Meeting of the CCTF GNSS Working group
Zoom, February 3, 2021 12h00 UTC

The meeting was held as a videoconference, due to the COVID19 crisis.
These minutes and all material presented during the meeting are available at https://www.bipm.org/en/committees/cc/cctf/wg/cctf-wggnss/2021-02-03.

Pascale Defraigne, chair of the WG, opened the meeting and presented the meeting's agenda.
She reminded that the CCTF 2021 will take place within 6 weeks so that a large part of the meeting will be devoted to related topics, notably a discussion on proposed Recommendations.

1. GNSS Calibrations (see slides)

G. Petit (GP) presented the status of the Group 1 calibrations, indicating that the 2020 trip was started in June 2020 and the APMP leg was completed in January 2021 despite some logistic problems due to the COVID pandemic. He noted a very good consistency between the 2020 and 2018 results based on 9 common receivers. The EURAMET G1 leg is about to start.
Representatives of the G1 laboratories presented a summary of their activities.

- A. Karaush for SU indicated that a visit to BY is planned for 2021-2022.
- A. Bauch (AB) for PTB reported a sustained program of G2 trips, which is ongoing despite delays due to the COVID crisis.
- H. Esteban (HE) for ROA reported one recent on-site G2 calibration.

HE mentioned that his ongoing measurement is for a receiver Septentrio PolaRx5, which is operated in 'Auto-compensation ON' where the 1PPS-in represents the internal reference. GP noted that measurements at the BIPM indicate that INTDLY values from calibration may differ by ~0.5 ns depending on the Auto-compensation mode chosen, and urged to explicitly report the chosen mode and not to change mode when operating the receiver. P. Waller (PW) confirmed that measurements during absolute calibration indicate discrepancies that can reach this level. P. Uhrich (PU) and D. Rovera argue that 'Auto-compensation OFF' should be privileged; however such a requirement does not seem justified.
GP noted that many labs are still uncalibrated, some of them inquiring with the BIPM. He asked the G1 representatives how they, or their RMO, deal with such new requests which may be from labs outside any RMO. M. Wouters indicated that he is coordinating this activity in the APMP and had no problems in dealing with requests so far. AB also reported that he considered several requests from outside EURAMET, even though some are now postponed. J. Levine indicated that NIST offers calibration service at a cost, GP noted that this does not seem directly linked to the activity as G1 laboratory.

P. Defraigne (PD) presented a study on the consistency between successive G2 calibration trips, involving 23 receivers in 12 pairs of GPS P1-P2 calibration trips repeating after a delay between 2 and 4 years. The consistency on the inferred P3 delays is well in line with the conventional uncertainty of 2.5 ns for P3 links in Circular T, with only 3 values out of 23 exceeding 2.5 ns. Furthermore, receivers pertaining to the same trip are generally much more consistent. All results are in line with what is expected from the distributed approach of G1/G2 calibrations.

2. Introduction of Galileo links in the UTC computation (see slides)

GP presented work at the BIPM for introducing Galileo links in UTC computation. He reminded that calibration of Galileo codes is an integral part of the G1/G2 system as nearly all G1 labs have now been provided with Galileo results. Several recently reported G2 trips have been GPS+Galileo. Since December 2020, Galileo dual-frequency code links are computed for UTC as additional links and results are posted with all links at https://webtai.bipm.org/ftp/pub/tai/timelinks/lkc/. They generally display better short term stability than GPS, but not necessarily at 6-12 hour averaging, and PU confirmed similar behavior in local comparisons at OP.

3. Update on Circular T, section 4 (see slides)

PD presented "Revised section 4 of circular T: Follow-up" reminding the choices made at last meeting for the content of section 4 (naming convention Broadcast_UTC_{GNSS}, values estimated at 1 point per day with data from selected G1 labs using dual frequency measurements). She presented the remaining issues:

1. Proposed choice of G1 stations: NIST, OP, NIM, NICT, for which GLONASS and BeiDou (2 and 3) calibration values, derived from absolute calibration measurements, need to be obtained. This requires action from the BIPM for GLONASS and BDS2 and from the providers of absolute calibration for BDS3. PW for ESTEC and J. Delporte for CNES confirmed that they will work on this issue.

2. Estimated values for the main sources of uncertainties: Different values of GNSSTIME – Broadcast_UTC_{GNSS} obtained from different satellites; Uncertainties from calibrations and from differences between single-frequency and dual-frequency solutions; Various effects (multipath, broadcast orbits and clocks, smoothing. She proposed values for each source and each GNSS.

A. Kuna proposed their help in assessing the values of GNSSTIME – Broadcast_UTC_{GNSS} from different satellites from a GTR receiver.

Discussion continued about whether adopting one single uncertainty valid for all cases or one uncertainty per GNSS for dual-frequency with additional provisions for single frequency users. The latter solution seems preferred.

4. News from the Task Force on traceability (see slides)

AB presented a report from the Task Group on "*traceability to UTC from GNSS measurements*". The group works in view of the coming CCTF. He discussed the responses to some questions of the CCTF questionnaire, notably those related to the system of G1/G2 calibration, that this WG is well aware of, and those related to the core question of time traceability to UTC through GNSS. Answers cover a whole range of opinions but the majority considers that additional information is necessary to provide the "unbroken chain of calibrations" required for traceability in metrology.

A meeting of the Task Force is planned before the CCTF meeting.

5. Discussion on Recommendations (see slides)

Two Recommendations are initially proposed.

1. On absolute calibration of GNSS stations

During the discussion it was recognized that this Recommendation, concerning the need to perform absolute calibration of GNSS receivers in time laboratories, was useful. In order to also address the need of absolute calibration for equipment used by GNSS providers and to ensure that accurate group delay values are determined between different GNSS signals, it was decided to include these issues in a second Recommendation[1] to be addressed to the GNSS providers.

2. On the use of existing time scales to generate GNSS inter-system information

The main goal of this Recommendation is to promote that no new time scale be generated by GNSS providers to provide a reference for inter-system biases. This position follows from past discussions at the ICG and from Decision CIPM/108-41 related to this issue. In the discussion, the wording was refined. It was also questioned whether the Rec should address GGTOs since some GNSS provide them and will likely continue to do so.

The meeting was closed at 15h30 UTC.

Published 16/02/2021 (P. Defraigne, G. Petit)

[1] The draft new Recommendation is included with this report, along with the other two Recommendations.

List of participants

Pascale Defraigne	Chair, ORB
Gérard Petit	Secretary, BIPM

WG Members

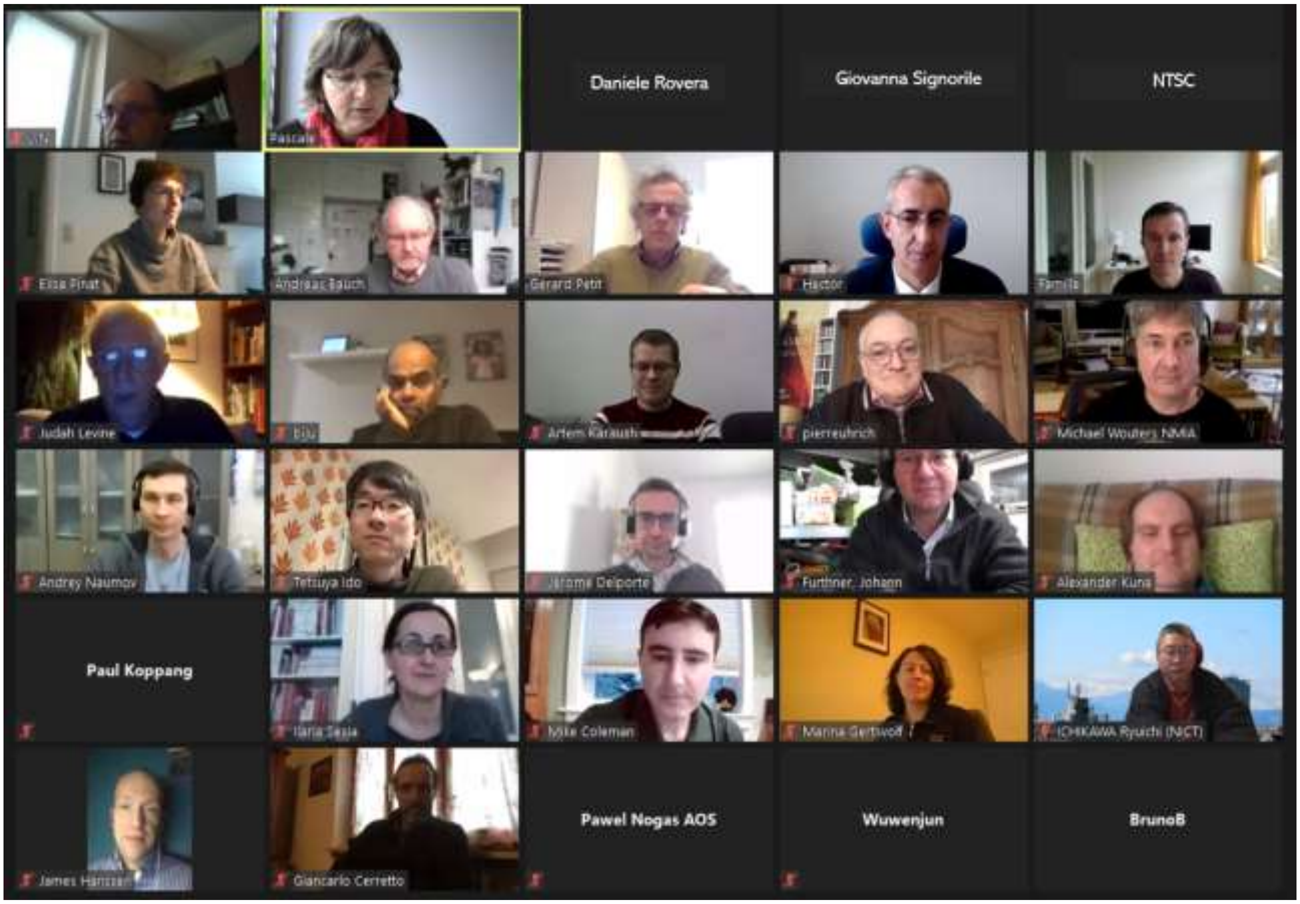
Group 1 representatives:

Andreas Bauch	PTB
Artem Karaush	VNIIFTRI
Pierre Uhrich	OP
Hector Esteban	ROA
Jay Hanssen	USNO
Ryuichi Ichikawa	NICT
Bijunath Patla	NIST

Giancarlo Cerretto	INRIM
Michael Coleman	NRL (IGS representative)
Jerome Delporte	CNES
Johann Furthner	DLR
Jerzy Nawrocki	AOS
Michael Wouters	NMIA
Daniele Rovera	OP
Paul Koppang	USNO
Andrey Naumov	VNIIFTRI
Wenjun Wu	NTSC
Marina Gertsvolf	NRC
Judah Levine	NIST
Pierre Waller	ESTEC
Alexander Kuna	TP

Invited

Pawel Nogas	AOS
Bruno Bertrand	ORB
Elisa Pinat	ORB
Giovanna Signorile	INRIM
Ilaria Sesia	INRIM
Wei Guang	NTSC
Tetsuya Ido	NICT


Pascale
Daniele Rovera
Giovanna Signorile
NTSC
Andreas Bauch
Gerard Petit
Hector
Judah Levine
Artem Karaush
pierreuhrich
Michael Wouters NMIA
Andrey Naumov
Tetsuya Ido
Jerome Delporte
Furthner, Johann
Alexander Kuna
Paul Koppang
Ilaria Sesia
Mike Coleman
Marina Gertsvolf
ICHIKAWA Ryuichi (NICT)
James Hanssen
Giancarlo Cerretto
Pawel Nogas AOS
Wuwenjun
BrunoB

RECOMMENDATION - DRAFT

On absolute calibration of GNSS equipment for time transfer

The Consultative Committee for Time and Frequency (CCTF)

considering that

- time and frequency transfer data reporting the reception of Global Navigation Satellite Systems (GNSS) signals at the contributing time laboratories “k” play an important role in the realization of UTC,
- the ability to measure accurately GNSS time scales against UTC(k) requires hardware delays of the time transfer equipment involved to be determined,
- GNSS constellations continuously improve their signals and increase the signal diversity,

noting that

- Recommendation CCTF 4 (2012) asked laboratories contributing to UTC to upgrade their GNSS equipment towards multi-frequency multi-constellation receiving systems providing code- and carrier-phase measurements and to supply data from at least three receivers,
- Recommendation CCTF 4 (2001) asked that absolute and differential calibration methods be continued to be developed and put into operation for all time transfer techniques used in TAI computation, with the aim of achieving 1 ns standard uncertainty,

recommends that

- Competent laboratories continue their efforts in determining signal delays in GNSS receiver installations, including, antenna, antenna cable and receiver electronics, providing so-called “absolute calibrations” for existing and emerging GNSS signals,
- BIPM maintains a list and a follow-up of the absolutely calibrated GNSS stations and their comparisons with the receiver systems operated in G1 laboratories stations,
- G1 laboratories provide relative calibration of receivers in G2 laboratories for as many GNSS as feasible.

RECOMMENDATION DRAFT

On the use of existing time scales to generate GNSS inter-system information

The Consultative Committee for Time and Frequency (CCTF)

realizing that

- Multi-GNSS is more and more used in the scientific and industrial world for time synchronization and syntonization
- Multi-GNSS users need to consider the variable time offset between the individual system times
- In situations of good visibility, the inter-system biases can be determined from the GNSS measurements, while in other situations a broadcast value may be needed

considering that

- The inter-system bias can be obtained by the user from the broadcast information of the offset of each GNSStime versus a unique reference
- A prediction of (UTC−GNSS Time) is made available in the navigation message of each GNSS,
- Multi-GNSS receivers can determine the inter-system biases from the predictions of (UTC-GNSStime) using the predicted UTC as common reference
- These predictions of (UTC−GNSS Time) are all validated from a link to UTC(k) time scales regularly compared to UTC in the BIPM Circular T
- Using UTC as common reference, the current uncertainty on the broadcast predictions of UTC has no significant impact on positioning and timing in situations where the inter-system bias cannot be determined from the measurements

noting that

- The CIPM decided (Decision CIPM/108-41) to support the International GNSS service (IGS) and the International GNSS Committee (ICG) in exploring the capacity of GNSS providers to ensure multi-GNSS interoperability, based on Coordinated Universal Time (UTC), with the final goal of avoiding the proliferation of international reference time scales.
- Users would still benefit from broadcast inter-system biases

recommends that

- GNSS providers do not make use of a new time scale as reference for broadcasting the inter-system biases, but if a reference is needed, consider using the predictions of UTC
- GNSS providers continue their efforts to improve the prediction of (UTC−GNSS Time) with the help of time laboratories.

and further recommends that

- Multi-GNSS receiver manufacturers explore the possibility to obtain the GNSS inter-system biases from the prediction of (UTC-GNSS Time)

RECOMMENDATION - DRAFT

On accurate timing information accessible via GNSS signals

The Consultative Committee for Time and Frequency (CCTF)

realizing that

- in addition to their primary function of providing position and navigation information, GNSS signals represent a valuable resource for distributing accurate time and are used world-wide in abundant applications, including safety-critical and strategic applications,

considering that

- a priori, the operational system time scales of the GNSS deviate from Coordinated Universal Time UTC by amounts ranging from hours (GLONASS) to seconds (GPS, Galileo, BeiDou) and small amounts of fractions of microseconds in all cases,
- that UTC has been recommended as time reference for civil, scientific, and industrial applications,
- the ability to accurately predict the offset between GNSS system times and UTC requires hardware delays of the receiving equipment involved to be determined with high accuracy,

noting that

- the use of GNSS-disciplined oscillators as time and/or frequency reference in calibration laboratories and also in a wider range of applications requires the maintenance of an unbroken chain of calibrations with documented uncertainty between UTC as the reference and the output of the devices,

recommends that

- GNSS providers continue their collaboration with UTC(k) laboratories to either accomplish absolute calibration of their receiving equipment or rely on calibrated equipment available in UTC(k)-laboratories, with the aim to provide accurate prediction of the respective system time offset from UTC,
- GNSS providers document the generation of the respective system time as well as of the information included in the navigation message following metrological practice in publicly accessible resources for widest use of the GNSS signals in all applications.
- GNSS providers continue their efforts in providing accurate group delays necessary for synchronization based on different signals.