



2018 IGS Workshop Recommendations

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Analysis and Reference Frame

Michael Moore, Paul Rebischung, Thomas Herring

Session Highlights:

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

- Include the Wuhan rapid products as a fully weighted solution

- completed
- Include the GFZ TIGA solution with the missing IGS stations into the Reference Frame IGS Combination
 - still in progress, there were quality issues with initial GFZ TIGA solutions, then personnel has moved on
- Propose the extension of SINEX to allow for a 9 character Station/Marker name
 - proposed at UAW, awaiting response from IERS SINEX format Working Group
- Investigate the extension of statistical reporting for the final products, and the underlying model to compute the 7 day arcs
 - in progress: ECOM2 , 1 stochastic pulse, need to recompute statistics to make them consistent
- Tabulation of antenna transmit power values in satellite metadata SINEX file for testing purposes
 - proposed
- Set up a location for testing the implementation of models between different ACs and encourage model developers to submit test data sets
 - in progress. Need some nominated data sets, and a centralized location. Possibly the IGS-ACC server.

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

- Establish the repro3 models and standards as soon as possible
 - Formalize list of ACs participating to repro3 and constellations they intend to contribute (MM)
 - Provide a repro3 website with guidelines on models and test data sets (MM)
 - Liaise with the HF EOP working group (TH)
 - Liaise with the ILRS to determine the low-degree time variable gravity model to use for repro3 (and prediction into the future) (TH)
 - ionosphere 3rd ,etc (TH,MM,PR)
 - Identify a priori orbit force models and provide test datasets to facilitate implementation by ACs (Orbit Modelling WG, TH)
 - Encourage repro3 ACs to provide tropo SINEX files, 30s clocks, bias SINEX files and satellite quaternions
- Work closely with the AWG on ANTEX file to be used for repro3 (PR, MM, TH, AWG, ACs)
 - Assess the impact of different possibilities proposed to handle L5/E5 ground antenna patterns

- Determine the best way to use Galileo satellite antenna calibrations without introducing
 - scale inconsistency between GPS/GLONASS and Galileo
- Assess the possibility of defining a “GNSS scale” based on Galileo satellite antenna calibrations
- If needed, provide an update of the IGS14 Reference Frame consistent with repro3 ANTEX file (PR)
- Aim to have the repro3 ANTEX file still usable once ITRF2020 is adopted by the IGS
- Encourage the AWG to update old satellite antenna PCVs
- Work towards multi-GNSS IGS combined products
 - Assess the impact of multi-GNSS solutions on RF products (PR, ACs)
 - Assess whether specific start dates for different constellations are needed in repro3
 - Form a pseudo working group on ACC2.0 (GFZ, WHU, GA, anyone welcome)
- Products and formats
 - Formalize an in-house data format for satellite quaternions
 - Use long names for repro3/operational products (MM, in consultation with the IC/DC)
 - Determine a clear recommendation for users in case 24h day boundary epochs are added into clock files (Stefan)

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

n/a

(If applicable) What impediments may prevent this WG from transitioning to multi-GNSS?

See above.

Antenna

Arturo Villiger

Session Highlights:

The main focus of the plenary session was the antenna calibration of receiver antennas and estimation of satellite antenna PCOs. Several institutions have shown their status on the capacity to calibrate receiver antennas. First results for Galileo and Beidou pattern have been shown. Additionally also the estimation of Beidou PCOs has been presented and the impact of the disclosed Galileo pre-launched chamber calibrated satellite antenna presented.

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

- Proposal for an “experimental” ANTEX file containing non-standard IGS patterns (e.g. GPS IIR chamber calibrated PV).
- ACs are encouraged to validate / verify / test the experimental values:
 - Is still open and has been addressed during the splinter meeting. The task is assigned.
- Include disclosed PCO/PCV patterns of the IOV satellites into the IGS ANTEX file (and same for FOC after testing their consistency)
 - Has been achieved
- Considering information on group phase variation for an intermediate update of the current ANTEX V1.4 (to V1.5) (by the end of September 2017)
 - Still open, will be done soon
- Considering a major update of the ANTEX format in conjunction with the MGEX satellite meta data developments (ANTEX V2.0):
 - Decision to active work on the new format was made.

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

- Encourage the calibration centers to start a dedicated validation campaign “ring-calibration”. To be presented at the next IGS Workshop 2020.
- Recognizes the lack of missing E5 antenna calibrations. The AWG encourages the calibration centers to extend their software for multi-frequency capacity.
- Working towards a next IGS ANTEX including L5/E5 pattern.
- Provide the IGS ANTEX file for the next reprocessing by June 2019. This includes exploring the possibility to include E5 calibrations and the impact of Galileo pre-launch satellite chamber calibrations.

- Creation of an updated ANTEX format 2.0 (separating satellite metadata and antenna calibrations).

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

The WG is already in the transition to multi-GNSS and one of its main focus are issues related to multi-GNSS

What impediments may prevent this WG from transitioning to multi-GNSS?

n/a

Bias & Calibration

Paris 2017 Recommendations

- The Bias-SINEX Format Version 1.00 shall be considered for final approval by the IGS.
- The IGS analysis and user community are encouraged in making use of this new bias format.
- A potential redefinition of the clock bias convention, in particular from the “rigid” GPS C1W/C2W to a flexible GNSS clock bias convention, has to be addressed by the IGS community.
- The Bias-SINEX Format Version 1.00 shall be considered for final approval by the IGS.
 - Closed
- The IGS analysis and user community are encouraged in making use of this new bias format.
 - Open/requested
- A potential redefinition of the clock bias convention, in particular from the “rigid” GPS C1W/C2W to a flexible GNSS clock bias convention, has to be addressed by the IGS community.
 - Open/requested

Wuhan 2018 Recommendations

- Integer-clock producing IGS ACs should report their phase (and code) bias information in Bias-SINEX to complement their Clock-RINEX results. A dedicated paragraph shall be

added to the Bias-SINEX format description to provide a clear guidance for the PPP-AR application (by the end of 2018).

- The IGS should open up the possibility to include the second midnight epoch (00:00 and 24:00) in orbit and clock product submissions.
- All IGS Ionosphere ACs are encouraged to provide their DCB information in accompanying Bias-SINEX files.

Infrastructure

Ignacio (Nacho) Romero

Progress on Paris Workshop Recommendations:

- 2017-1. To implement a Station product participation table for the IGS station webpage to show each station inclusion in the different IGS products - ONGOING
- 2017-2. To create a way forward to provide at least weekly positions for ALL IGS network station – in progress with RF WG/TIGA
- 2017-3. To investigate and create a plan of what to do with parallel station installation data when upgrading antennas - TBD
- 2017-4. To support the Antenna WG in the new test activity to check available individual antenna calibrations in the existing IGS stations – in progress
- 2017-5. To request NSWG pictures from station antennas especially for those that do provide individual antenna calibrations - REQUESTED
- 2017-6. To request antenna's ground plane distance to the ground (local height) (< 10cm accuracy) - Needs to be reworded and requested (TBD)

Recommendations:

(We will continue tracking and implementation of the 2017 Recommendations)

All actions are aimed to be implemented by the next IGS Workshop:

- 2018-1. To implement IGS Global/Regional DC data/performance checks at the IC
- 2018-2. To implement across IGS DCs that For each high-rate site 96 sub-hourly files ⇒ 1 daily high-rate tar file
- 2018-3. To prepare the necessary ToR and Charter changes to end the DC WG and to create the DC Coordinator position
- 2018-4. To coordinate DC, IC and NC so as to move away from Z compression for all IGS files (data and products) and into using gzip (.gz)



- 2018-5. To integrate at the DCs data prior to 2016 in MGEX campaign directories into main GNSS directory structures
- 2018-6. To prepare and integrate GLONASS data and products into the regular GNSS directory structure
- 2018-7. To prepare and integrate MGEX data and products into the regular GNSS directory Structure

Does this WG actively plan to transition its work to multi-GNSS?

YES

If yes, when? Done!

What impediments may prevent this WG from transitioning to multi-GNSS?

n/a

International GNSS Monitoring and Assessment

Urs Hugentobler

Session Highlights:

- 2 plenary presentations, 5 posters

Progress on Paris Workshop Recommendations:

- Three test campaigns performed, however low progress due to missing efficient leadership
- Proposed steps, to be iterated in WG:
 - specification of algorithms based on experience available in WG
 - report to GB at December meeting
 - results from at least three ACs by April 2019
 - goal: simple procedure eventually running e.g. in combination

- Urs Huguenobler will step down as chair of the WG, discussion within WG on successor, proposal for December GB meeting.

Recommendations:

- n/a
- start moving

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

Work is inherently multi-GNSS.

Ionosphere

Andrzej Krankowski

Session Highlights:

This plenary session, poster session and splinter meeting have been an excellent forum for discussing possible improvements of IGS ionospheric products by incorporating new VTEC GIMs from one new IGS Ionosphere Associated Analysis Centre - DGFI-TUM in Munich.

The newly introduced IGS TEC fluctuation product – ROTI maps, global and regional distributions of ROTI presented by CAS, DLR, Shanghai's Observatory – were also discussed.

In addition, Empirical model such as IRI model and the International LOFAR Telescope datasets have been also evaluated.

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

“The IONEX format shall be updated in order to accommodate contributions using multiple constellations and adequately describe the associated resulting differential code biases”

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

- 1) To accept DGFI-TUM as new Ionospheric Analysis Center, contributing to the IGS combined VTEC GIMs.
- 2) To aim to additional real-time ionospheric analysis centers to join to the going-on experimental real-time IGS Global Ionospheric Maps combination.
- 3) To aim to additional ionospheric analysis centers to join to the going-on experimental IGS ionospheric ROTI fluctuations maps combination.
- 4) Cooperation with IRI COSPAR group for potential improvement of both IRI and IGS TEC.
- 5) Cooperation with International LOFAR Telescope (ILT) for potential synergies.

Does this WG actively plan to transition its work to multi-GNSS? If yes, when? (If applicable) What impediments may prevent this WG from transitioning to multi-GNSS?

Yes, the ionospheric analysis centers are actively incorporating multi-GNSS in the elaboration of the GIMs and DCBs; and we don't foresee any impediment in this regard.

Multi-GNSS

Oliver Montenbruck

Session Highlights:

- Substantial evolution in GNSS constellations (QZSS completed, BDS-3 halfway, Galileo nearly complete)
- Lacking support of BDS-3 tracking in IGS network
- Persistent lack of GNSS receiver antenna calibrations for “new” signals
- Continuously increasing number and quality of multi-GNSS products
- No combination product, yet, but prototype combination and new combination s/w under study at GFZ
- Improved quality of combined multi-GNSS broadcast ephemeris products
- First releases of SINEX satellite metadata file

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

Recommendation	Status
Adopt and implement new SINEX satellite metadata format	First files distributed by DLR; use by ACs pending
Explore attitude exchange format and conduct test campaign with selected ACs	Dormant
Update ANTEX model with full set of (satellite- and frequency-specific) PCOs and PVs of Galileo IOV as published by the EU	Done
Establish a quality controlled broadcast ephemeris product	Improved QC for BRDC; New DLR BRDM and GOP BRDM upcoming
Promote robot calibration of receiver antennas for new constellations and signals	Promoted, but no response
Promote revision of ANTEX format for improved transmit antenna handling and support of group delays	Work in progress
No splinter meetings in parallel to free beer	No beer at all ☹

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

- Move to long product file names for MGEX products (by 1 Jan 2019) and store the products in standard IGS directory tree
- Generate and host multi-GNSS ultra-rapid products
- Implement initial prototype of orbit & clock combination process
- IGS GB to take concrete action for multi-GNSS receiver antenna calibrations

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

n/a

What impediments may prevent this WG from transitioning to multi-GNSS?

n/a

Real-Time

Axel Rülke

Session Highlights:

- Software developments to move the IGS real-time service towards multi-GNSS
- Real-time ionosphere as a future operational product of the IGS Real-Time-Service (IGS RTS) for space weather monitoring
- Suggestions for improvements of the accuracy and reliability of the IGS RTS products, such as machine learning algorithms

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

- I. Implementation of long RINEX3 file name based mount point naming across all IGS casters
Resolved for the top level casters, still need to be implemented for regional casters
Removal of old mount points in the near future. (cf. Wuhan recommendation I)
- II. Raise the level of IT security at IGS Real Time Casters
ongoing
- III. Implement quality control of source tables
solved
- IV. Encourage IGS members to implement proposed SSR corrections messages for interoperability testing

No progress within the respective RTCM committee (cf. Wuhan recommendation IV)

- V. Encourage real time station operators to switch to multi-GNSS tracking

Ongoing, while significant improvements have been reached throughout the entire IGS real-time network

- VI. Start disseminating a real time ionospheric combination product

Ongoing, while a significant step forward has been reached, presented in a poster by David Roma-Dollase et al.

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

- I. Complete the joint point renaming on all observation casters of the IGS. Develop a more intuitive naming of product mount points

IGS RT DC: Carey Noll, Wolfgang Söhne, Ryan Ruddick, David Maggert

- II. Improve the validation of broadcast ephemerides records in merged streams

André Hauschild, Andrea Stürze

- III. Make the IGS RTS ready for the transition to a real multiGNSS service. The RT ACs are encouraged to move towards multi-GNSS processing. Capabilities for comparison and validation of multi-GNSS RT solutions need to be built up. As a prerequisite, the RT WG requests the availability of multi-GNSS orbit predictions.

RT ACs: André Hauschild, Denis Laurichesse, Guillermo Tobias, Andrea Stürze, Simon Banville, Wenwu Ding, Jing Guo, GFZ Potsdam; RT-ACC: Loukis Agrotis

- IV. The options available for broadcasting multi-GNSS RT SSR correction data using an open format have to be evaluated and a suitable format has to be selected for the IGS RTS.

Andrea Stürze, André Hauschild, Denis Laurichesse, Ken MacLeod

- V. New IT developments broadcasting real time streams in a better scalable way will be actively supported

Wolfgang Söhne, Ryan Ruddick

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

The IGS-RTS clearly states its willingness to move forward towards multi-GNSS. A number of prerequisites need to be fulfilled, such as the availability of predicted orbits for all constellations, the availability of processing, combination and validation capabilities as well as the selection of a suitable transfer format. It is expected, that at least at an experimental basis significant progress can be reached until the next IGS Workshop in summer 2020.

(If applicable) What impediments may prevent this WG from transitioning to multi-GNSS?

n/a

Satellite Vehicle Orbit Dynamics

Rolf Dach, Tim Springer

Session Highlights:

- With 6 oral and 13 posters one of the most successful sessions; all contributions have been of a high quality.
- Many papers on different approaches for using apriori models for SRP modelling that did show a clear benefit for this approach.
- For the BeiDou satellites the disclosure of the satellite properties was announced.
- It was also an option presented how proprietary detailed satellite design models can be represented in a way that a satellite force model can be published.

Progress on Paris Workshop Recommendations:

Recommendations from the IGS Paris Workshop:

- Draconitic effects in network solutions are significant and the problem needs to be solved. These effects appear similar in all AC solutions. We need to put thought into the origins of this problem.
- ACs should start considering and discussing their strategies for Repro3 leading into ITRF2020

As the presentations have shown a lot of research work has been done in this field by several groups. So far there is no “golden break through” with a solution that completely takes all

draconitic signals out in repro3. For a better interpretation of the repro3 results it was decided at the splinter meeting to compile a detailed documentation of the orbit modelling by each AC.

Recommendations:

1. Regarding the strong influence of orbit modeling on IGS products the working group for “Space Vehicle Orbit Dynamics” needs to become active again. An updated list of members has been established as a first step.
2. The current orbit modelling in the individual AC solutions has to be well documented before the repro3 activity starts (all ACs are asked even if they do not plan to participate in the repro3 activity).
3. The working group takes the responsibility to define and introduce a format for documenting the attitude used for the GNSS satellites before repro3.
4. Promising orbit models shall be exchanged and tested among the members of the working group/ACs. The models shall be provided in a form that groups with less experience in orbit modelling can implement them.

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

It is if it becomes active again.

What impediments may prevent this WG from transitioning to multi-GNSS?

... continue sleeping

Tide Gauge

TIGA Objectives

- Maintain a global virtual GNSS @ TG network
 - Select a set of tide gauges equipped with GNSS, with a long and reliable history, useful for sea level studies.
 - IGS network operation standards should be applied.
 - Promote the establishment of local ties (leveling) between GNSS and TGBMs.
 - Promote the establishment of more continuous operating GNSS stations, in particular in the southern hemisphere.

- Provide meta information, e.g. on leveling between benchmarks or data access
- Compute precise coordinates and velocities of GNSS stations at or near tide gauges with a significant delay to allow as many as possible stations to participate (aka repro).
- Provide training to tide gauge operators through workshops, encourage station operators to provide necessary metadata. Through GLOSS advice station operators about the operation of GNSS @ TG stations.

TIGA-WG Recommendations

- TIGA-ACs should be included in preparations of repro3
- Ask IGS-AC's to include as many as possible GNSS@TG stations for repro3
- Ask the IGS-AC+ACC+RF to study the impact of multi-GNSS combinations on long-term homogeneity of the vertical of GPS-only time series (req. sub-mm/a)
- Encourage IGS community
 - to explore possibilities to establish new GNSS stations at or near tide gauges
 - to provide resources for establishing ties between GNSS-ARP and TG-TGZ/TGBM

Troposphere

Sharyl Byram, Rosa Pacione

Session Highlights:

Status of the IGS FTE, Updated Website: twg.igs.org, SINEX_TRO v2.0 format

Progress on Paris Workshop Recommendations:

(indicate which recommendations have been resolved, which are still in progress, and what impediments there are to completion)

1. Finish the tropo comparison site -> done
2. Repro2 zpd values -> currently testing solutions and determining best option
3. Finalize Tropo Sinex format -> done

Recommendations:

(Please also indicate who in your group is the point of contact/responsible person for each recommendation, and their contact information)

1. To disseminate troposphere delay values, the IGS Tropo WG requests to adopt the SINEX_TRO v2.0 format developed in the framework of the COST Action ES1206 (GNSS4SWEC)

Contact persons: R. Pacione, J. Dousa

Format Description available at http://twg.igs.org/documents/sinex_tro_v2.00.pdf

Does this WG actively plan to transition its work to multi-GNSS? If yes, when?

(If applicable) What impediments may prevent this WG from transitioning to multi-GNSS?

1. The IGS Tropo coordinator is testing Rinex3 data.
2. Several WG members are testing Multi-GNSS solution and troposphere combination.
3. However to move from testing to operational Multi-GNSS IGS products are needed and Galileo and BeiDou PCV at ground stations should be available.