Requirements and Recommendations for National Time and Frequency Laboratories

Results of considerations at NICT T&F Training Program (Oct. 15-23, 2009)

1. Preface

During the lectures and hands-on training of the NICT Time and Frequency Training Program, it appeared there are a lot of demands from participants for the information about what is really required to establish national time and frequency standard system. Since the standard time is a quite important infrastructure for all nations, the national time and frequency laboratories have responsibilities to generate and maintain accurate and reliable standard time and disseminate it. Therefore, we determined to use the round discussions scheduled in the last day afternoon to complete this working document trying to describe the minimum requirements for the national time and frequency laboratories and additional recommendations and suggestions to improve the quality of the standard and services.

2. Infrastructure and staff

Environments of the laboratory room affect the performance of the time and frequency systems. Especially, temperature and humidity of the laboratory room should be carefully controlled to minimize variations. If it is possible, it is advisable to have a small chamber to place sensitive components including frequency standard systems. It is advisable to keep the temperature of the room or the chamber between +/-0.5 degree C to the target temperature and +/-10% to the target humidity.

Electromagnetic variation has a potential to affect the performance of the atomic clocks, some laboratories may consider to have electro-magnetic shield. NICT has installed shielded room using Permalloy which has a shielding performance of about 40dB.

Interruption of electronic power should be avoided. Adequate capacity of the UPS (Uninterruptible Power Supply) should be used to cope with the power failures. Some models of the standard system can run with the DC battery. It is advisable to have an enough capacity of the battery to run the system. If there is a risk of having longer power failure than the capacity of the power backup, it will be necessary to have a motor generator to keep the power.

To run the time and frequency standard, specialized knowledge to handle and maintain the system is required. It is necessary to have enough number of trained staffs at the laboratories. It is quite important to educate the staffs as an on-going task.

3. Frequency Standard System

At least two high quality frequency standard systems are required to maintain the national time and frequency standard. In addition, it is advisable to have more than two systems improve the reliability and stability of the system. If there are 5 or more standard systems, it becomes possible to establish ensemble time scale and the stability of the time scale will be improved.

Normal tube cesium frequency standard has a typical stability of 2.0x10-13 at 1 day, while high performance cesium frequency standard has a stability of 3.0x10-14 at 1 day. It is necessary to consider about continuous maintenance to keep the good performance of the standard systems. Normal tube systems have to be maintained at least every 10 years and high performance systems have to be maintained at least every 5 years.

Hydrogen maser systems have good stability at shorter time range compared with cesium standard systems. If the reference signal from a hydrogen maser is used to establish the ensemble time scale, it has a possibility to improve the stability of the time scale in general.

Monitoring system is also important to detect failures of cesium frequency standard systems and other components. By continuously monitoring the performance and stability of the cesium frequency standards, it becomes possible to know when one system failed to keep its performance. For this purpose, at least three cesium frequency standards are necessary.

4. Time and Frequency Transfer

To ensure the traceability of the time and frequency standard system to the UTC, at least one of the precise time and frequency transfer methods have to be taken. A multi-channel, single frequency GPS receiver will be a good choice to start the time and frequency transfer. Antenna has to be placed on the stable mount. The location of the

antenna has to be chosen to ensure clear sky and to avoid multi-path problem. The choke-ring antennas are known to perform better with respect to the multi-path problem from the ground and buildings. It is advisable to place not directly on the ground and use a pole to ensure some height.

TWSTFT (Two Way Satellite Time and Frequency Transfer) is known to have a better stability at long time interval.

5. Calibration

Calibration services can be started with a national time and frequency standard system and a simple time interval counter. If the calibration has to be recognized under the MRA (Mutual Recognition Arrangement) and to establish the international traceability, the quality system has to be established and accredited by other national accreditation body according to the ISO17025. Then the CMC (Calibration Measurement Capability) table has to be prepared and reviewed by specialist from other institutes. Arrangements will be coordinated by the RMOs like APMP.

6. Dissemination

It may not be a minimum requirement, but it is advisable to offer dissemination services to the public users in each country. Calibration service is one of the important services of the dissemination. As the other dissemination methods, NTP (Network Time Protocol) server will be a good idea to disseminate accurate standard time to the public users. In addition, it will be useful to many people in each country to establish authenticated time stamp services and radio emission of standard signal.

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Acronyms for Institutes

NICT	National Institute of Information and Communications Technology
NIM	National Institute of Metrology
KazInMetr	Kazakhstan Institute of Metrology
KIM-LIPI	Indonesian Institute of Sciences, Research Center for Calibration, Instrumentation and Metrology
NIMT	National Institute of Metrology Thailand
NISIT	National Institute of Standards and Industrial Technology
MUSSD	Department of Measurement Units, Standards and Service
NTSC	National Time Service Center, Chinese Academy of Science
NSCL	National Standards & Calibration Laboratory
NML-ITDI	National Metrology Laboratory, Industrial Technology Development

	Institute
NMC	National Metrology Centre, A*STAR