CCTF

Promoting the Mutual Benefits of UTC and GNSS

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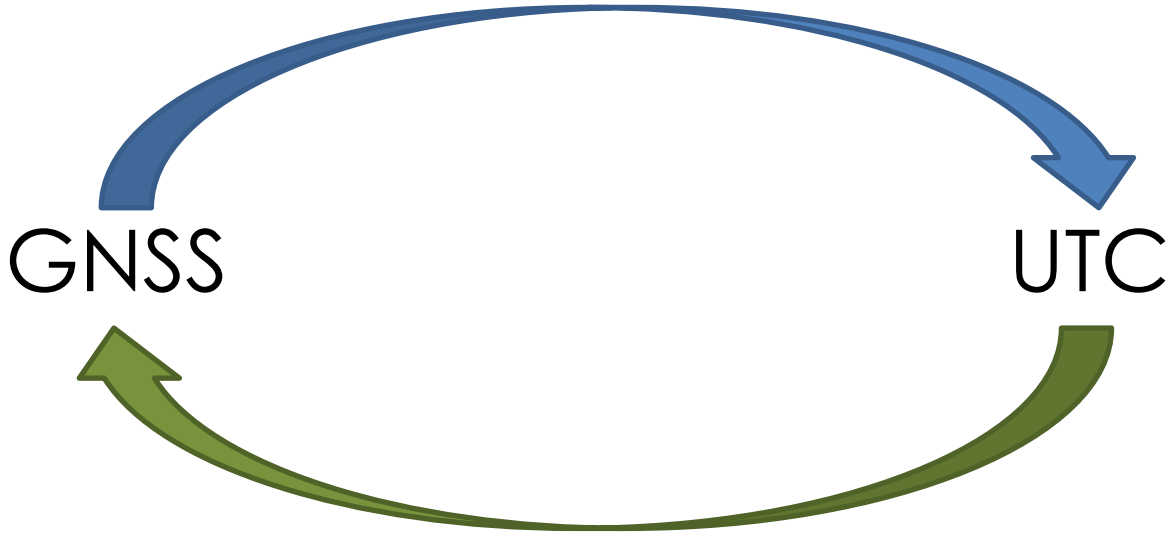
CONSULTATIVE COMMITTEE
FOR TIME AND FREQUENCY

Mutual Benefits of UTC and GNSS

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



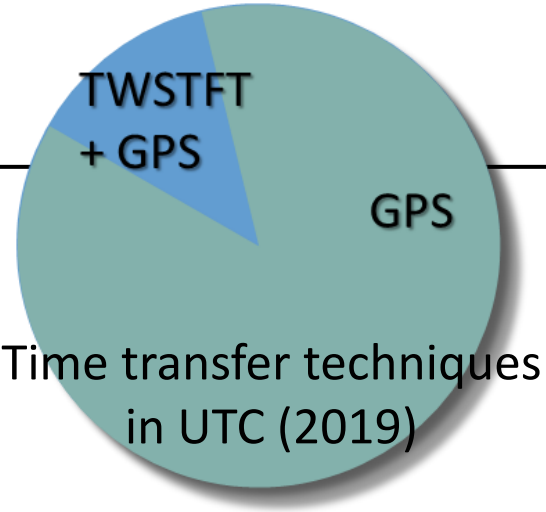
1. Contribution to GNSS from NMIs and time laboratories
2. UTC disseminated by GNSS
3. Contribution to the ICG
4. Traceability to UTC from GNSS measurements

Benefits of GNSS to UTC

GNSS

UTC

Current use of GNSS for UTC



Time transfer techniques in UTC (2019)

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

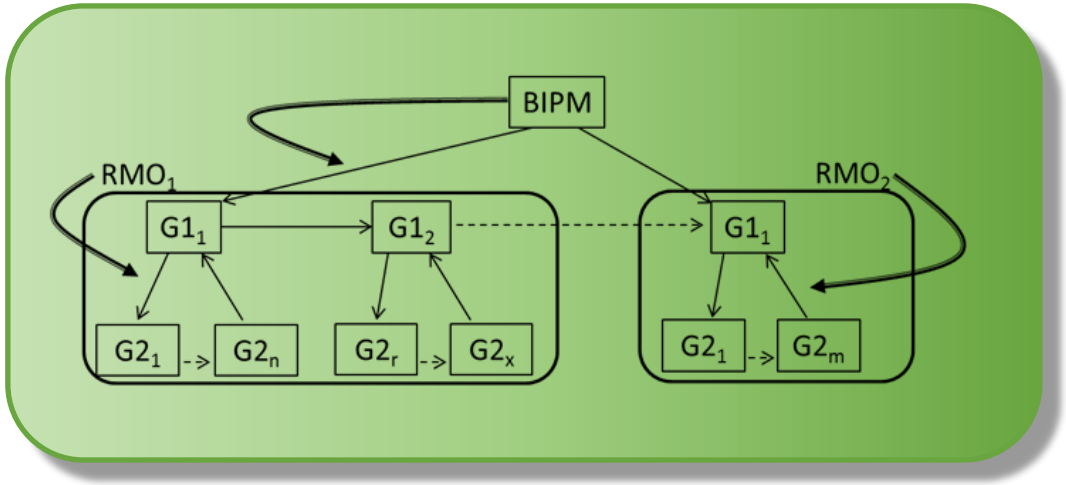
Calibration for GNSS hardware delays

- 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?

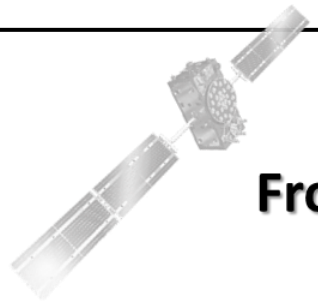
Do you have requests or suggestions ?



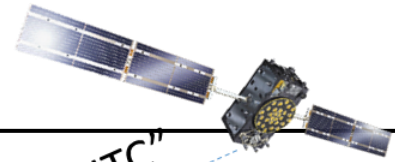
Benefits of UTC to GNSS

Contribution to GNSS from NMIs and time laboratories

UTC disseminated by GNSS



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



t_{GNSS} – "UTC"

+

($t_{receiver}$ – "UTC")

- "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) :
  [UTC–UTC(USNO)_GPS] = C0',
  [UTC–UTC(SU)_GLONASS]= C1',
- The WG prepares the upgrade of Section 4 to include Galileo and BeiDou, with new naming convention: [UTC–Broadcast_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**

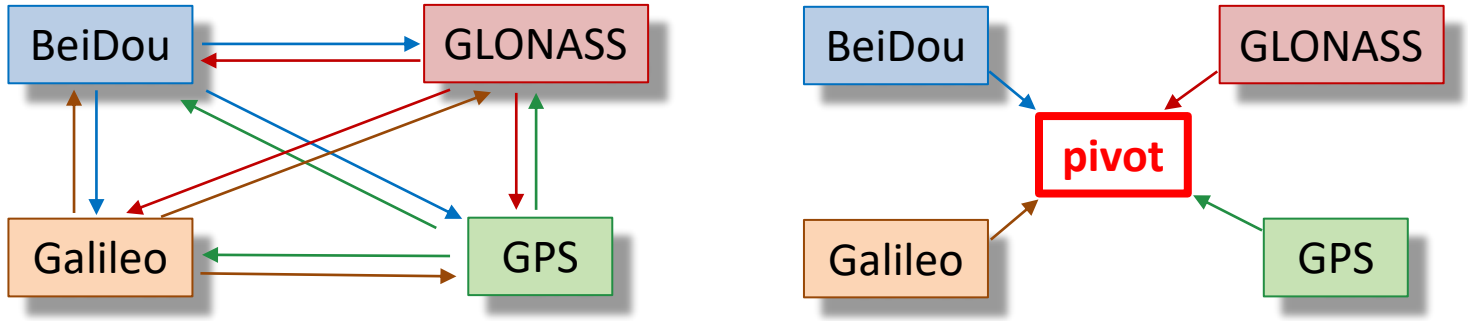
Timing aspects:

From GNSS1 : position + ($t_{receiver} - t_{GNSS1}$)

From GNSS2 : position + ($t_{receiver} - t_{GNSS2}$)

for combination : need ($t_{GNSS1} - t_{GNSS2}$) → Inter-system bias

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_UTC_{GNSS} (each systems already provides its GNSST- Broadcast_UTC_{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:

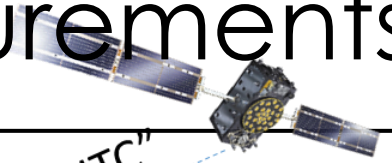
-*Performances of using Broadcast_UTC_{GNSS} as pivot*: Max 20 ns error on inter-system bias so-obtained°, because of differences in Broadcast_UTC_{GNSS}

-*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



t_{GNSS} – "UTC"

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

+

($t_{receiver}$ – "UTC")

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

CCTF

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

Background	Number	Comments
TCTF of RMOs	15	Majority from APMP and EURAMET
Non NMI nor DI	6	
CCTF WG MRA	4	
BIPM	2	Gianna Panfilo, Secretary
GNSS	6	From institutes collaborating with BeiDou, Galileo, GLONASS and GPS

Task Group on "traceability to UTC from GNSS measurements"

Name:	First name:	Association
Panfilo	Gianna	BIPM
Petit	Gerard	BIPM
Bauch	Andreas	EU / Chair Task Group
Achkar	Joseph	EU / MRA
Dierikx	Erik	EU / MRA
Gertsvolf	Marina	SIM / MRA
Lin	Huang-Tien	APMP / MRA
Coleman	Michael J.	SIM / GPS
Defraigne	Pascale	EU /Chair EG GNSS
Delporte	Jérôme	EU /Galileo
Koppang	Paul	SIM / GPS
Nawrocki	Jerzy	EU

Association
per region, EU for EURAMET

Name:	First name:	Association
Waller	Pierre	EU / Galileo
Esteban	Hector	EU
Huang	Yi-Jiun	APMP
Ichikawa	Ryuichi	APMP
Karaush	Artyom	COOMET / GLONASS
Kuna	Alexander	EU
Levine	Judah	SIM
Liang	Kun	APMP
Sesia	Ilaria	EU / Galileo
Uhrich	Pierre	EU
Whibberly	Peter	EU
Wouters	Michael	APMP
Wu	Wenjun	APMP / BeiDou

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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Pascale Defraigne, p.defraigne@oma.be

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