Consultative Committee for Time and Frequency (CCTF)
President L Erard, Executive Secretary F Arias

Meets every - 3 years **Last meeting** - September 2015 **Members/Observers** 29/3	**Working groups**: International Atomic Time (WG TAI), Algorithms (WG Algo); Primary and Secondary Frequency Standards (WG PSFS); Global Navigation Satellite Systems (WG GNSS); Two-Way Satellite Time and Frequency Transfer (WG TWSTFT); Coordination of the Development of Advanced Time and Frequency Transfer Techniques (WG ATFT); CIPM MRA (WG MRA); Strategic Planning (WG SP); CCL-CCTF Frequency Standards Working Group (CCL-CCTF FSWG)		
Comparison activity	**Completed**	**In progress**	**Planned**
CCTF UTC (on-going, monthly)	1	1	1
RMO KCs (& SCs)	0	0	0
BIPM comparisons (all on-going)	0	0	0
CC Pilot studies	0	0	0
CMCs	738 CMCs in 19 service categories		

Pointers to the future, stakeholder needs and technological developments

- **Time scale realizations**, national and international levels: Possible redefinition of the SI second and its realization (10 year timeframe), emergence & co-exist of different timescales for different applications (particularly GNSS). Dynamical timescale based on astronomical millisecond-pulsar observations, potential of a combined dynamical-atomic timescale to give long-term stability beyond the annual TT(BIPM) for use by astronomical community. Clock comparison at a distance for NMIs, and comparison with UTC. New GNSS systems, European Galileo and the Chinese BeiDou. Increasing number of timescales: Need for clear and accessible statements, as far as possible, about the relationships between UTC and the diversity of time scales. Real time UTC: UTC more accessible in real time, with more rapid predictions of UTC.
- **Time and frequency transfer**: Ground-based optical fibre: frequency transfer with uncertainties of less than 10^{-17} for distances > 1000 km and of time transfer with uncertainties of 1 ns over a few hundred km now feasible. Possibility of regular services connecting major timing centres in Europe. The long-term vision for a further improvement in accuracy and density of the links. GNSS-based time transfer aiming to establish time transfer with 0.1 ns uncertainty among sites contributing to TAI, and below 10^{-16} for frequency transfer.
- **Primary frequency standards:** Continued development of cesium fountains and second generation fountains by NMI. If/when the second is redefined (probably using an optical transition) a priority task will be to determine the best value of the Cs SI second and its uncertainty. Portable yet highly accurate primary standards may be developed.
- **Algorithms for time scales**: Algorithms for the treatment of time and frequency measures are expected to increase in the next ten years for: Time scale realization particularly noting the availability of different type of atomic clocks (Cesium beam, Hydrogen maser) and the availability of different primary frequency standards. Real time applications: driven by GNSS but also of important application in timekeeping.
- **Optical frequency standards:** Comparative stability, uncertainty and reproducibility of optical atomic reference transitions are currently being studied, within the two generic categories of electromagnetically trapped single ions and multiple atoms trapped in optical lattices, notably on 2 atom species (87Sr and 171Yb). Not yet clear whether there is a preferred candidate for redefinition, but it seems likely one or other (or both) will achieve
- 10^{-18} accuracy.

Workload Trend & Workload Management

- NMIs maintain atomic clocks and primary standards, operate time transfer devices (GNSS receivers, TWSTFT stations, optical fibres), and communicate data to the BIPM on a daily basis. In each laboratory resource depends on the number and quality of clocks, the time transfer techniques and manpower. The equipment involved is different and operated in different locations. Comparison conducted monthly, best estimate of resources per comparison is: Pilot (BIPM): 8 pm (3pm for monthly calculation/publication; 4 pm for laboratory's technical support + development + software maintenance + 1 pm for internal/international coordination) Participation: about 200 pm distributed in 75 contributing laboratories

BIPM – references to laboratory activity at the BIPM

- Key comparison & monthly provision of UTC (CCTF-K001.UTC and BIPM Circular T) including process of calculation, studies on time transfer and use of primary and secondary standards, development of statistical methods for application in the algorithm for the construction of TAI, studies on calibration of time transfer equipment and organization of calibration campaigns, provision of other time scales such as TT(BIPM), on an annual basis with monthly extrapolations.
- The development of rapid products started by the regular provision of the rapid UTC on a weekly basis starting in July 2013. Rapid UTC could be the basis of a more frequent publication of the key comparison on time in the future.
- The coming ten years will focus on the improvement of T&F transfer for the comparison of optical clocks, with two targets: (i) in the short term their use for improving the accuracy of TAI, (ii) in the mean/long term for contributing to a redefinition of the SI second.