The Time Department continued to work on improvements to the estimation of time transfer uncertainty for Coordinated Universal Time (UTC) in 2016. The department’s proposal to optimize the calibration of Global Navigation Satellite Systems (GNSS) equipment received an excellent response from the RMOs. Results of Global Positioning System (GPS) calibrations organized by EURAMET laboratories have been implemented in the computation of UTC. The BIPM has started the second calibration campaign in selected institutes; measurements have been completed by the APMP and are in progress within EURAMET. With this continuous process in place, the number of laboratories with calibration uncertainty at or below 2.5 ns is increasing. The BIPM is coordinating a pilot study that aims to reduce the additional noise, with diurnal signature, observed in most Two-Way Satellite Time and Frequency Transfer (TWSTFT) links. The first results obtained with the operation of a “software designed radio” (SDR) in TWSTFT stations has shown a substantial reduction of the diurnal noise, which may help to understand the origin of the perturbation.

Research into a new approach to UTC calculation proved that the frequency stability of UTC can be significantly improved by using a Kalman filter\(^4\). Revision of the algorithm for the uncertainty of \([\text{UTC-UTC}(k)]\) has started with the aim of correcting undesired effects that come from the present procedure. A new approach is under development that takes into account the correlations, which are not fully considered in the current algorithm.

A paper was published in Metrologia giving a detailed comparison of two continuous GPS carrier-phase time transfer techniques\(^5\). In this paper, the performance of continuous GPS carrier-phase time transfer techniques is discussed and it is clarified that one recently published such method, known as RRS, does not provide significantly better frequency stability than other similar techniques.

Advances in optical frequency standards at the NMIs indicate that the definition of the second will probably be revised during the next decade. In preparation, the Consultative Committee for Time and Frequency (CCTF) is identifying candidate transitions for recommendation by the CIPM as secondary representations of the second (SRS). However, before any individual atom/ion species can be chosen among these candidates, a thorough investigation of its properties and suitability to become the base of a redefined second must be undertaken. To this end “direct frequency ratio measurements between standards” is a major tool and such measurements are already in progress at several NMIs. The BIPM has developed a novel method to allow the study of consistency within the set of frequency ratio measurements to be compared to the estimated individual uncertainties of the standards\(^6\). A technique based on “graph theory concepts” readily isolates inconsistencies and allows evaluation of the full set of ratio measurements, providing an interesting and simplified alternative to the non-linear least squares approach.

BIPM Circular T is published monthly and gives traceability to the SI second via UTC to its local realizations in national laboratories. It is the most frequent key comparison, with one evaluation of the key comparison reference value UTC and the degrees of equivalence \([\text{UTC - UTC}(k)]\) every five days for the 77 participants that together contribute data from about 500 atomic clocks.

The Time Department improved the archiving and dissemination of its services in 2016. A new HTML version of monthly Circular T with improved access to the data, results and plots supporting the values published in its sections was launched. User access to the FTP server has been redesigned to allow easier consultation and historical information on timescales has been added to allow the tracking of laboratories’ contributions over the long term. A database has been developed that gives an inventory of the complete set of information relevant to the time scales calculated at the BIPM; it is linked to the processes involved in the computation of time scales within the department. Since September 2016 the database has been available at: webtai.bipm.org/database/html/.

The World Radiocommunication Conference (2015) called for stronger links between the International Telecommunication Union (ITU) and the BIPM in coming to a decision on the adoption of a continuous reference time scale by 2023. As a consequence, the Time Department actively contributed to the work of a Task Group created by the CCTF in 2016 to provide formal definitions of the current time scales International Atomic Time (TAI) and UTC and to recommend actions to be proposed to the CGPM in 2018.

International metrology in the field of Time and frequency: www.bipm.org/metrology/time-frequency/