The BIPM support to the GNSS interoperability

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WG S-D Joint Session

Bureau International des Poids et Mesures

Recommendations at ICG-11 and ICG-12 on organizing a workshop to discuss GNSS time offsets among the systems

#21-B: On the monitoring of offsets of GNSS times

- 2017 wording of Recommends 4:

"*In order to promote GNSS compatibility and interoperability, GNSS providers and time relevant organizations, including the BIPM, actively develop methods to monitor the offsets between GNSS times, share the monitoring data and relevant research results and actively collaborate with the relevant experts in WG D and S.*"

- 2nd Joint timing workshop of WG S and WG D: 20 June 2018
  - Well attended by experts of GNSS providers and time relevant organizations;
  - Several interesting presentations, including new methods to determine the offsets between GNSS times;
  - No clear consensus emerging: Additional work is necessary to assess the accuracy goals for the GNSS time offsets, and consequently the methods to determine them;
- The WG D will discuss tomorrow; work stemming from Recommendation 21B should continue.

GNSS system times offsets / evaluation and broadcast

- Broadcast of GNSS system times offsets is « necessary » for the systems interoperability
  - E.g. GPS-Galileo offset (GGTO) is currently evaluated and broadcast by Galileo (using a GPS/Galileo calibrated chain)

- Strategy is to be defined for the procedure of evaluation of all system time offsets (by Service Providers)

- The BIPM is keen to work together with GNSS and timing experts with the common aim to find a solution ensuring interoperability

Options proposed (as discussed at Joint workshop) 1/2

Each GNSS computes and broadcast the offset of its system time with respect to **a reference adopted by convention** which can be

1. A simple average of all GNSS times as realized by a calibrated multi-sytem receiver

   See work by Sesia et al. and ESA presentations at the June 2018 workshop

   This solution requires that each GNSS Provider manages a calibrated multi-GNSS Rx, computes and predicts the « average » with identical algorithm (e.g. outliers), uploads with similar latency.

   Special care to calibrations, changes in systems, real time algorithms…

Options proposed (as discussed at Joint workshop) 2/2

Each GNSS computes and broadcast the offset of its system time with respect to **a reference adopted by convention** which can be

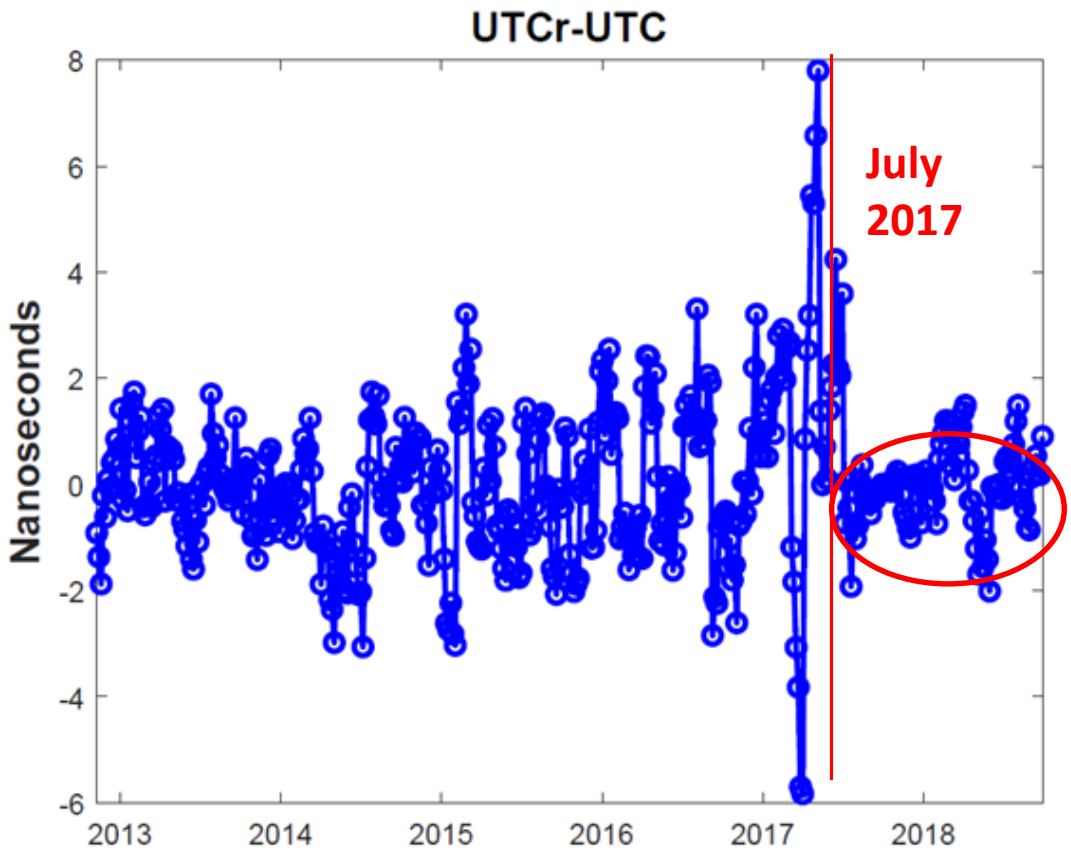
2. A proxy of UTC e.g.
   a. the presently realized « prediction of UTC/UTC(k)» already computed and broadcast by each system (see Sesia et al.)

      This is bound by the degree of equivalence of all « predictions of UTC/UTC(k) » and by the accuracy of such predictions.

   b. A prediction of UTCr as can be accessed by each GNSS through a UTC(k) participating to UTCr

      This improves over 2a by levelling the degree of equivalence of all « predictions of UTC/UTC(k) », the uncertainty is to be assessed.

Improvement in Rapid UTC (UTCr)



Since Summer 2017:
New computation procedure

UTCr-UTC now well below 1 ns RMS, 0.4 ns Tdev, +/-2 ns p-p.

UTCr can be better extrapolated.

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Rôle of UTCr in solution 2 (proxy of UTC)

- Solution 2a: « Main labs » UTC(k) realize UTC within 1.5 – 3 ns RMS. Thus assimilating UTC(k) to UTC(l) causes errors of 2-3 ns RMS (6-12 ns range).
  (This example uses data since July 2017, date of a change of algorithm in UTCr)

- Solution 2b: Using UTCr, which can be accessed by each GNSS through a UTC(k), as a conventional reference, would suppress this « assimilation error ».
  - BUT [UTCr – UTC(k)] must be extrapolated, presently over 3-9 days. This extrapolation error must be estimated and added.
  - Extrapolation would be reduced if UTCr is available more often.
  - The BIPM has a work program which is approved by member states. New proposals have to be evaluated before possible application.

BIPM opinions

- Does not encourage the creation of a new time scale or a new ensemble time as a common reference

Proliferation of time scales is already a problem, the realization of an ensemble time scale and its real-time accessibility by all GNSS providers is a quite complex solution

- Supports solutions where each GNSS computes and broadcast the offset of its system time with respect to a reference adopted by convention:
- In Solution 1 (using a calibrated multi-sytem receiver) the « average of GNSS times » should be considered as a necessary step to compute GGTO, not as a new timescale. This solution requires developments by GNSS providers.
- In solution 2 (proxy of UTC)
  - 2a is readily available, as the offset UTC-GNSStime already exists in the nav message, with uncertainty to be assessed.
  - The BIPM can help evaluate the interest of using UTCr in solution 2b

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