and available*** PNT system of systems that can support the worlds ever-expanding human and robotic space operations around and on the surface of the moon
- ICG will analyse planned lunar PNT systems and their interactions with GNSS and propose recommendations that may be taken up by GNSS providers and lunar PNT developers

The collaborative efforts of ICG, including the GNSS SSV initiative, serves as a model for this international exploration initiative



https://www.unoosa.org/res/oosadoc/data/documents/2021/stspace/stspace75rev_1_0_html/st_space_75rev01E.pdf

ICG: Working Group D Recommendations

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On the use of the broadcast prediction of UTC to determine the offsets between GNSS times for non-space-based users (Joint WGs B, S & D)

- In the case a common pivot method is chosen to provide the user with GNSS inter-system time biases, multi-GNSS receiver manufacturers consider the benefit of using the common pivot bUTCGNSS contained in the GNSS navigation message.
  - This approach comes in addition to the two other existing methods (estimation at user level or use of broadcast GNSS-to-GNSS time offset).
  - For mass-market non-space-based users, this eliminates the need to create an ad hoc time scale as a common pivot.
- GNSS providers continue their efforts to improve the prediction of UTC broadcast in the navigation message with the help of time laboratories, with the aim to improve their time dissemination service.

Continuous effort in monitoring and validating all GNSS-to-GNSS time offset is to be pursued also promoting the collaboration among the different involved groups. The needs of space users may lead to different conclusions that may require revisiting this recommendation.

ICG: Working Group D Recommendations

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Development of GNSS-based techniques for applications related to disaster risk reduction and natural hazards monitoring

- The Disaster Risk Reduction (DRR) TF should
  - demonstrate the deployment of a multi- GNSS station in an area of sparse coverage;
  - define a step-by-step guide for future such deployments, including critical details such as (but not limited to) the administrative and technical requirements, the cost and timing estimates, and the potential sources of funding to which one could apply.
- ICG should encourage the development of open-source, freely available, and readily- and easily-usable software. In addition, ICG should encourage the publication of open-access, real-time, high-rate, accurate, and precise multi-GNSS data and products.
- The science community should pursue the development of data assimilation, data fusion for various types of datasets, and crowd-sourcing GNSS data to their full, synergistic potential

The DRR TF has explored the GNSS-based techniques and their potential and current applications to DRR. Over the past year, the TF collected diverse worldwide expertise from Australia, Chile, China, France, Germany, Italy, Japan, New Zealand, Spain, and the United States.

ICG: Information Dissemination & Capacity Building

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- Cooperation ICG & The University of Tokyo, Japan: *To focus on GNSS data types, GNSS errors, coordinate systems and applications, and low-cost receiver system data*
  - GNSS Training Programme, Nepal (The University of Tokyo), 12 – 16 January 2024
- Cooperation ICG, ICTP, Italy and Boston College, US: *To enhance capacity building on GNSS for Space Weather monitoring*
  - GNSS and Space Weather, Italy, 22 – 31 October 2024
- Cooperation ICG, FIG, IAG and IGS: *To focus on reference frames in general with a specific focus on UN initiatives, global and regional frames as well selected national case studies*
  - Technical Seminar on Reference Frames in Practice, Accra, Ghana, 18 – 19 May 2024
- Workshop on GNSS, 10 – 13 December 2024, Hanoi, Vietnam

African Capacity Building Workshop on Space Weather and Ionospheric Research

Low-cost GNSS receiver system for space weather data

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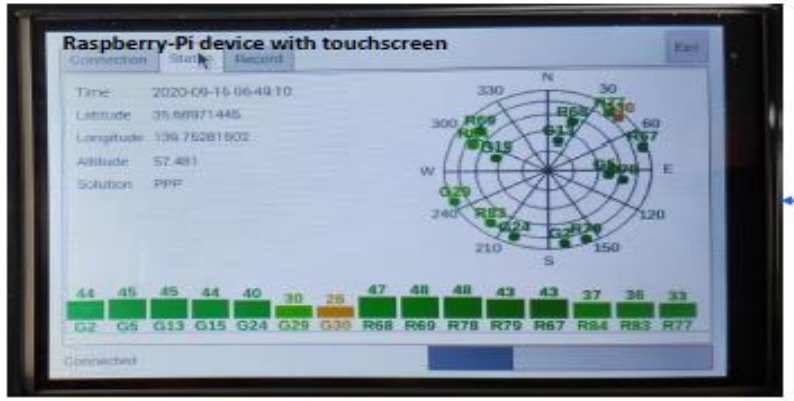
- Exploring low-cost GNSS receivers that satisfies space weather needs both in terms of scintillation and total electron content (TEC)
  - *any receiver that is capable to output raw data*
  - *dual frequency receiver*
  - *cost (less than $1000, including antenna and data logging system)*
- *N.B.: No preferences of whatsoever on any brand/name. The examples are based on the selection*

Instrument Types:

Type - A	Commercially available external GNSS Receiver connected to RapsberryPi device	Type - B	Septentrio MOSAIC GNSS Receiver



Antenna

GNSS Receiver

Antenna

Low-cost GNSS receiver system for space weather data

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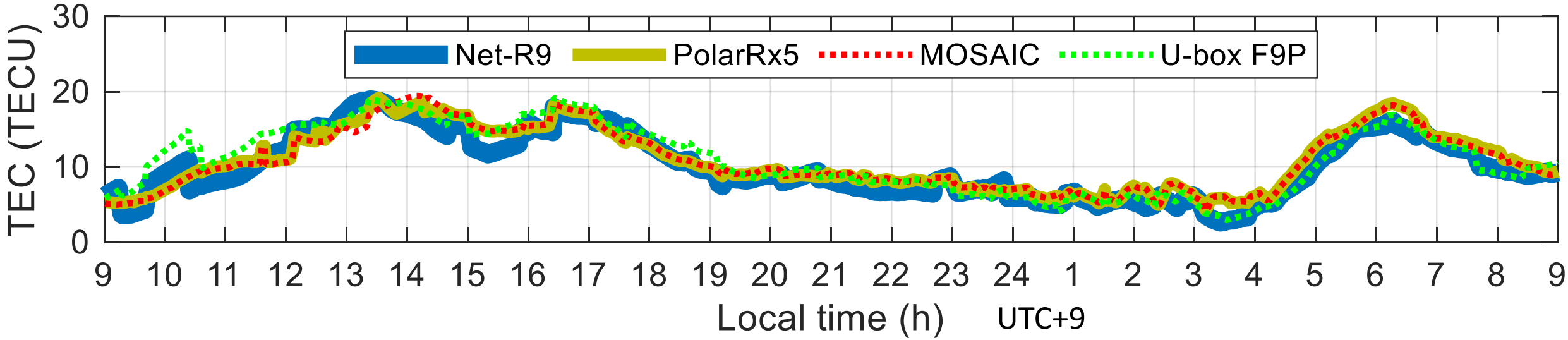
Comparison of TEC Results



- The low-cost receiver VTEC values have similar results to the high-end receiver VTEC values.
- MOSAIC receiver VTEC values are equivalent to PolaRx5 receiver VTEC values.

Instrument Limitations and Challenges:

- Raw data are logged in proprietary data format
- Common raw data format, data type, and observation frequency shall be defined
- Scintillation computation is yet to be verified. It may be limited to only code-phase scintillation data
- Data processing algorithms shall be standardized

Low-cost GNSS receiver system for space weather data

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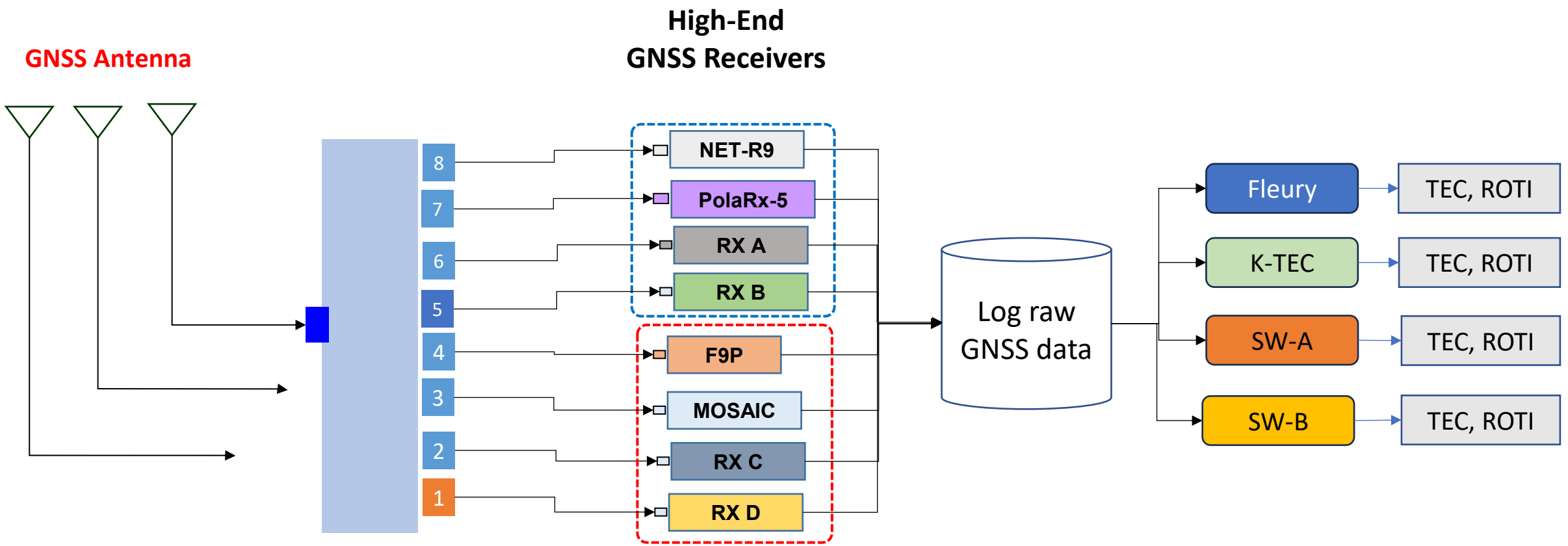

- Test more receiver/ antenna types
- Compute using different software

ICG-18 meeting

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Date: **6 – 11 October 2024**

Location: **Wellington**
New Zealand

	AM		PM	
Sunday **6 October**			1st Providers' Forum Meeting (chaired by the United States)	Meeting with the Working Groups Co-chairs
Monday **7 October**	1st Plenary Session of ICG - Welcome Remarks - GNSS Systems Updates	Lunch Break	Presentations by Members, Associate Members, Observers, Invited observers, etc. on matters of interest to ICG	Experts Seminar Welcome Reception
Tuesday **8 October**	(in parallel) Working Groups Meetings		(in parallel) Working Groups Meetings (Continued)	
Wednesday **9 October**	(in parallel) Working Groups Meetings (Continued)		Technical Tour	
Thursday **10 October**	(in parallel) Working Groups Meetings (Continued)		2nd Plenary session of ICG	2nd Providers' Forum Meeting (Chaired by the United States)
Friday **11 October**	3rd Plenary Session of ICG			

- Expert Seminar: ***Use of GNSS for natural hazard preparedness, resilience and response***

Thank you

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