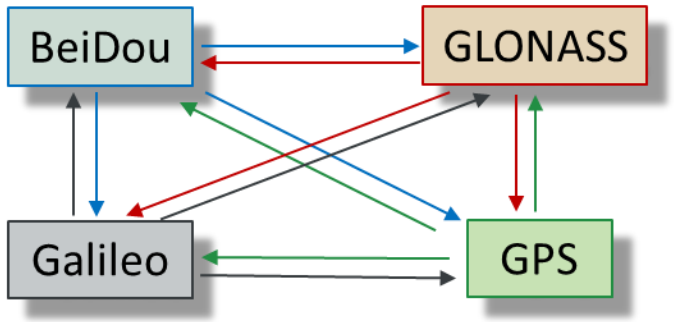
Draft Recommendation on Timing Interoperability

Context

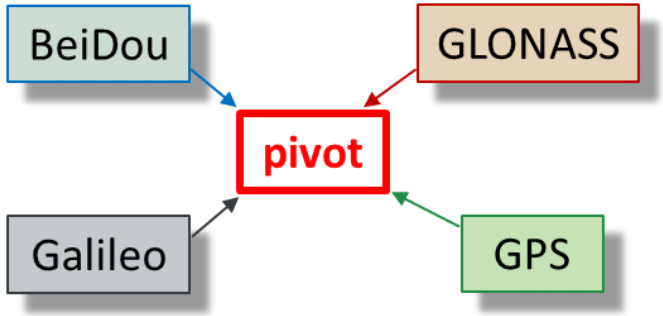
3 solutions for the inter-system biases,
also called GNSS to GNSS Time Offset (GGTO):

1. Determine GGTO from Observations

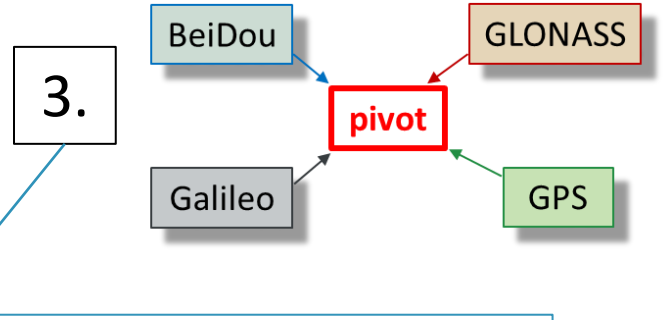
2. Broadcast : [$GNSS_1T - GNSS_2T$]



3. Broadcast : [GNSST – pivot]



Broadcast : [GNSST – pivot]



ICG 2018 : Proposition for a Pivot called MGET: a new time scale, common, system independent, generated, provided and maintained by an entity, made available for GNSS providers.

BIPM : - Such a Pivot already exists : UTC

→ some studies with mass market receivers show that the differences between the bUTC_GNSS is sufficient for these ground users. (high precision users will use option 1.)

- Creating a new time scale would continue the proliferation of GNSS time scales with an increased risk of confusion.

→ CCTF Recommendation (2021).

CCTF RECOMMENDATION 2021:

recommends that

• GNSS providers and multi-GNSS stakeholders consider the benefit of using the predictions of (UTC-GNSStime) as reference for computing the inter-system biases, which avoids the need to create an ad-hoc common reference time scale,

• GNSS providers continue their efforts to improve the prediction of (UTC-GNSStime) 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 these predictions of (UTC-GNSStime),

• The International Committee on GNSS of United Nations supports this recommendation.

The ICG recommendation is proposed now

- To avoid this proliferation of new time scales
- To avoid the risk of confusion

And

- To inform that if a pivot approach is used, then bUTC_GNSS should be considered as pivot, at least for ground users.

IV. Discussion on timing interoperability

- Recent research showed that, <u>for a ground user</u>:
  - 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} (can be improved)
  - Impact of an error on the inter-system bias from broadcast information:
    For mass-market receivers, an error of 20 ns has no impact on positioning/timing

Sesia *et al. GPS Solut* **25,** 61 (2021)
Defraigne *et al. GPS Solut* **25,** 2 (2021)

- This shows that the use of UTC as a pivot to determine the GNSS inter-system biases is a viable method (and it makes use of already-existing broadcast messages)
- The needs of space users may lead to other requirements and conclusions, but they are not known to us at this stage
- New proposed recommendation that eliminates the creation of an ad hoc time scale to be used as pivot has been presented to WG-B and WG-S

IV. Proposed recommendation [1/2]

Recommendation for Committee Decision

Prepared by: Working Group D

Issue Title: On the use of the broadcast prediction of UTC to determine the offsets between GNSS times for ground/air users

Background/Brief Description of the Issue:
Multi-GNSS is more and more used in a variety of applications. Multi-GNSS users need to know the timing offsets between the individual GNSS, also called inter-system timing biases.

In ICG 2017, a discussion was raised on the possibility to use a single pivot time scale as reference to estimate the different GNSS time offsets, so that each GNSS would need to broadcast only one parameter. In recent years, the use of the prediction of UTC already broadcast by the GNSS as this single pivot has proved to be a viable solution, without the need to create a new time scale. On this topic the Consultative Committee for Time and Frequency of the BIPM issued a Recommendation in 2021 “On the use of existing time scales to generate GNSS inter-system information” recommending to avoid the proliferation of unnecessary time scales.

Discussion/Analyses:
The inter-system time biases can be determined by three different approaches:

- determination at user level when a sufficient number of GNSS satellites are in view
- use of direct broadcast information (GNSS-to-GNSS time offset) when available
- use of the prediction of UTC (called $bUTC_{GNSS}$) that each GNSS currently broadcasts through the message (GNSStime - $bUTC_{GNSS}$) as a pivot to determine related inter-system time biases

IV. Proposed recommendation [2/2]

Even if the $bUTC_{GNSS}$ is not the same for the different GNSS (different UTC(k) are used by the GNSS as intermediate references), they are sufficiently close to one another for that purpose. Recent studies have confirmed that with the current differences between the $bUTC_{GNSS}$ broadcast by the different GNSS, the resulting error on the inter-system time bias has no significant impact on positioning and timing in situations where ground mass-market receivers cannot determine the inter-system bias directly from the measurements.

The prediction of UTC broadcast by the GNSS is expected to improve in the future, which will benefit to GNSS interoperability and to time dissemination accuracy.

The feasibility/performance of the three approaches depend on many factors such as the number of GNSS satellites in view, the noise level of the receiver and the accuracy of the broadcast messages.

Continuous effort in monitoring and validating all GNSS-to-GNSS time offset is to be pursued also promoting the collaboration among the different involved groups.

The needs of space users may lead to different conclusions that might lead to revisit this recommendation.

Recommendation of Committee Action:

1. If a common pivot method is chosen to provide the user with GNSS inter-system time biases, GNSS Providers and multi-GNSS receiver manufacturers consider the benefit of using the common pivot $bUTC_{GNSS}$ *contained in the GNSS navigation message. This approach comes in addition to the two other existing methods (estimation at user level or use of broadcast GNSS-to-GNSS time offset). For standard ground/air users, this eliminates the need to create an ad hoc time scale as common pivot.*

2. GNSS providers continue their efforts to improve the prediction of UTC broadcast in the navigation message with the help of time laboratories, with the aim to improve their time dissemination service and also the GNSS interoperability.