International Committee on GNSS

Recent Developments

UNITED NATIONS
Office for Outer Space Affairs

Committee on the Peaceful Uses of Outer Space

UNITED NATIONS
Office for Outer Space Affairs

Some of the key themes:

Space Debris	Long-term Sustainability	Small satellites / Constellations
Space Traffic Management	Space Resources	GNSS
Space weather	Near-Earth Objects	Global health

Meetings:

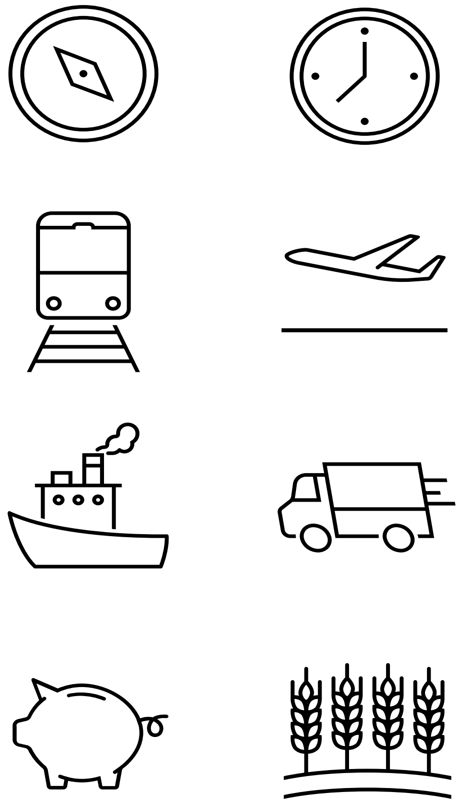
- ❑ **Scientific and Technical Subcommittee**
  - ➢ *ISWI Steering Committee, ICG WG meetings*
- ❑ **Legal Subcommittee**
- ❑ **Committee on the Peaceful Uses of Outer Space**
  - ➢ *ICG Providers' Forum Meeting*

Exec. Secretariat to Int’l Committee on GNSS

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 & Capacity-building;*** Reference Frames, Timing and Applications
Provider’s Forum
• ***Compatibility & interoperability***

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



International Committee on GNSS

UNITED NATIONS
Office for Outer Space Affairs

The ICG is an **important vehicle** in the multi-lateral arena, as satellite-based positioning, navigation and timing becomes more and more a **genuine multinational cooperative venture**.

- Encourages **coordination** among GNSS providers
- Promotes the introduction and **utilization** of GNSS services **in developing countries**
- **Assists GNSS users** with their development plans and applications
- **Assure** GNSS **interoperability and compatibility** among providers and users globally for enhanced services and applications

Open to all countries and entities that are either GNSS providers or users of GNSS services, and are interested and willing to actively be engaged in ICG work

ICG International Committee on Global Navigation Satellite Systems

Exec. Secretariat to Int'l Committee on GNSS

UNITED NATIONS
Office for Outer Space Affairs

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

UNITED NATIONS
Office for Outer Space Affairs

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

15 – 20 October 2023, Madrid

ICG: Working Groups

UNITED NATIONS
Office for Outer Space Affairs

- **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

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

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-17 by ICG would be effective.*

ICG: Working Group S Recommendations

UNITED NATIONS
Office for Outer Space Affairs

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.

ICG: Working Group B Recommendation

UNITED NATIONS
Office for Outer Space Affairs

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

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

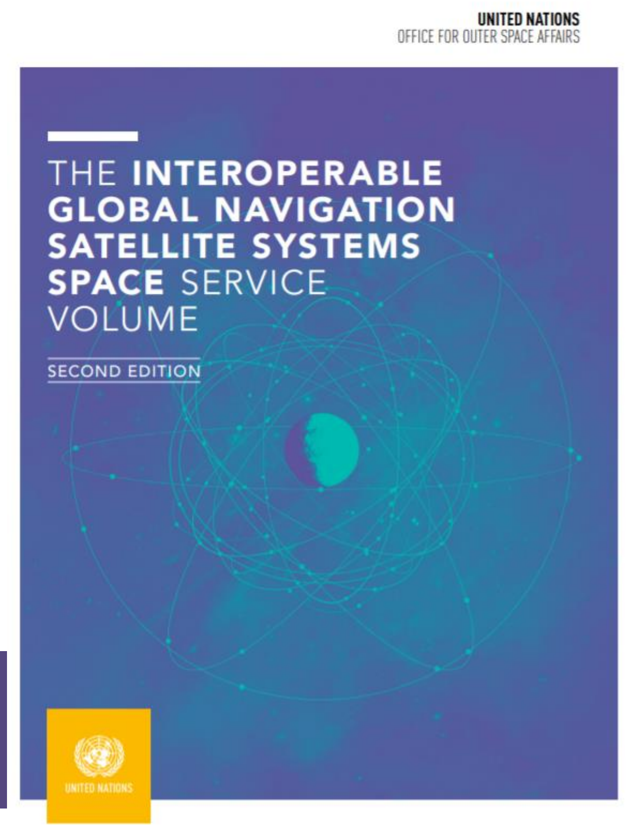
Enhancement of GNSS Performance, New Services and Capabilities (WG B)

UNITED NATIONS
Office for Outer Space Affairs

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

UNITED NATIONS
Office for Outer Space Affairs

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

UNITED NATIONS
Office for Outer Space Affairs

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.

GNSS Applications

The Applications of GNSS for Disaster Risk Reduction (WG D/WG B)

- Natural hazards *generate atmospheric waves.*
- These waves *propagate through the atmosphere* (up to the ionosphere), and *cause perturbations along the way*.
- These perturbations can be detected using *various GNSS-based remote sensing techniques*, at *next-to-no cost*, in *near-real-time*, and with a *worldwide coverage*.

technique	probing region	relevant to
GNSS Reflectometry	surface conditions (soil moisture)	earthquakes, storms, floods
GNSS Radio Occultation (RO)	surface to mid-stratosphere (temperature + moisture)	tsunamis, wildfires
GNSS Polarimetric RO	surface to mid-stratosphere (temp. + moist. + heavy precipitation)	volcanic eruptions
GNSS-Based Ionospheric TEC	***ionosphere (100-1500 km) (Total Electron Content - TEC)***	***solar storms***, ***CMEs***

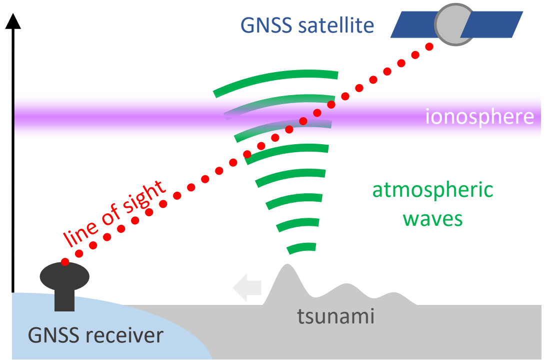


Figure: schematic of tsunami-induced atmospheric waves and ground-based GNSS measurements.

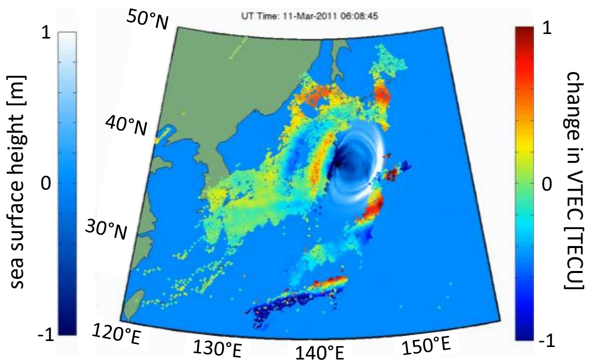


Figure: Ionospheric TEC and sea surface height map for the 2011 Tōhoku-Oki event (Galvan *et al.*, 2012).

jpl.nasa.gov

<u>Objective:</u> use GNSS to **augment monitoring capabilities and early warning systems** for natural hazards.

ICG: Information Dissemination & Capacity Building

- Regional Workshops: To provide updated knowledge of how GNSS operate and their applications; to describe the science of SW; and how to perform ionospheric and SW research with GNSS data
- Workshop on ISWI, 26 – 30 June 2023, Vienna
    - *Germany (10 – 14 June, 2024, Neustrelitz),*
    - *Nigeria (2025) and Republic of Korea (2026)*
- Workshop on the applications of GNSS, 23 – 26 October 2023, Finland
    - *Philippines (22- 26 April, 2024, Manila), Spain (November, 2024, Malaga),*
- Seminar on GNSS Spectrum Protection and Interference Detection and Mitigation (WG S)
    - *to highlight the importance of GNSS spectrum protection at the national level and to explain how to reap the benefits of GNSS*

ICG: Information Dissemination & Capacity Building

UNITED NATIONS
Office for Outer Space Affairs

- 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

Space weather monitoring using low-cost receiver system

UNITED NATIONS
Office for Outer Space Affairs

- Exploring low-cost GNSS receivers that satisfies space weather needs both in terms of scintillation and total electron content
  - *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 criteria.*

	e.g., U-Blox F9P	e.g. Septentrio MOSAIC
GNSS	GPS, GLONASS, Galileo, BDS, QZSS, SBAS	
Frequency Bands	L1, L2, E5b	L1, L2, L5
Raw Data	Code Phase, Carrier Phase, Doppler, Signal quality related data	
Navigation Frame Data	Yes, including data bits	
Output Rate	Max 20Hz	Up to 100 Hz for Measurement 50Hz for RTK
RTK / PPP Capable	Yes	
TEC Computation	Yes	
S4 Computation	(is being currently studied)	
Price ($)	300	700

Space weather monitoring using low-cost receiver system

UNITED NATIONS
Office for Outer Space Affairs

- Exploring software that could be used to process data from low-cost GNSS receivers in order to compute TEC, scintillation and other space weather related parameters
  - NeQuick (*free download* https://www.itu.int/rec/R-REC-P.531-14-201908-I/en)
- United Nations Workshop on ISWI, June 2023, Vienna
  - (ICTP) Performance in estimating TEC is *comparable to those of geodetic/scientific grade receivers and can therefore be used to monitor the ionosphere*
  - *(The University of Tokyo) Data formats and processing algorithms shall be standardized for uniform results*
  - *(Boston College) Space weather monitoring implies TEC and scintillation (both phase and intensity), and the preliminary results are promising. Full analysis of performance including tracking and other characteristics are in progress*

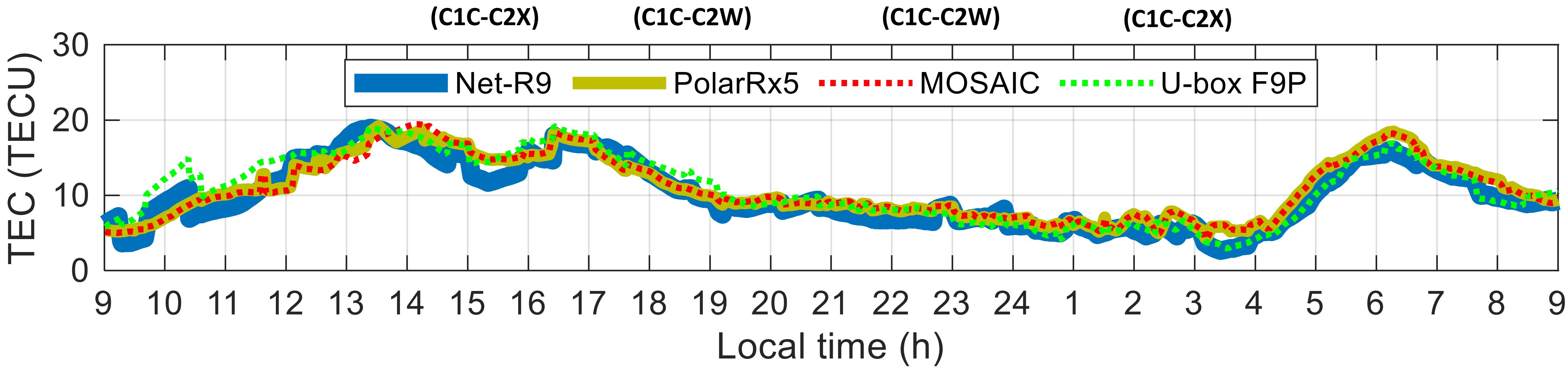
  https://www.unoosa.org/oosa/en/ourwork/psa/schedule/2023/2023-iswi-workshop_presentations.html

- *The preliminary results of a comparison between high-end and low-cost GNSS receivers showed a good correlation with regard to VTEC, the rate of change of TEC index and code phase scintillation*

Space weather monitoring using low-cost receiver system

UNITED NATIONS
Office for Outer Space Affairs

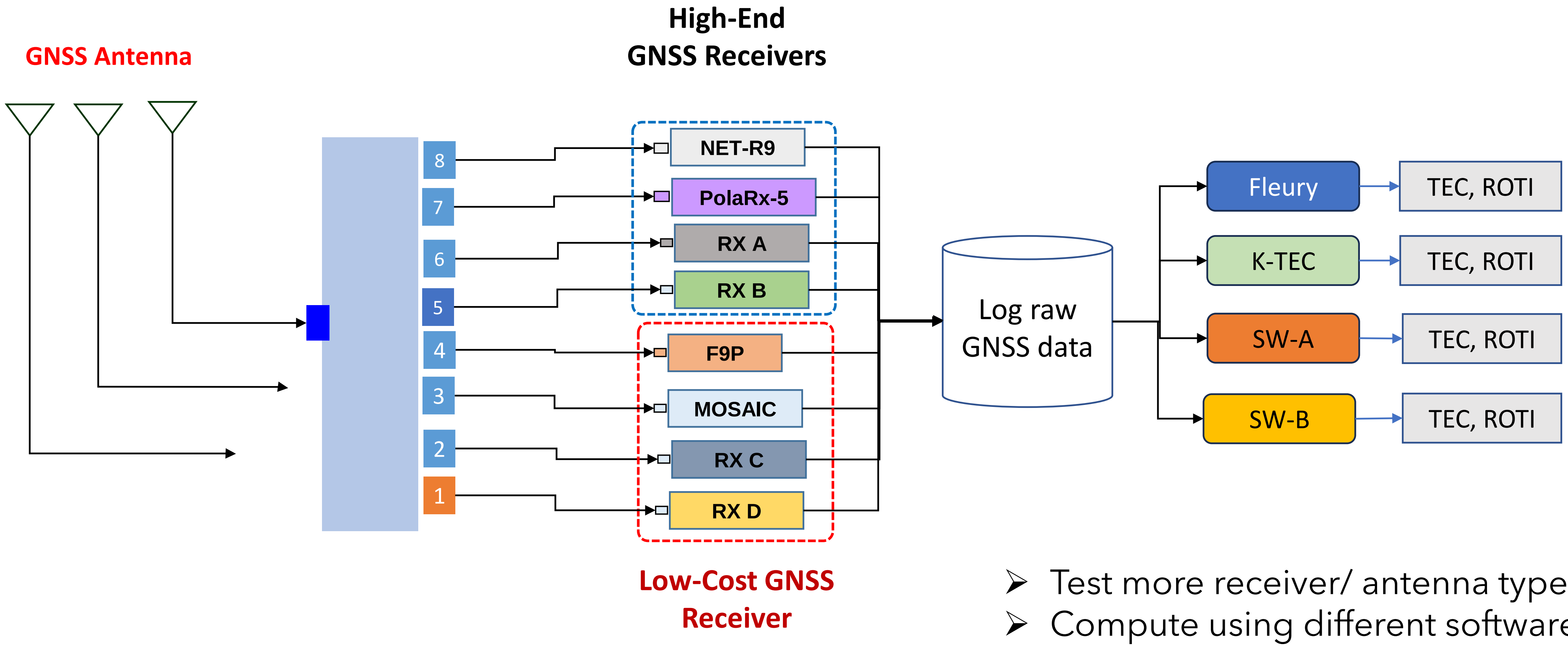
Comparison of VTEC Results



- ➢ 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.

Space weather monitoring using low-cost receiver system

UNITED NATIONS
Office for Outer Space Affairs



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

ICG: Information Centres

UNITED NATIONS
Office for Outer Space Affairs

The United Nations Programme of Space Applications established regional centres (***also acting as the ICG information centres***) in each region covered by the United Nations Economic Commissions: Africa (1998), Asia and the Pacific (1995/2014), Latin America and the Caribbean (2003), and Western Asia (2012)

- Satellite meteorology and global climate
- Satellite Communications
- Space and Atmospheric Science
- RS & GIS
- GNSS (2013)
- Space Law (2014)

ICG: Information Portal

UNITED NATIONS
Office for Outer Space Affairs

In 2022, humanity crossed a symbolic milestone as the world's population reached 8 billion. Science has been among the main drivers of this growth, gradually increasing the human lifespan thanks to advances in public health, water, sanitation and hygiene, and nutrition, among many others. There are 8 billion stories, minds, bright ideas and new perspectives, all waiting to leave their mark in improving life on our cosmic spaceship – planet Earth (UNOOSA-EUSPA).

WWW.UNOOSA.ORG

WWW.UNOOSA.ORG/OOSA/EN/OURWORK/ICG/ICG.HTML

https://www.unoosa.org/res/oosadoc/data/documents/2023/stspace/stspace85_0_html/st_space_085E.pdf

The activities and opportunities provided through the ICG result in the development and growth of capacities that will enable each country to enhance its knowledge, understanding and practical experience in those aspects of GNSS technology that have the potential for a greater impact on its economic and social development, including the preservation of its environment

ICG-18

Date: 6 – 11 October 2024

Location: Te Whanganui-a-Tara / Wellington
Aotearoa New Zealand

Venue: Tākina Wellington Convention Centre

Te Kāwanatanga o Aotearoa
New Zealand Government

Australian Government
Geoscience Australia

Thank you

UNITED NATIONS
Office for Outer Space Affairs