The BIPM Capacity Building and Knowledge Transfer program on Time Scale Realization

P.Tavella [(1)] and Y. Hanado [(2)]
(1) Bureau International des Poids et Mesures, Sevres, France, http://www.bipm.org
(2) National Institute of Information and Communications Technology, Tokyo, Japan

Abstract

In the frame of the Capacity Building and Knowledge Transfer program at the *Bureau International des Poids et Mesures* (BIPM), a course on time scale realization is under realization. This course, thought for new and small time metrology laboratories, includes practical exercises for the monitoring and computation of the time scale, based on open source software codes, in some cases appositely developed.

1 Introduction

Realizing a national standard time based on atomic clocks is one of the most important tasks of National Measurement Institutes (NMI). It requires not only theoretical knowledge (atomic clock, time scale, error propagation, metrological evaluation), but also practical skill to manage the actual data with high precision and reliability. Such knowledge and skills are usually accumulated and inherited by a few specialists in each organization, however, new staff and new laboratories may not always have the opportunity to learn and develop useful tools. Common occasions of education are therefore required.

The BIPM is active in the "Capacity Building and Knowledge Transfer (CBKT) programme" which aims to increase the effectiveness within the world-wide metrology community of Member State and Associates with emerging metrology systems [1]. The Time department of BIPM is fully involved in the CBKT activity and organized a training in 2018 which was mainly focused on GNSS (global navigation satellite system) time transfer and its calibration. Considering the high number of new laboratories participating to the Coordinated Universal Time (UTC), the BIPM Time Department has proposed an additional CBKT course on time scale realization and algorithms.

In collaboration with the working groups of the Consultative Committee for Time and Frequency (CCTF) a survey on the necessity on timescale training was undertaken during the summer 2019 addressed to all the time laboratories participating to UTC. As the result, several NMIs showed interest on training about timescale algorithms, calibration of timing equipment, steering of local UTC(k) time scale, quality data check, and performance evaluations. Based on such feedback, a new CBKT course is under preparation.

The CCTF is currently discussing the possibility to share resources among the different time laboratories for increasing the capacity building and the efficiency in the realization of UTC. (see presentation on https://www.bipm.org/cc/CCTF/Allowed/22nd-1/CBKT_CCTF.pdf)

2 Plan of CBKT training on timescale and algorithms

The drivers for developing the new course are mostly based on the aim to provide to the users some tools to be used in their daily activity in the time laboratories. The course will focus on the needs in terms of hardware and software for the generation of a national time scale, and on the possibilities to check the quality of data and the time scale performance. Data checking and validation is in fact fundamental factor that helps a better realization of the national times scale, as well as a better contribution to the BIPM resulting in a more stable and reliable UTC.

To this aim some open source software codes are under development with the aim to provide to the users some tools of easy access and to be immediately used in the laboratory daily activity.

We set therefore the following aims for the development of the course:

1. Develop a course with tutorial lectures and training, aiming to complement the CBKT2018 named "Efficient participation to UTC".
2. The course is organized in modules that can be arranged together differently depending on the needs of the different course edition.
3. The course can be carried out at the BIPM or in Regional Metrology Organization (RMO) areas with the support of the metrological laboratories of that RMO.
4. The targeted attendees are beginners who are/will be in charge of operating national standard time and participating to UTC.
5. The lecturers are expert from the BIPM and UTC laboratories. When the course is given at RMO, the local laboratory experts are involved.
6. In addition to the lectures, some practical exercise, simulations tools, and demonstrative videos will be offered during the course and also be available for permanent (remote) training hosted on the BIPM web page.
7. The simulation tools could become an open collaborative development platform like GIT-LAB on the BIPM web page in future.

3 Content of the CBKT course

The lectures include general introduction to the international standard time and the necessary knowledge for a time laboratory in the practical generation of national standard time UTC(k). The lectures will be organized in different modules as follows:

The realization of a UTC(k) time scale

- National and International impact of a UTC(k) time scale
- Basic study of time scale generation
- Basic study of time comparison techniques
- Basic study of statistical methods to estimate stability and uncertainty

---

Lecture and practical exercise for basic technical skills

- lecture on issues to be considered to ensure accurate time measurements
- Exercise for data processing (data retrieval, plotting, selecting, filtering, best fit, ...)
- Exercise for clock anomaly detection (outlier removal, jump in frequency)
- Exercise for steering UTC(k) (real time offset estimation and compensation)

Lecture on national time laboratory operation and advanced exercise

- Lecture on national/international time keeping and how to join UTC Key Comparison
- Advanced exercise for generation and monitoring of the time scale
- Examples of APMP lab time scale setup and operations

The possibility of practical exercises is emphasized in this training course as well as lectures. Figure 1 shows a plan of the exercises which can help in the process of generating a UTC(k) time scale. The first are laboratory exercises relevant with hardware operation (Ex-0 and Ex-1). The following exercises (Ex-2 / Ex-7) deal with data analysis and with the formation of an ensemble time scale. These exercises will be based on the use of open source software already existing or appositely developed that will be made freely available to the students as an aiding tool for their everyday life in the laboratory.

4 CBKT course planned at the APMP RMO

The above plan of CBKT training shows a framework, and actual realizations will be carried out by the BIPM or RMO. We started a collaboration with the Asia and Pacific Metrology Programme (APMP) [2] to hold a first training course in Asia in the summer 2020.
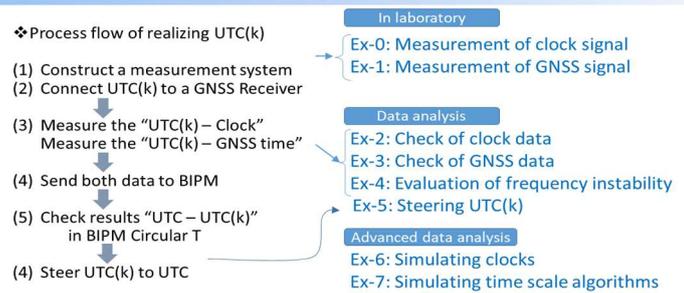

Figure 1. Plan of the exercises in the training.

Figure 2 shows the basic idea of this collaboration and the role of each organization in this implementation. The BIPM Time department is developing the framework and takes care of the content and training tools with the support of the CCTF working groups on "Algorithms". The APMP regional metrology organization takes care of the organization and logistics with the support of the APMP Technical Committee in Time and Frequency (TCTF). For this first edition of the course we have received the support of the MEDEA project [3] kindly supported by PTB, the German metrology institute.

This joint initiative called BIPM-AMPM CBKT Training on Timescale Algorithms ("TTA2020") was to be held at Thailand on July 1-3. The feedback from this training was to be presented to the URSI GASS 2020. However, this plan is suspended by Covid-19 and it is under re-planning with a remote style.
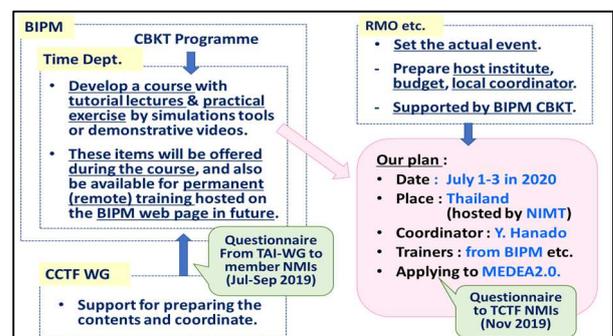

Figure 2. Relation of the collaboration for training.

5 Acknowledgements

6 References

1. https://www.bipm.org/en/cbkt/
2. http://www.apmpweb.org/
3. https://www.ptb.de/lac/index.php?id=medea