(Preprint) AAS 13-503

EXPERIENCES OF LEAP SECOND ADJUSTMENT OPERATIONS AND QUESTIONNAIRES IN JAPAN

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The National Institute of Information and Communications Technology (NICT) in Japan has responsibilities for Japan Standard Time (JST) and is trying to generate and maintain a stable and reliable time scale. NICT has been trying to perform smooth operations of the past leap second adjustments to JST and there has been no major confusion in Japan as the result of careful preparations. Along with these efforts, questionnaires were conducted to gather information concerning the influences from leap second adjustments and opinions towards possible future changes to UTC in 2001 and 2007. The results of these questionnaires are summarized along with the experiences of the operations of leap second adjustments.

INTRODUCTION

The National Institute of Information and Communications Technology (NICT) in Japan has responsibilities to generate and to maintain Japan Standard Time (JST), and to disseminate JST throughout the country.[1] For these purposes, NICT is operating multiple sets of Cesium frequency standard systems and Hydrogen maser systems to generate a stable and reliable time scale. JST is generated and maintained from the ensemble of the signals from these frequency standards. NICT operates satellite communication links for TWSTFT (Two-Way Satellite Time and Frequency Transfer) connecting the Asian region and the European region, through the collaborations with National Metrological Institutes to contribute in establishing Coordinated Universal Time (UTC). NICT is also participating in the GNSS (Global Navigation Satellite Systems) time link network, and both TWSTFT and GNSS data are used for UTC establishment.

In addition to these responsibilities, NICT is conducting various research and developments which have close relation with UTC. First of all, NICT is operating Very Long Baseline Interferometry (VLBI) observing stations at Kashima and Koganei, as network stations of the International VLBI Service for Geodesy and Astrometry. NICT is participating in global VLBI experiments for the precise monitoring of the Earth Orientation Parameters (EOP), including the time difference between UTC and Universal Time (UT1), and for the improvement of the Terrestrial and Celestial Reference Frames. NICT is also operating a Satellite Laser Ranging observing station at Koganei as a ground station of International Laser Ranging Service (ILRS), and two IGS (International GNSS Service) sites at Koganei and Kashima. The site at Koganei is the only site

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in Japan where three independent Space Geodetic techniques are collocated. Space Geodetic techniques are the key techniques to measure the UT1−UTC value and also they are the users of the information UTC−TAI (International Atomic Time).

Secondly, NICT is also conducting various space missions and precise orbit determinations that rely on UT1−UTC and UTC−TAI information. The Quasi-Zenith Satellite System (QZSS) is a regional navigation satellite system which compliments the other GNSS signals, and NICT participated in experiments with responsibilities for the Time Management System of QZSS. As these activities suggest, NICT has a broad relationship with UTC in many aspects.

GENERATION AND MAINTENANCE OF JST

From the circumstances described in the Introduction, NICT has been generating and maintaining JST. UTC(NICT), which is the base of JST, is a realization of an average timescale made by an ensemble of 18 commercial Cesium atomic clocks at NICT. NICT is also operating 4 hydrogen masers and one of them is used as the source of the actual signal of UTC(NICT). The current generation system of JST started regular operations in February 2006. UTC(NICT) has been synchronized with UTC(BIPM) almost within ±20 ns.[2]

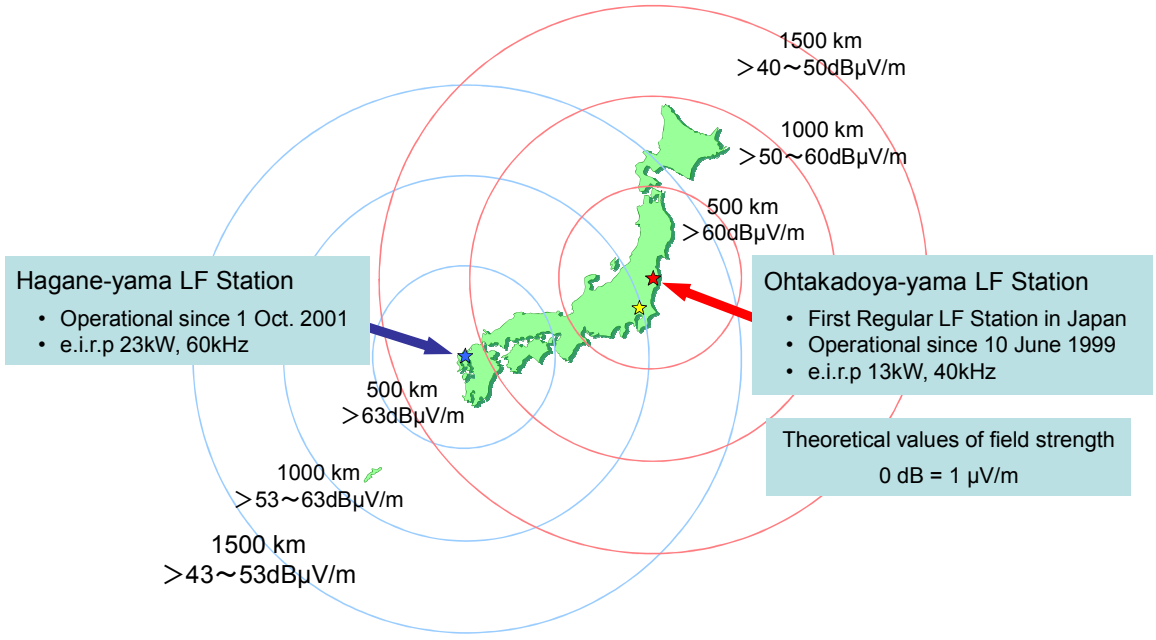

Figure 1. LF time and frequency service in Japan. The values under the distance (km) shows the approximate strength calculated as the assumed electric field.

DISSEMINATION OF JST

Standard-Frequency and Time-Signal Emissions

NICT provides the dissemination service of standard-frequency and time-signal via LF band, as shown in Figure 1. Figure 2 shows pictures of the two LF stations, namely Ohtakadoya-yama station and Hagane-yama station. These two stations cover the whole area of Japan. Table 1 shows the characteristics of the stations. Both stations are continuously operated for 24 hours a day, except for annual maintenance and sporadic temporary suspensions to prevent lightning

damages. Currently, radio controlled clocks and watches have become very popular in Japan and it is estimated more that 50 million units have been sold in total.

Figure 2. Pictures of two LF time and frequency standard signal transmission stations.

Table 1. Specifications of the two LF stations.

	Ohtakadoya-yama	Hagane-yama
Frequency	40 kHz	60 kHz
E.I.R.P.*	13 kW	23 kW
Antenna Height	250 m	200 m
Latitude	37°22' N	33°28' N
Longitude	140°51' E	130°11' E

Public Network Time Protocol Service

NICT has been providing public Network Time Protocol (NTP) service since 2006 using a Field Programmable Gate Array (FPGA)-based NTP server, which can accept up to 1 million NTP requests every second. NICT has also developed a stand-alone NTP server which consists of a Linux controller unit integrated on the FPGA and the NTP server hardware (Figure 3). The stand-alone NTP servers started operations in 2008, and they are receiving about 100 million accesses every day on average.

* effective isotropically radiated power

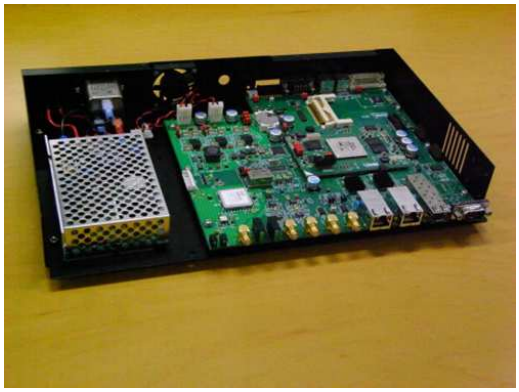

Figure 3. Hardware SNTP Server Developed by NICT.

Telephone JJY System

For the users who require reliable access to JST, NICT operates a Telephone JJY System.* This system can communicate with the client servers by using acoustic couplers and public telephone lines. By measuring the time difference between the server and the client using two way measurements, an accuracy of about 200 μs can be realized. Figure 4 shows a picture of the Telephone JJY System.

Figure 4. Telephone JJY System.

GNSS Time Transfer Services for Time Stamp Service Authorities

An accreditation program for time-stamping services in Japan has existed since February 2005. In this program, the clock of the time-stamping server is calibrated within the prescribed accuracy and traceability to UTC(NICT) to make sure all time stamps are reliably traceable to UTC. For this purpose, NICT is providing GNSS Time Transfer data to the time stamp service authorities.[3]

* JJY is the call sign of Japan's LF radio time signal.

LEAP SECOND ADJUSTMENT OPERATIONS

In the events of all adjustments of leap seconds in the past, NICT conducted smooth operation with all of the dissemination services mentioned in the previous section. In addition, NICT tried to provide necessary information to the users of JST in advance by holding public lectures and issuing press releases in Japan. As the result of such careful preparations and efforts, there has been no major confusion in the dissemination services provided by NICT.

On the other hand, suspension of some services and some malfunctions of computer systems caused by the leap second adjustment were reported in Japan. All time-stamping authorities in Japan suspended their operations well before the leap second adjustments to prevent wrong timing information being provided. In the case of the leap second adjustment in 2012, they suspended their operations for about two hours on average. They restarted their services after the correct insertion of the leap second was confirmed. It was found that there is a bug in certain versions of Linux kernels and it caused the malfunction of computer systems. Because of this malfunction, a well-known Social Network System service and Internet Service Providers reported delays or failures in their services. These facts were summarized in report documents and reported by NICT to the Working Party 7A (WP-7A) – Time signals and frequency standard emissions, in the Study Group 7 (SG7) – Science services, in the Radiocommunication Sector of International Telecommunication Union (ITU-R).[4, 5]

QUESTIONNAIRE

Along with the efforts for smooth and correct leap second adjustment operations, questionnaires were conducted to gather information concerning the influences from leap second adjustments, and opinions towards the possible future changes to UTC in 2001 and again in 2007. The questionnaire in 2001 was conducted by Communications Research Laboratory, formerly NICT. The questionnaire in 2007 was conducted by the Ministry of Internal Affairs and Communications. The results of these questionnaires have been submitted to the ITU-R SG7 WP-7A.[6, 7] In the questionnaire conducted in 2007, there was no opposing opinion to terminating the leap second adjustment. Instead, it was only mentioned by the GPS manufacture companies that 5 to 10 years of preparation is desirable. On the other hand, the broadcasting carriers, telecommunication carriers and time stamp authorities expressed agreement for the proposed change to eliminate leap second adjustment to the UTC.

CONCLUSION

In Japan, NICT is paying every effort to generate and maintain JST as a reliable time scale in the country in accordance with UTC. Past leap second adjustment operations have been conducted without any confusion or problem for its dissemination services as the result of careful preparations and announcements. However, it is becoming impossible to secure such perfection because there are so many systems, and some systems may have unnoticed bugs or malfunctions. The results of questionnaires conducted in Japan implied that there were no opposing opinions to eliminate the leap second adjustment, but there were supporting opinions to do so.

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Internal Affairs and Communications in Japan for their support to NICT to conduct various activities in time and frequency standards. The authors would like to acknowledge that the various activities to generate, maintain, and disseminate JST are the results of the continuous hard work of the staff members of NICT, especially in the Space-Time Standard Laboratory of the Applied Electromagnetic Research Institute.

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