Promoting the Mutual Benefits of UTC and GNSS

Pascale Defraigne, Chair of WG on GNSS Time Transfer
Andreas Bauch, Chair of the Task Force on the Traceability to UTC from GNSS measurements
Mutual Benefits of UTC and GNSS

1. Current use of GNSS for UTC
2. Calibration for GNSS hardware delays

1. Contribution to GNSS from NMIs and time laboratories
2. UTC disseminated by GNSS
3. Contribution to the ICG
4. Traceability to UTC from GNSS measurements
Benefits of GNSS to UTC
Current use of GNSS for UTC

To date: all UTC(k) labs are connected via GPS, and 87% of the links are entirely based on GPS.

GLONASS was used for some links during more than ten years.

The accurate receiver calibration for GLONASS signals is still an issue. The GLONASS common view is used as back up for some links.

Galileo: data analysis shows a better performances than GPS in terms of code noise.
- Calibration available since June 2020
- Use in UTC – in preparation

BeiDou: transition from BDS-2 to BDS-3 (different signals and frequencies)
- only a few receivers get the BeiDou 3 signals
- No calibration yet available for BDS-3

Regional systems (e.g. QZSS or NAVIC): to be studied
Calibration for GNSS hardware delays

- Needed for the links UTC(k)-UTC based on GNSS
- The calibration of the full UTC network is one of our goals
- Only based on relative calibrations with respect to a reference
- BIPM organizes G1 calibration, and G1 labs have the task to calibrate G2
- To date, 69% of the stations are calibrated for GPS with the BIPM/RMO procedure, giving uncertainties < 2.5 ns

Question to NMIs:
Are you satisfied with the current G1/G2 situation? Do you have requests or suggestions?
Benefits of UTC to GNSS
Contribution to GNSS from NMI and time laboratories

- USNO → GPS
- SU → GLONASS
- NIM, NTSC → BDS
- IT, OP, PTB, SP, ROA, NPL, CNES, ORB → Galileo

www.bipm.org
UTC disseminated by GNSS

From GNSS: \( \text{position} + (t_{\text{receiver}} - t_{\text{GNSS}}) \)

- "UTC" is the prediction of UTC provided by the GNSS
- It allows the user to synchronize a clock on "UTC"
- Each GNSS constellation broadcasts a different prediction, based on different UTC(k)s
- The BIPM currently provides in Circular T (Section 4):
  - \([\text{UTC} - \text{UTC(USNO)}_{\text{GPS}}] = C0'\)
  - \([\text{UTC} - \text{UTC(SU)}_{\text{GLONASS}}] = C1'\)
- The WG prepares the upgrade of Section 4 to include Galileo and BeiDou, with new naming convention: \([\text{UTC–Broadcast}\_\text{UTCxxx}]\) (xxx for GPS, BDS, GAL, GLO)
Contribution to the ICG (1)

ICG = International GNSS Committee
= Committee of the United Nations

WG-S / subgroup on **Interoperability**

**Timing aspects:**
- From GNSS1: position + (t\text{receiver} - t_{\text{GNSS1}})
- From GNSS2: position + (t\text{receiver} - t_{\text{GNSS2}})

_for combination_: need (t_{\text{GNSS1}} - t_{\text{GNSS2}})

Proposed at the ICG:
Each system can provide GNSS-to-GNSS Time Offsets.
But it was proposed to use a unique pivot, so that
each GNSS broadcasts only GNSS-pivot
Contribution to the ICG (2)

This **Pivot** would be - one of the GNSST
- a new time scale
- Broadcast$_{\text{UTC}}^{\text{GNSS}}$

(Each systems already provides its GNSST- Broadcast$_{\text{UTC}}^{\text{GNSS}}$)

**Decision CIPM/108-41**: The CIPM decided 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.

**Timing community provides information:**
- Performances of using Broadcast$_{\text{UTC}}^{\text{GNSS}}$ as pivot:
  Max 20 ns error on inter-system bias so-obtained°, because of differences in Broadcast$_{\text{UTC}}^{\text{GNSS}}$
- Impact of an error on the inter-system bias from broadcast information: For mass-market receiver, an error of 20 ns has no impact on positioning/timing"°

° Sesia et al. GPS Solutions / °° Defraigne et al. GPS solutions

**We propose to:** (recommendation for CCTF 2021)
- recommend to GNSS not making use of a new time scale
- recommend that GNSS providers continue their efforts to improve the prediction of UTC with the help of time laboratories.
Traceability to UTC from GNSS measurements

From GNSS: position + (t_{receiver} - t_{GNSS})

Increasing use of GNSS for synchronization & increasing demand for traceability

Need for guidelines on
- how the user can get UTC from GNSS (including equipment and calibration)
- and how traceability can be obtained when using GNSS for synchronization to UTC (UTC from Signal in Space or UTC from UTC(k))

Task force of the GNSS WG, with the help of the WG on MRA.
TASK FORCE
on
Traceability to UTC from GNSS measurements

1) Working team
2) Terms of Reference and topics to be addressed
3) Status of activities, initial results and next steps
4) Questions to CCTF delegate
Task Group on “traceability to UTC from GNSS measurements”

Working team:
In total 25 participants at Kick-Off and on the mailing list

Distribution of background (duplicate mentioning possible)

Chair:
Andreas Bauch, PTB

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<thead>
<tr>
<th>Background</th>
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<th>Comments</th>
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<tbody>
<tr>
<td>TCTF of RMOs</td>
<td>15</td>
<td>Majority from APMP and EURAMET</td>
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<td>Non NMI nor DI</td>
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<td>CCTF WG MRA</td>
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<tr>
<td>BIPM</td>
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<td>Gianna Panfilo, Secretary</td>
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<td>GNSS</td>
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<td>From institutes collaborating with BeiDou, Galileo, GLONASS and GPS</td>
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## Task Group on “traceability to UTC from GNSS measurements”

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Association per region, EU for EURAMET
Task Group on “traceability to UTC from GNSS measurements”

Terms of Reference (3rd draft)

First steps:
- Assemble the information on GNSS regarding definition and generation of the respective system time and of the prediction of “GNSST-UTC”
- Collect existing recommendations in the RMOs and NMI practices
- Collect sets of user needs from the various application sectors.

Second steps:
- Propose guidelines on how to get traceability to a realization of UTC through GNSS measurements
- Propose a suitable way for documentation of GNSS measurements, e.g., as a bulletin issued by an NMI
- Disseminate the information to the end user, via e.g. RMOs, ICG, GNSS providers, GNSS stakeholders.
Task Group on “traceability to UTC from GNSS measurements”

First iteration of ToR and observations during the initial phase of the work:

➢ The term „traceability“ is used with different connotation in the various user groups, often ignoring the definition of (metrological) traceability in the Vocabulaire International de Metrology.

➢ Reception of GNSS signals happens for getting a reference for frequency, for epoch, for time-of-day, with quite different accuracy requirements.

Which activities / users have to obey rules as specified e. g. in ISO/IEC 17025 or by laboratory accreditation organizations?

➢ We are faced with the status-quo: Ten-thousands of GPS-receivers as sources of (UTC) time are in operation in the sectors telecommunications, electricity supply and finance.
Task Group on “traceability to UTC from GNSS measurements”

Questions:

1. Are you in contact with users who report „time traceable to UTC“ by operating a GNSS-clock? Do you or would you accept this wording? and if not, what do you recommend how to call what they get?

2. Do you support getting traceability to your UTC(k) by offering services to customers or the public in general? If yes which ones, if no, do you consider to start activities in this direction?

3. Which user communities have contacted your NMI/DI to get advice / support in issues of traceability when using GNSS?

Questions to be brought also to the attention of RMO‘s TCTF Chairs and members for triggering discussion at TCTF meetings.
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