



2024 IGS Workshop Recommendations

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Analysis Centres and Reference Frame

Name of Working Group(s) in this Session: Analysis Centers and Reference Frame

Name of Working Group Chair(s): Paul Rebischung, Thomas Herring, Salim Masoumi

Name of Session Chair(s): Paul Rebischung, Thomas Herring, Salim Masoumi

Rapporteur: Paul Rebischung, Thomas Herring, Salim Masoumi

Participants:

- Analysis Center representatives
- Other interested participants

Discussion Highlights:

- Status of the actions from previous workshop
- Updated IGS ACs charter
- Transition to the new ACC and multi-GNSS roadmap
- Recent and upcoming improvements:
 - [New solar radiation force model](#) (PosiTim)
 - [JAXA QZSS shadow model](#)
 - FES2022b (<https://doi.org/10.24400/527896/a01-2024.004>) and FES2024 (soon available) ocean tide models
- BDS/QZSS campaign update
- ITRF2020 yearly updates
- ESA new CHAMP products using ESA antenna model
- Inclusion of 24:00 epoch in the SP3, CLK, other IGS files
- LEO inclusion in the IGS final products
- Individual frequency products
- LEO PNT

Key Issues:

- Transition to the new ACC and multi-GNSS roadmap (including multi-GNSS combinations)
- On-going research on observed scale discrepancies between different geodetic techniques
- ITRF2020 yearly updates
- BDS/QZSS campaign

Emerging Ideas:

- LEO processing by ACs
- LEO PNT – feasibility of inclusion in IGS

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

Reference Frame Recommendations from the 2022 workshop:

- Understand higher precision of TUG station position estimates compared to other ACs.
 - **Rebischung, P., Altamimi, Z., Métivier, L. *et al.* Analysis of the IGS contribution to ITRF2020. *J Geod* 98, 49 (2024).**
<https://doi.org/10.1007/s00190-024-01870-1>
- Aim at further reducing spurious periodic signals in IGS station position time series, by further advances in orbit and tide modeling.
 - **Rebischung, P., Altamimi, Z., Métivier, L. *et al.* Analysis of the IGS contribution to ITRF2020. *J Geod* 98, 49 (2024).**
<https://doi.org/10.1007/s00190-024-01870-1>
- Investigate terrestrial scale [rate] differences between GNSS and the other space geodetic techniques.
 - **IAG/IGS JWG 1.2.1: GNSS scale information for global reference frames created and first meeting completed;**
https://docs.google.com/document/d/1Di3zix51nBMokZtO-1_Ocvgfio5zJj5STcn7Abn48Y
- Aim at mitigating the impact of offsets on the long-term stability of the ITRF by:
 - **Also included in IAG/IGS JWG 1.2.1: GNSS scale information for global reference frames created and first meeting completed**
- Finalize and publish IGS20/igs20.atx by July 22, 2022.
 - **Completed: [IGS Constellations Issue 5](#).**

ACC Recommendations from the 2022 workshop:

- Publish the Repro3 combined orbit/clock/bias products along with reference attitudes
 - **Completed: [Repro3 Solutions Now Available – International GNSS Service \(igs.org\)](#).**
- Consolidate and formalize the assessments of the Repro3 orbits/clock/bias products.

- Zajdel, R., Masoumi, S., Sośnica, K. *et al.* Combination and SLR validation of IGS Repro3 orbits for ITRF2020. *J Geod* 97, 87 (2023).
<https://doi.org/10.1007/s00190-023-01777-3>
 - Geng, J., Yan, Z., Wen, Q. *et al.* Integrated satellite clock and code/phase bias combination in the third IGS reprocessing campaign. *GPS Solut* 28, 150 (2024).
<https://doi.org/10.1007/s10291-024-01693-9>
- Work with the multi-GNSS working group for a multi-GNSS combination task force; BDS processing.
 - **Multi-GNSS combination task force formed and continues to have regular meetings with progress in combination pieces of software.**
- Update of the ACC charter, specifically on the process for becoming an IGS AC, but also on the operational model of the ACC (and potentially on its relationship with the multi-GNSS working group and multi-GNSS combination task force)
 - **Completed:** [IGS ACC Charter Mar2024](#)
- Decision on CoM vs CoF issue, and recommendation on SINEX/orbit/clock alignment strategies.
 - **AC meeting about this question held in January 2023. Decision not to use the ITRF2020 seasonal terms within the IGS.**
- Coordination between ACs and Data Centers for the transition to long filenames.
 - **Transition to long filenames completed:** [Updated Guidelines on Long Product Filenames in the IGS – International GNSS Service](#)

RF/ACC Recommendations from the 2022 workshop:

- Transition of the IGS products to IGS20/igs20.atx and the repro3-standards (and long filenames) with trial period August-September 2022, and the final switch October 2022. The trial period was further extended post workshop, with the final switch occurring at the end of November 2022.
 - **Completed:** [IGS switch to IGS20/igs20.atx and repro3 standards – International GNSS Service](#)

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

ACs charter updated: [IGS ACC Charter Mar2024](#).

Recommendations (please include a projected timeline, if possible):

- Transition process to the new ACC, and roadmap to multi-GNSS as a priority for ACC
- RF coordinator and ACC to assess ESA new products using esa23.atx to ensure the IGS products maintain providing access to ITRF2020
- ACs are encouraged to provide the second midnight (24:00) epochs in their products. ACC to include in the combined products upon provision by all ACs.
- Investigation of scale discrepancies between different geodetic techniques continue to be carried out
- Preparation for ITRF2020 yearly updates
- BDS/QZSS campaign to be completed by the end of 2024
- ACs are encouraged to experiment with the new PosiTim [solar radiation force model](#), [the JAXA QZSS shadow model](#), the [FES2022b](#) and FES2024 (soon available) ocean tide models.
- ACs to consider processing LEO measurements and assess potential to include in their final set of products
- LEO PNT processing to be discussed further with a potential to create an independent working group/pilot project
- ACs to consider providing individual frequency products
- Communication between Analysis Centre Coordinators, Reference Frame Coordinator and Analysis Centers:
 - It was suggested that while having AC meetings when required, AC meetings occur at least every three to six months

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Directly working on this objective
	Coordinating (and tracking progress) the various multi-GNSS contributions (achievements) across all Working Groups and Infrastructural components	Directly working on this objective
	Identify and incubate aspects of IGS component work that need special attention to make a strong step toward multi-GNSS	Directly working on this objective

GOALS	OBJECTIVES	STATUS
	Advocate the benefit and critical need of multi-GNSS through case studies, leadership, and demonstration	Directly working on this objective
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Directly working on this objective
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Indirectly contributing to this objective
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	Indirectly contributing to this objective
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Directly working on this objective
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Directly working on this objective
	Coordinating technological and geographical infrastructural innovation and diversity	Indirectly contributing to this objective
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Directly working on this objective
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Indirectly contributing to this objective



At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

Maintaining and improving the IGS contribution to the ITRF, and the access to the ITRF for users of the IGS products, through improvements in the modeling, as well as multi-GNSS inclusion

What impediments do you think are preventing the group from successfully realizing its recommendations?

Several open points and limited resources

What is one thing that your group members wish the public knew about the IGS?

Depending on the definition of “public”, for other scientific groups that indirectly rely on IGS products (e.g., altimeter and GRACE type higher level products), knowing they rely on IGS products would be useful. If we had the resources, then some case studies of “this is what happens if IGS products were to go away” would be interesting to have on hand.

Antenna

Name of Working Group(s) in this Session: Antenna

Name of Working Group Chair(s): Arturo Villiger

Name of Session Chair(s): Arturo Villiger

Rapporteur: Arturo Villiger

Participants:

- n/a

Discussion Highlights:

- n/a

Key Issues:

- n/a

Emerging Ideas:

- n/a

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- The IGS20 ANTEX file igs20.atx was released
- The project Antenna Ring calibrations was initiated and is currently successfully ongoing

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

Recommendations (please include a projected timeline, if possible):

- **IGS Calibration Facility Guideline:** The AWG recognizes the valuable effort put into the ring antenna calibration campaign. These findings should serve as the foundation for creating new guidelines on how to become an official IGS calibration facility.
- **ANTEX 2.0 Development:** The AWG acknowledges that the current IGS ANTEX 1.4 format has limitations (e.g., multiple antennas, GCV, gain patterns). Therefore, propose introducing an extended ANTEX 1.4 version as the new ANTEX 2.0 format. Prepare an initial version for discussion among the IGS ACs.
- **Receiver Antenna Calibration Updates:** Historically, receiver antenna patterns were updated only alongside new ITRF releases. Given the extended life cycle of ITRF 2020, explore alternative methods for updating calibrations independently of ITRF updates.
- **Disclosed Satellite Antenna Pattern:** The AWG encourages the scientific community to explore the disclosed GPS and Galileo satellite antenna patterns, e.g. GNSS induced scale. (GPS-Pattern available at: Montenbruck et al., 2024, <https://doi.org/10.1007/s00190-023-01809-y>)

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	NA
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all	NA

GOALS	OBJECTIVES	STATUS
	Working Groups and Infrastructural components	
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Directly working on this objective
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	Directly working on this objective
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Not Applicable
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Not Applicable
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	Not Applicable
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Directly working on this objective
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Not Applicable
	Coordinating technological and geographical infrastructural innovation and diversity	Not Applicable
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Indirectly contributing to this objective
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Not Applicable

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

The main target of the AWG is to provide the antenna calibrations associated with the IGS realization to the user community and coordinate activities between calibration facilities as well as antenna related work.

What impediments do you think are preventing the group from successfully realizing its recommendations?

There are many open points and only limited capacity (time availability)

What is one thing that your group members wish the public knew about the IGS?

n/a

Bias and Calibration and PPP-AR

Name of Working Group(s) in this Session: PPP-AR & Bias

Name of Working Group Chair(s): Jianghui Geng, Stefan Schaer

Name of Session Chair(s): Stefan Schaer

Rapporteur: Stefan Schaer

Participants:

- All listeners in lecture hall A6 on July 4, 2024, 14:00-15:30

Discussion Highlights:

- The first part dealt with “PPP-AR,” followed by topics on “Bias (and Calibration).”

Key Issues:

- Future work regarding PPP-AR:

- Encourage more ACs to produce and release GPS/Galileo/BDS/QZSS phase bias products
 - Work with the Bias Committee to ensure continuity of orbits/clocks/biases at day boundaries
 - 24:00 epochs added or not
 - Work in partnership with the Clock WG on time scale issues associated with continuous “phase” clocks
 - Encourage more multi-frequency phase bias products, and start a pilot project to validate them across ACs
- Long filenames (TTT=PRD and LEN=00U)
 - Re-selection of GPS reference signals for clock product generation
 - Satellite antenna PCO correction (IGS iono ACs)
 - Three bias product trees (clock/PPP-AR, iono/DCB, weekly/monthly DCB/OCB)
 - GNSS satellite antenna PC/PCO information for **all** frequencies
 - Source of IGS AC PPP-AR (GPS) OCB (not OPB) does not appear to be independent
 - To update Bias-SINEX Format due to LEO-PNT activities (and possibly other requirements)
 - Future of Bias and Calibration Committee

Emerging Ideas:

- The question was raised as to whether the Bias and Calibration committee should be integrated into another committee (e.g., PPP-AR), or whether the role of a Bias and Calibration coordinator would be useful.
- Two specific aspects regarding IGS long filenames (TTT=PRD and LEN=00U) were discussed in plenary. A consensus was reached. The corresponding outcome still needs to be prepared and fed into the Infrastructure committee.

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

-

Any changes or updates to the group’s charter, goals, or objectives? If yes, please describe:

-

Recommendations (please include a projected timeline, if possible):

- Encourage more ACs to produce GPS/Galileo/BDS phase clock/bias

- Recommend the GB and ACC to introduce a combined clock/bias solution as an official IGS satellite product
- Add 24:00 epoch to orbit and clock products

Key Recommendation:

- To encourage the IGS ACs (and ACC) to include 24:00 epoch information in their analysis product files, in particular in orbit (SP3) and clock (CLK) files, but also in all other product files (such as, e.g., ATT.OBX)

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

- To further develop and refine PPP-AR methods.
- To combine such (orbit/clock/bias) analysis products in a rigorous way.
- To provide GNSS pseudorange bias information and to maintain a corresponding data format interface (for pseudorange as well as phase biases).
- To coordinate bias-related issue among the various IGS committees.

What impediments do you think are preventing the group from successfully realizing its recommendations?

-

What is one thing that your group members wish the public knew about the IGS?

- That the IGS and all its components play a leading role in the generation, standardization and modeling of GNSS tracking data and resulting analysis products that meet highest accuracy requirements on a global scale.

IDEA

Name of Working Group(s) in this Session: IDEA (Inclusion, Diversity, Equity, Accessibility) WG

Name of Working Group Chair(s): Camille Martire, Elisabetta d'Anastasio

Name of Session Chair(s): Camille Martire, Elisabetta d'Anastasio

Rapporteur: Camille Martire, Elisabetta d'Anastasio

Discussion Highlights:

- Most of the discussion revolved around the drafting of the IDEA Guidelines for IGS Components and Event Organisers. A number of key topics were raised, and will eventually be consolidated into said Guidelines.
- Another important point was the need to implement a way for the IGS Community to provide feedback, on a potentially anonymous basis. It was decided that the IGS.org “Contact Us” (<https://igs.org/contact-us/>) form can be used for that purpose.
- The IDEA WG will also work towards establishing metrics, that can be measured on a regular basis to evaluate the progress of the IGS and its Components towards the ideals of IDEA. The main metrics will be demographics and seniority, but the IDEA WG also suggested tracking the number of issues raised and the proportion of those that were corrected.
- See also the [IDEA Splinter Meeting Minutes](#).

Key Issues:

- Community members may perceive the work of the IDEA WG as prescriptive, pedantic, and/or unnecessary, and may therefore reject it without giving it a chance. It is very important to present the IDEA WG work in a carefully curated way, along with the full rationale behind this work. **The IDEA WG’s first effort after this Workshop will be to start a short campaign to help the IGS Community better understand the why and how of this WG.**

Emerging Ideas:

- The IDEA WG supports the CB’s Call for Secondments. Secondments would allow to source types of expertise that are currently lacking in IGS.
- The IDEA WG explored ways to contact and sample the private sector for the relevant IGS objectives and strategic objectives (*e.g.*, data licensing).

Major accomplishments since the 2022 Workshop, and progress on 2022 (and earlier) Workshop recommendations:

- Not applicable: the WG was created in 2024.

Any changes or updates to the group’s charter, goals, or objectives? If yes, please describe:

- Not applicable: the first version of the WG Charter was published in early 2024 and was not significantly changed since then.

Recommendations (please include a projected timeline, if possible):

The IDEA WG recommends:

- **Drafting guidelines for institutions to become an IGS AC.**
 - The IGS ACC Charter gives general guidelines and requirements for this, but does not fully detail the application process.

- Developing and releasing scientific software as open-access (at least) or open-source (at best).
- Organising all meetings in a hybrid manner (in-person + virtual or virtual only), and ensuring that all participants are given equal opportunity to contribute (whether online or in-person).
- Making presentations and recordings available online after all public IGS events.
- Implementing a reduced fee for online participants and for student participants (for events subject to a registration fee).
- Accounting for the working hours of all participants in a given collaboration group, in particular when scheduling meetings.
 - This could be achieved by cycling through the meeting times to avoid having some participants always having to participate at uncomfortable hours.
 - Tools such as <https://www.worldtimebuddy.com/> can help in that endeavour.
- Encouraging early career contributions as often as possible.
- Pursuing capacity development in underrepresented regions, namely through the establishment of new IGS stations.

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	not addressing
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	not addressing
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	not addressing
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	not addressing
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	in progress
	Coordinating outreach to relevant agencies &	in progress

GOALS	OBJECTIVES	STATUS
	institutions, to attract and promote IGS scientific and user applications	
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	in progress
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	in progress
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	in progress
	Coordinating technological and geographical infrastructural innovation and diversity	in progress
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	not addressing
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	in progress

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

- The IDEA WG intends to make the IGS even more welcoming than it already is, namely by encouraging diverse new participants, pushing IGS Components to strive for inclusive and accessible practices, and ensuring the whole IGS Community has equitable chances at contributing to the IGS.

What impediments do you think are preventing the group from successfully realising its recommendations?

- Community members may perceive the work of the IDEA WG as prescriptive, pedantic, and/or unnecessary, and may therefore reject it without giving it a chance. It is very important to present the IDEA WG work in a carefully curated way, along with the full rationale behind this work.

What is one thing that your group members wish the public knew about the IGS?

- The IGS is already a particularly diverse, inclusive, and welcoming organisation, with representatives from dozens of countries and regions around the world. This is very encouraging, and should therefore be advertised and encouraged further.

Infrastructure

Name of Working Group(s) in this Session: Infrastructure Committee

Name of Working Group Chair(s): Markus Bradke, Ryan Ruddick

Name of Session Chair(s): Markus Bradke, Ryan Ruddick

Rapporteur: Markus Bradke, Ryan Ruddick

Participants:

50 on-site, 5 remote participants

Discussion Highlights:

- Improve tracking network to be fully multi-GNSS (including all signals)
- Presentation by ISRO regarding the improved tracking of NavIC in the IGS network
- Presentation by ROB regarding GNSS DCAT-AP, a metadata schema for GNSS observation data
- Proposal by L. Huisman to standardize code lists for co-located instruments, in particular InSAR equipment
- Users request to establish APIs to query data from data centers

Key Issues:

- Community highly dependent on one Global Data Center (CDDIS)
- Information Security is the biggest threat to reputational damage
- Quality check standards are not consistent between data centers
- Lack of standardization to make data discoverable

Emerging Ideas:

- Cloud-native storage for GNSS observation (and other) data

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- Establishment of a sub-committee as entry point for station proposals
- Establishment of the “Guidelines for Continuously Operating Reference Stations in the IGS”
- Establishment of the “Guidelines for Long Product Filenames in the IGS”
- Implementation and execution of the RINEX version 4 transition plan
- Direct support for Central Bureau for the implementation of the SiteLog Manager
- Direct support to make GeodesyML an official IGS standard
- Direct support for the transition of MGEX products to the official IGS portfolio
- Direct support for the transition of Differential Code Bias products

Any changes or updates to the group’s charter, goals, or objectives? If yes, please describe:

No.

Recommendations (please include a projected timeline, if possible):

#	Recommendation	Timeframe	Performance measure
1	Encourage IGS station operators to track NavIC for stations within the footprint and analysis centers to analyze the data.	2 years	Increase in the number of IGS stations tracking NAVIC
2	Develop a policy for the inclusion and exclusion of stations.	2024/25	Policy completed
3	Develop an extensible way to categorize stations by their use for the community.	2025/26	Categorisation schema developed and implemented within IGS web services
4	Develop a charter for IGS data centers.	2024/25	Charter completed
5	Establish a taskforce on exploring cloud native storage formats.	2 years	Host a dedicated workshop and provide recommendations
6	Contributing to the GGOS Data and Information System Committee to ensure	4 years	GNSS included

	the improvement of FAIR GNSS data and metadata.		
7	Harmonize the code lists within the IGS station metadata.	2024/25	IGS SLM updated to include code lists.
8	Inclusion of more active members of the IC.	2 years	New members

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Directly working on this objective
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	Directly working on this objective
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Directly working on this objective
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	Indirectly contributing to this objective
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Directly working on this objective
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Indirectly contributing to this objective
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	Indirectly contributing to this objective

GOALS	OBJECTIVES	STATUS
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Directly working on this objective
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Directly working on this objective
	Coordinating technological and geographical infrastructural innovation and diversity	Directly working on this objective
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Directly working on this objective
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Directly working on this objective

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

To coordinate, sustain and enhance the global IGS infrastructure to ensure the community has secure and easy access to the highest quality Multi-GNSS observation data and accurate station metadata.

What impediments do you think are preventing the group from successfully realizing its recommendations?

- The voluntary nature of the IGS infrastructure presents a risk to the continuous availability of the data
- The voluntary nature of the IGS and the community involved presents a risk in realizing the committees' recommendations

What is one thing that your group members wish the public knew about the IGS?

The IGS plays a critical role in ensuring the accuracy, reliability, and integrity of GNSS data and products worldwide.

Ionosphere

Name of Working Group(s) in this Session: Ionosphere

Name of Working Group Chair(s): Andrzej Krankowski

Name of Session Chair(s): Andrzej Krankowski

Rapporteur: Andrzej Krankowski

Participants - 27

- | | | | |
|----|--|----|--|
| 1 | Andrzej Krankowski, UWM Poland | 15 | Richard Langley, UNB Canada |
| 2 | Adam Fron, UWM Poland | 16 | Giles Wautelet, UL Belgium |
| 3 | Zishen Li, AIR/CAS China | 17 | Andreas Holt, Fugro Norway |
| 4 | Mattia Crespi, SUR Italy | 18 | Michael Meindl, Leica Geosystems Switzerland |
| 5 | Manuel Hernandez-Pajares, UPC-IONSAT Spain | 19 | Stefan Schaer, Swisstopo/AIUB Switzerland |
| 6 | Michela Ravanelli, SUR Italy | 20 | Rida Awad, Technion/IIT Israel |
| 7 | Haixia Lyu, WU China | 21 | Francisco Gini, ESA |
| 8 | Andreas Brack, GFZ Germany | 22 | Camille Martire, JPL USA |
| 9 | Bragbery Dunn, TUM Germany | 23 | Phil Lamothe, NRC Canada |
| 10 | Miguel Gonzalez Hidalgo, NGI Spain | 24 | Abi Komanduru, JPL USA |
| 11 | Kacper Kotulak, UWM Poland | 25 | Attila Komjathy, JPL USA |
| 12 | Marija Pejakovic, SGA Croatia | 26 | Volker Mayer, ESA |
| 13 | Beata Milanowska, UWM Poland | 27 | Tim Springer, ESA |
| 14 | Ningbo Wang, AIR/CAS China | | |

Discussion Highlights:

- Celebration of 25th Anniversary of IGS ionospheric activity
- A progress towards the final real-time global ionospheric maps have been discussed – performance of the two independent IGS combined real-time products has been presented.

- The final ROTI ionospheric fluctuation product development towards covering the southern hemisphere and equatorial region has been presented.
- Creation of 2 new Study Groups: „Ionospheric Mapping Function” and „ New Methodology for Combining IGS Ionospheric products”
- Establishment of long file naming convention expansion for different predicted ionospheric products
- A progress within the cooperation between IGS and IRI groups regarding the development of the VTEC maps as an input for the GIRO GAMBIT system.
- A progress within simultaneous ionospheric observations with GNSS and LOFAR systems have been presented.

Key Issues:

- IGS real-time service for global ionospheric total electron content modeling
- IGS ROTI Maps: Current Status and Its Extension towards Equatorial Region and Southern Hemisphere
- Towards Cooperative Global Mapping of the Ionosphere: Fusion Feasibility for IGS and IRI with Global Climate VTEC Maps
- Cooperation with International LOFAR Telescope (ILT) for potential synergies
- Creation of 2 new Study Groups: „Ionospheric Mapping Function” and „ New Methodology for Combining IGS Ionospheric products”

Emerging Ideas:

- Moving toward real-time multi-constellation ionosphere products including VTEC maps, ROTI maps, scintillation products.

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- Further expansion of the real-time global ionospheric maps has been achieved – currently two IGS combined real-time products are available (results published in three papers)
- ROTI Northern-hemisphere polar maps are being supplemented with products covering also Southern hemisphere and equatorial region (results published in six papers)
- Four manuscripts concerning cooperation with ILT and IRI communities have been published in high impact factor peer-reviewed journals.

Any changes or updates to the group’s charter, goals, or objectives? If yes, please describe:

No

Recommendations (please include a projected timeline, if possible):

- Preparation of final version of IGS RT-GIMs
- Preparation of final version of IGS ROTI maps extension towards low latitudes and Southern Hemisphere
- Continuation of works of new Study Groups: „Ionospheric Mapping Function” and „ New Methodology for Combining IGS Ionospheric products”
- Close cooperation with the Real-Time Working Group in order to elaborate full real-time VTEC and ROTI products.
- Continuation of cooperation with IRI, LOFAR-ERIC and ICG communities

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Directly working on this objective
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	Directly working on this objective
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Directly working on this objective
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	Directly working on this objective
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Directly working on this objective
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Directly working on this objective
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at	Directly working on this objective

GOALS	OBJECTIVES	STATUS
	organizations and early career scientists	
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Directly working on this objective
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Directly working on this objective
	Coordinating technological and geographical infrastructural innovation and diversity	Directly working on this objective
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Not Applicable
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Indirectly contributing to this objective

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

Providing highest possible quality ionospheric products for the geodetic and other science communities, industry, and various other users

What impediments do you think are preventing the group from successfully realizing its recommendations?

There are no particular impediments. The group is continuously improving the quality of the provided products.

What is one thing that your group members wish the public knew about the IGS?

Dedication and selflessness of the researchers participating in international collaborations.

MGEX

Name of Working Group(s) in this Session: MGPP & CTF

Name of Working Group Chair(s): Peter Steigenberger (MGPP), Oliver Montenbruck (CTF)

Name of Session Chair(s): Peter Steigenberger, Oliver Montenbruck

Rapporteur: Peter Steigenberger

Discussion Highlights:

- Role of the IGS in LEO PNT
- Usage of GPS L5 by ACs

Key Issues:

- Multi-GNSS capable orbit/clock/bias combination software

Emerging Ideas:

- Establish an IGS entity on LEO PNT
- Establishment of a backup combination center

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- Relocate all MGEX products to standard IGS products directory (completed Feb 2024)
- Request GB approval for Satellite Metadata SINEX File Format and Product (endorsed by GB in Dec 2022)
- Establish a Task Force to define and implement a tool chain for multi-GNSS orbit/clock/(bias) combination and to establish an operational product. (CTF established Sep 2022)

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

- Termination upon first operational combined multi-GNSS products by ACC

Recommendations (please include a projected timeline, if possible):

- Request GB approval for Satellite Metadata SINEX File Format 1.10 (ASAP)

- Station owners are requested to transition to RINEX 4 subject to support by the receiver/conversion software (ASAP)
- Include 24:00 epoch in all IGS orbit products (ASAP)
- OPS ACs are encouraged to participate in step 3 of the BDS-3/QZSS satellite antenna calibration campaign (impact on OPS products) to include these constellations in their operational products (Q1/2025)
- Suggest parallel testing of GA orbit combination s/w and SPOCC orbit/clock combination software by new ACC to consolidate multi-GNSS combination and decide on final software (2025)
- Establish an IGS component addressing LEO PNT (Q4/2024)

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	In progress
	Coordinating (and tracking progress) the various multi-GNSS contributions (achievements) across all Working Groups and Infrastructural components	In progress
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multi-GNSS	In progress
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	In progress
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	n/a
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	n/a
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at	n/a

GOALS	OBJECTIVES	STATUS
	organizations and early career scientists	
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	n/a
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	In progress
	Coordinating technological and geographical infrastructural innovation and diversity	n/a
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	n/a
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	n/a

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

Multi-GNSS in all IGS data and products.

What impediments do you think are preventing the group from successfully realizing its recommendations?

Idleness of individual station operators and analysis centers.

What is one thing that your group members wish the public knew about the IGS?

n/a

PPP-AR

Name of Working Group(s) in this Session: Precise Point Positioning with Ambiguity Resolution (PPP-AR)

Name of Working Group Chair(s): Jianghui Geng

Name of Session Chair(s): Jianghui Geng

Rapporteur: Jianghui Geng

Participants:

- ~150 participants

Discussion Highlights:

- Add 24:00 epoch for orbit and integer clock products
 - Facilitate fixing discontinuities in orbit/clock/bias products
- BDS/QZSS phase biases
 - Only GFZ and Wuhan provide BDS-2/3 phase biases at the moment
 - GRG provides BDS-3 phase biases, but there are problems with IGSO satellites (C38/C39/C40)
- More phase bias products would strengthen the robustness of clock/bias combination
 - GPS/Galileo combinations benefit from 5 contributing ACs
 - BDS-2 combination might be downgraded because of only 2 ACs

Key Issues:

- Progress of the PPP-AR Pilot Project since the 2022 workshop
- Current status of PPP-AR products at representative ACs
- Demonstration of routine multi-GNSS orbit/clock/bias combination
- Roadmap to multi-GNSS & multi-frequency phase bias products

Emerging Ideas:

- 24:00 epoch is added for orbit, clock and attitude quaternion products for the sake of fixing discontinuities at the day boundary.
- New bias-SINEX format containing the discontinuity information of orbit/clock/bias products at the day boundary is proposed.

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- ACs providing phase bias products
 - 3 ACs provide BDS, 1 AC provides QZSS and 1 AC provides real-time phase biases
 - A new convention on the APC model for both code and phase biases has been agreed on
- Routine orbit/clock/bias combination (since GPS Week 2280, GPS/Galileo/BDS-2&3)
 - An operational combination process to cross-validate AC-specific bias products
 - Statistics and PPP-AR results are illustrated online (e.g., <https://igs.org/wg/ppp-ar/#rapid>)
 - Combined products released to the public (WMCODEM, <ftp://igs.gnsswhu.cn/pub/whu/phasebias>)
- Day-boundary discontinuity of satellite orbit/clock/bias products
 - WUM Rapid has fixed these discontinuities for GPS/Galileo/BDS orbits/clocks/biases
- All-frequency code/phase bias products from Wuhan
 - WUM Rapid products have released all-frequency phase biases, which can contribute to PPP-AR over any frequency choices

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

Goals

Phase 1

- Survey the technical practices and problems from current phase bias estimates.
- Encourage more ACs to produce GPS/Galileo/BDS phase clock/bias products.
- Start a cross-validation task to assess the phase clock/bias qualities and improve the consistency among the contributing products.
- Work with the Bias WG to ensure continuity of clocks/biases at day boundaries by using the integer properties of the combined products.
- Initiate a project to expose the combined clock/bias solution to open testing for the public.
- Develop a phase clock/bias combination software open-sourced across the IGS community.
- Recommend the GB and ACC to introduce a combined clock/bias solution as an official IGS satellite product.

Phase 2

- Work in partnership with the Clock WG on time scale issues associated with continuous “phase” clocks.
- Encourage the RT WG to compute and broadcast real-time phase biases by sharing knowledge on phase bias generation.

- Survey proper models, algorithms, and requirements for multi-frequency phase bias products, and start a pilot project to generate such products.
- Assess the versatility and scalability of multi-frequency phase biases for all conceivable observable combinations and frequency choices, and start a pilot combination task.

Recommendations (please include a projected timeline, if possible):

- Encourage more ACs to produce and release GPS/Galileo/BDS/QZSS phase bias products
- Recommend the GB and ACC to introduce a combined clock/bias solution as an official IGS satellite product
- Work with the Bias Committee to ensure continuity of orbits/clocks/biases at day boundaries
- Work in partnership with the Clock WG on time scale issues associated with continuous “phase” clocks
- Encourage more multi-frequency phase bias products, and start a pilot project to validate them across ACs

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Indirectly contributing to this objective
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	Directly working on this objective
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Directly working on this objective
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	Directly working on this objective
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Indirectly contributing to this objective

GOALS	OBJECTIVES	STATUS
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Directly working on this objective
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	Indirectly contributing to this objective
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Indirectly contributing to this objective
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Directly working on this objective
	Coordinating technological and geographical infrastructural innovation and diversity	Indirectly contributing to this objective
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Indirectly contributing to this objective
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Indirectly contributing to this objective

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

Investigates the inter-operability of PPP-AR products generated by various analysis centers and analyze the feasibility and benefits of having the IGS adopt a modernized combination process considering the consistency of the satellite clock and bias products. Ultimately, support high-precision scientific applications requiring globally applicable point positioning technique and rapid access to the international terrestrial reference frame.

What impediments do you think are preventing the group from successfully realizing its recommendations?

Limited resources in some ACs to provide extra satellite products. Insufficient software which requires great efforts and manpower to improve to multi-GNSS and multi-frequency capability.

What is one thing that your group members wish the public knew about the IGS?

The IGS members work on a best effort and voluntary basis for the benefit of society. This work is expected to be recognized by the academic community and acknowledged in their publications.

Real-Time

Name of Working Group(s) in this Session: Real-Time Committee

Name of Working Group Chair(s): Axel Rülke, Federal Agency for Cartography and Geodesy (BKG), Germany

Ningbo Wang, Aerospace Information Research Institute (AIR), Chinese Academy of Sciences, China

Name of Session Chair(s): IGS-WS 2024 Session 3: Giving Access To The Reference Frame Through GNSS

Axel Rülke (RT GNSS)

Stefan Schaer (Biases)

Michael Joseph Coleman (Timing)

Rapporteur: Axel Rülke for Real Time Committee

Participants:

Members of the RT Committee and interested guests.

Discussion Highlights:

- The new RT-ACC Andrea Stürze has completely renewed the validation and combination process within the IGS Real Time Service (IGS RTS). While the combination now comprises 4G multiGNSS constellations, the validation is still 3G and will be developed to 4G as soon as possible.
- Product data streams by individual ACs gain more user attention than the combined IGS product streams. This is due to a lower latency and a better consistency. Comparisons and combinations performed by the RT-ACC allow an enhanced quality assessment of the individual products.
- The IGS RTS is competitive with other global PPP services, such as Galileo HAS. The IGS RTS should strive to provide products for PPP with 10cm level of positioning accuracy and ambiguity fixing.
- The development of independent, open source real time capable software packages, such as GINAN by Geoscience Australia, is an important component of the IGS RTS and highly appreciated.

Key Issues:

- The standardization of State Space Representation (SSR) messages with RTCM is still pending. The format descriptions will not be available before 2025. IGS should keep and develop the IGS-SSR format. New suggested message types for IGS-SSR include satellite attitude, satellite offsets, PCV/GDV information, ionosphere VTEC map accuracy information.
- The increasing number of RT data users is a challenge for the RT data centers. Alternative RT data centers are welcome to popular the use of IGS RTS.

Emerging Ideas:

- IGS RTS is not only limited to positioning. The provided RT ionosphere products are of special interest within the user community. We should also listen to the timing community and their demands.

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- The RT-ACC transition from Loukis Agrotis (ESOC/ESA) to Andrea Stürze (BKG). This included a complete renewal of the RT-ACC analyses.
- IGS-SSR Task Force formed to develop new message formats of IGS-SSR Multi-GNSS standard. This task has been reformulated in the WS2024 recommendations.

- Improved broadcast ephemeris quality in IGS combined streams, and a new combined ephemeris stream with integrity monitoring is available from IGS RTS.
- New ACs (JPL and APM) contribute to the IGS RTS and the number of active RT ACs increases to 8.
- Two independent RT ionospheric combination product streams provided by the IGS RTS with co-operation with ionosphere committee.

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

The committee charter needs some revision. This will be done until end of 2024.

Recommendations (please include a projected timeline, if possible):

- Enhance IGS Real Time Service product descriptions on the igs.org website. Real Time ACs provide detailed information on used data, correction models and parameter modelling of their products. [end of 2024]
- Enhance IGS-SSR format by additional messages on satellite attitude, satellite offset and satellite PCV/GDV. [end of 2025]
- Major application of the IGS Real Time Service rely on a 10cm position accuracy with fixed ambiguities. Real Time ACs are encouraged to develop their products to reach this goal. [end of 2025]

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Select status
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	Select status
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Select status
	Advocate the benefit and critical need of	Select status

GOALS	OBJECTIVES	STATUS
	Multi-GNSS through case studies, leadership, and demonstration	
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Select status
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Select status
	Incubating the next generation of IGS community members through Inclusion campaigns targeted at organizations and early career scientists	Select status
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Select status
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Select status
	Coordinating technological and geographical infrastructural innovation and diversity	Select status
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Select status
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Select status

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

The RT committee integrates all GNSS real time activities within the IGS. It closely cooperates with other IGS Committees, such as the ionosphere committee, the infrastructure committee and the PPP-AR committee which specifically cover part aspects of the RT committee.

The largest contribution and heavily used by the global GNSS community is the real time observation data streams by the global IGS network through the IGS real time data centers.

Ionosphere products with short latencies provided in cooperation with the ionosphere committee are of special interest within the global space weather community.

What impediments do you think are preventing the group from successfully realizing its recommendations?

Two out of three recommendations from the 2022 Workshop are related to the development of new formats. The development of new message formats needs significant effort by a number of group members.

Since real time GNSS positioning is also of commercial value, there might occur conflicts of interest in some cases.

What is one thing that your group members wish the public knew about the IGS?

The IGS strongly supports real time GNSS applications not only for research and governmental users but also for commercial users by its observation network, its real time data centers and its real time analysis centers.



Figure 1: IGS Real Time Committee Chair Axel Rülke, BKG (right) and Co-Chair Ningbo Wang, AIR CAS (left)

RINEX

Name of Working Group(s) in this Session: RINEX Committee

Name of Working Group Chair(s): Francesco Gini

Name of Session Chair(s): Francesco Gini

Rapporteur: Francesco Gini

Participants:

- About 30 people in the room + 5 online

Discussion Highlights:

- Status Update
- RINEX evolution: 4.02 consolidation
- Overview of Future Navigation – impact on RINEX format:
 - Moon navigation (towards and around)
 - LEO PNT
 - RINEX format evolution

Key Issues:

- Next RINEX version (4.02) is needed to keep up with the GNSS system evolution
- LEO PNT is a new technology that potentially will have an impact on the entire IGS, hence the RINEX format as well
- The current RINEX format is not suitable for Artificial Intelligence applications and Cloud Computing

Emerging Ideas:

- **Lunar Navigation:** GNSS (and hence the RINEX format) will soon be used for the first time for the Lunar Navigation. No evident limitations of the current format (4.xx) are expected.
- **LEO PNT:** Institutes conducting R&D in the LEO PNT domain are already asking IGS how to include the new LEO satellites' signals in the RINEX format.
 - IGS must agree on the way forward, whether they want to get involved in this topic. Decision must be made at an early stage (now) for a coordinated approach. If IGS decides to get involved, shall the current RINEX format be expanded to accommodate LEO-PNT requirements, or shall IGS look into a new format?
- **RINEX evolution:** RINEX evolution for AI and Cloud Computing. IGS shall start looking into a new "RINEX" format that allows the current technology to efficiently store the GNSS data for quick access, processing and dissemination. This message has come across the RINEX splinter session, as well as the Infrastructure splinter session and the IGS Symposium Infrastructure and Standards session (session 1)

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- Publication of RINEX 4.xx formats

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

- None

Recommendations (please include a projected timeline, if possible):

- LEO PNT:** IGS shall answer the question: *should IGS get involved in the LEO PNT activities?* (possibly by end 2024/early 2025).
 If Yes, this will impact IGS at all levels (e.g., formats, Acs, RFs) and will need quite some work and coordination and will potentially require dedicated Pilot Project/Projects?
- RINEX evolution:** RINEX needs a format evolution for AI and Cloud Computing applications. This requires IGS to agree on a way forward for a format evolution. Coordination between RINEX and Infrastructure Committees is needed and will potentially require a new dedicated Pilot Project.

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Apply
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	n/a
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Apply
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	n/a
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Apply
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Apply
	Incubating the next generation of IGS community	n/a

GOALS	OBJECTIVES	STATUS
	members through Inclusion campaigns targeted at organizations and early career scientists	
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Apply
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Apply
	Coordinating technological and geographical infrastructural innovation and diversity	Apply
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	n/a
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Apply

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

- Standardization and maintenance of one single format for GNSS – RINEX
- Facilitate GNSS data dissemination and exploitation by the entire community

What impediments do you think are preventing the group from successfully realizing its recommendations?

- The current RINEX ASCII format is THE standard and the entire community relies on it, although it is not straightforward to maintain. RINEX ASCII format shall remain.
- The current format is not efficient for AI and Cloud Computing applications and hence requires the identification of a parallel format, more suited for these tasks. This requires an IGS agreement, followed by coordination between IGS committees and the community, experimentation and set up of an operational solution.

What is one thing that your group members wish the public knew about the IGS?

- RINEX is the corner stone of the IGS processing. Although it is merely a format, it requires careful adjustments and monitoring of the GNSS systems evolution to stay up to date and to allow completeness and compatibility.

Troposphere

Name of Working Group(s) in this Session: Troposphere Committee

Name of Working Group Chair(s): Sharyl Byram

Name of Session Chair(s):

Rapporteur: Sharyl Byram

Participants:

- Attendees of 2024 IGS Workshop

Discussion Highlights:

- Status of IGS Final Troposphere estimates
- Presentation on “IAG WG4.3.11 on GNSS tropospheric products for climate” from Oliver Bock

Key Issues:

- Repro3 processing
- Multi-GNSS testing

Emerging Ideas:

- Testing newer troposphere models in the final estimate processing

Major Accomplishments since the 2022 workshop, and progress on 2022 (and earlier) workshop recommendations:

- Updates to robustness of IGS Final Estimate processing
- Updating to IGS20 reference frame
- Switch to long file name format for IGS Final estimates
- Inclusion of Rinex 4.0 observation files (now ingest 2.0-4.0)

- Restoration of archive on USNO's maia website (CDDIS is still official location for file downloads)

Any changes or updates to the group's charter, goals, or objectives? If yes, please describe:

n/a

Recommendations (please include a projected timeline, if possible):

- Comparisons for Repro3 estimates

Which of the IGS 2021+ Strategic Plan Goals and Objectives is your group addressing? (update status for all that apply)

GOALS	OBJECTIVES	STATUS
Goal 1 Multi-GNSS Technical Excellence	Identify impediments to multi-GNSS in each working group and infrastructural component, and facilitate solutions to these blockages	Select status
	Coordinating (and tracking progress) the various multiGNSS contributions (achievements) across all Working Groups and Infrastructural components	Select status
	Identify and incubate aspects of IGS component work that are in need of special attention to make a strong step toward multiGNSS	Select status
	Advocate the benefit and critical need of Multi-GNSS through case studies, leadership, and demonstration	Select status
Goal 2 Outreach and Engagement	Facilitating collaborations with stakeholder organizations and groups to diversify and increase participation of IGS users and contributors	Select status
	Coordinating outreach to relevant agencies & institutions, to attract and promote IGS scientific and user applications	Select status
	Incubating the next generation of IGS community	Select status

GOALS	OBJECTIVES	STATUS
	members through Inclusion campaigns targeted at organizations and early career scientists	
	Advocating for standardization and interoperability essential to organizational sustainability and user community engagement	Select status
Goal 3 Sustainability and Resilience	Facilitating integration and evolution as both a collaborative research program and operational service	Select status
	Coordinating technological and geographical infrastructural innovation and diversity	Select status
	Incubating organizational sustainability and resilience through personnel redundancy and modularity	Select status
	Advocating for open access geodetic and multi-GNSS data, products, and metadata via alignments with major United Nations frameworks and national/regional agendas	Select status

At this point in its development, what does the group think its major purpose is, in the IGS and in the greater geodesy community?

From the Tropo Charter:

- Assess/improve the accuracy/precision of IGS GNSS-based troposphere estimates
- Improve the usability of IGS troposphere estimates
- Confer with outside agencies interested in the use of IGS products
- Assess which new estimates should be added as “official” IGS products, and which, if any, official troposphere product sets should be discontinued
- Provide and maintain expertise in troposphere-estimate techniques, issues and applications



What impediments do you think are preventing the group from successfully realizing its recommendations?

Lack of volunteers to perform the work. There are great ideas but few people to make the ideas a reality

What is one thing that your group members wish the public knew about the IGS?

(We did not discuss this at the meeting.)