Bureau International des Poids et Mesures

How to get GNSS calibration for UTC(k) laboratories

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All UTC(k) Laboratories today exchange their GNSS measurements as a time transfer link for participating in UTC. For the vast majority of these laboratories, this is the unique time transfer technique in use. To ensure a quantified uncertainty limit on the UTC(k) realizations, as well as to provide an overall consistency between them, calibration of the GNSS equipment operated in every UTC(k) Laboratory is required. Since 2014 BIPM and Regional Metrology Organizations (RMO) started collaboration for calibrating the GNSS equipment in all time laboratories participating to UTC. The complete GNSS calibration scheme is described in the "Guidelines for GNSS equipment calibration", available at https://webtai.bipm.org/ftp/pub/tai/publication/gnss-calibration/guidelines/ .

The present document summarizes the different options for time laboratories to get calibration.

To improve the efficiency and reduce the customs administrative load, the BIPM provides the calibration of only a few laboratories named Group 1 laboratories (G1 hereafter) which have been selected in each RMO. These G1 laboratories are then hosting several reference stations and are responsible for the calibration of the other laboratories (named Group 2 laboratories, G2) in their RMO.

The current (as of 2021) BIPM calibration covers both GPS and Galileo.

In the following, the calibration uncertainty is a conventional value defined by the CCTF WG GNSS, depending on the chosen calibration procedure, that is applied to UTC links between any G1 station (e.g. PTB in the set-up of UTC links used in 2023) and the calibrated G2 station. In addition to the calibration uncertainty, an aging uncertainty is applied that increases with the age of the calibration. For this reason, it is advised to perform calibration at regular intervals, ideally every 3 years.

CALIBRATION PROCEDURES FOR G2 LABS:

1. The classical procedure is a **calibration trip with closure (CC)**: the G1 calibrates a GNSS traveling station G1-TS (GNSS receiver, cable and antenna) against its BIPM-calibrated reference, sends it to the G2, where G1-TS is installed, connected to UTC(k), and collects data for at least 4 days. Then the G1-TS is sent back to the G1 where closure measurements are performed against the G1 reference. The conventional uncertainty for this calibration procedure is 2.5 ns (dual-frequency combination), for each GNSS.
2. Alternatively, a **direct calibration (DC)** procedure may be used: here the G2 sends its complete equipment (GNSS receiver, cable and antenna) to the G1 (or possibly to the BIPM if there is no G1 in this RMO). The G2 station is installed at G1 premises and collects data for at least 4 days, to be calibrated against the G1 reference. The conventional uncertainty for this calibration procedure is 4 ns (dual-frequency combination), for each GNSS.
3. Finally, the GNSS station can also be calibrated by an "authorized third party (A3P)", which can be a G2 laboratory, a manufacturer of GNSS receivers, or another entity e.g. a laboratory with **absolute calibration (AC)** facility. The A3P must have their calibration procedure first validated by the BIPM. In the A3P case, all procedures (CC, DC and AC) can be considered. The uncertainty for this A3P calibration will be validated by the BIPM, and will generally be between 5.0 and 7.0 ns.

Each calibration exercise as described above receives an identifier called Cal_Id. The list of all GNSS calibrations can be found at https://webtai.bipm.org/database/calib.html

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CHANGE OF GNSS SETUP AT UTC(k) AFTER CALIBRATION:

Some changes in the GNSS setup can occur after a calibration exercise, either on cables, receiver, antenna, or a new GNSS station can be added. In these cases, the following procedures allow to keep or restore the calibration before the next calibration campaign is organized with a G1 lab or with the BIPM.

If the calibration results are expressed as INTDLY or SYSDLY and the change concerns only the REFDLY (due to a change of the link between the UTC(k) and the receiver, or possibly to a change in the UTC(k) generation) the newly measured value of REFDLY should be used to generate the CGGTTS files and the BIPM should be informed of the change. This update will result in no change to Cal_Id or uncertainty.

In all other cases**, as well as for the setup of a new GNSS station in the lab:** If a second GNSS station connected to UTC(k) is available, and did not undergo any setup change, the new results can be determined through a **transfer of calibration** performed by the UTC(k) laboratory. The procedure consists of determining the differences of code pseudoranges between the two stations (the one with setup change and the one without) over a few days before and a few days after the setup change. A report describing the operations and the computations of the relevant results shall be submitted to the BIPM. The BIPM will validate the results, possibly providing a new Cal_Id depending on the changes. The calibration uncertainty will be expanded by the BIPM to reflect the uncertainty of the transfer.

PROCEDURE FOR G2 UTC(k) LABORATORIES TO REQUEST A CALIBRATION:

see the list of contacts in RMOs and G1 labs here below

- If your RMO is covered by G1:
  Contact the TCTF G1 Coordinator, if exists. Otherwise contact a G1 laboratory of your RMO
  A G1 lab will organize a DC or a CC
- If there is no G1 laboratory in your RMO (i.e. AFRIMETS and GULFMET):
  contact either a G1 from another RMO or the BIPM that will help find a G1 or organize a DC
- In all cases, the practical aspects of the calibration trip (shipment, customs administrative procedures…) should be considered well in advance of the planned trip.

Group 1 laboratories and contact names (as of 2021)
The list of G1 contacts may be found in the membership of the WG GNSS at
https://www.bipm.org/fr/committees/cc/cctf/wg/cctf-wggnss

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