Time

Robustness of the UTC algorithm

The robustness of the Coordinated Universal Time (UTC) algorithm was tested in collaboration with NMIs that realize their national time scale with the support of primary frequency standards. The aim is to study long-term instabilities induced by the frequency steering in UTC and in the local realizations UTC(*k*)[9].

Time transfer using BeiDou and Galileo

The activity on time transfer techniques based on the Global Navigation Satellite Systems (GNSS) focused mainly on testing the new Chinese BeiDou and European Galileo systems within the current algorithm for the computation of UTC. Results show that the time transfer obtained by Galileo observations is as good as that achieved from GPS[10]; the BeiDou system is still under test, particularly its latest generation, BDT3.

Calibration of GNSS equipment

The department continued with its work on the absolute and differential calibration of GNSS equipment in 2019. A BIPM receiver has been absolutely calibrated for all the available GNSSs in collaboration with the European Space Agency (ESA). In addition, in collaboration with the Royal Observatory of Belgium an overall evaluation of all the available differential and absolute calibration data has been carried out with the aim of fixing the reference values for the GNSS measures in the computation of UTC and also for the publication of GNSS time dissemination services in BIPM *Circular T*.

GNSS calibration campaigns

The GNSS calibration campaigns, in coordination with the RMOs, are progressing as expected, with the aim of visiting the G1 laboratories in each RMO every two years. The third complete voyage of the BIPM travelling apparatus was concluded with a visit to the SIM G1 laboratories. A final calibration report was published and the results are available on the BIPM website. This latest campaign included Galileo observations for the first time.

Calibration travelling box

The Time Department, in collaboration with the OP SYRTE (France), has developed a new "calibration travelling box", which is currently under test. The apparatus includes a carefully designed measurement chain, which is aimed at calibrating GNSS and Two Way Satellite Time and Frequency Transfer (TWSTFT) equipment when the TWSTFT mobile calibrating station is not available or is not suitable.

IPPP research

The BIPM is collaborating with the CNRS (France) on research into the use of Integer Precise Point Positioning (IPPP) as an improved treatment of the GNSS carrier phase measures to avoid cycle slips that degrade the stability of the time transfer solution[11, 12]. Dedicated software has been developed and used to validate other time transfer techniques such as optical fibres or Very-long-baseline interferometry (VLBI), in collaboration with the laboratories involved. Plans to use IPPP in the computation of UTC are under development.

Ensuring the accuracy of UTC

To ensure the accuracy of UTC, the role of primary and secondary frequency standards is fundamental. The department is following the development in the NMIs and supporting the introduction of frequency measurements in UTC, particularly the newly developed optical frequency standards.

CBKT training course

The Time Department, in collaboration with a secondee from NICT (Japan), has prepared a training course on "Time scale and algorithms", within the framework of the BIPM CBKT programme. The course will be given at the BIPM or within the RMOs.

Atomic Clock Ensemble in Space

The BIPM has started working with the Working Group for the exploitation of the Atomic Clock Ensemble in Space (ACES) experiment on the International Space Station (ISS) with the aim of studying a high-accuracy microwave link for possible future use in UTC, and related effects of relativity on clocks[13, 14, 15].

BIPM frequency comb successfully installed by INTI

Following its dismantling, a number of pieces of equipment from the former BIPM Length Section's laser laboratory were identified as being worth offering to NMIs for use in their work programmes. In particular, there were two frequency combs, which had been built by the BIPM and which are used in comparing microwave to optical frequency radiations. Information about the frequency combs was circulated among the NMIs and INTI (Argentina) offered to acquire one of the combs.

It took more than nine month to receive the custom clearance, and on 16 October 2019 the comb left the BIPM. It arrived at INTI a few days later and has been successfully installed in its length laboratory.