TWSTFT activities at NTSC

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***Abstract*—NTSC (National Time Service Center) is responsible for Chinese national time scale generation and has being applied TWSTFT (Two-Way Satellite Time and Frequency Transfer, TW for short) for time transfer since 1998. NTSC was one of the first UTC laboratories practicing TWSTFT in China. From 2002 to 2004, TWSTFT was the major technique for NTSC contributing to UTC. Since 2007, direct NTSC-European TWSTFT time links have been established between NTSC , VSL (Delft, Netherlands) and OP (Paris, France). In 2008, TWSTFT time link between NTSC and PTB (Braunschweig, Germany) becomes operational and will be used as the primary technique for UTC time transfer.**

In this paper, we present the major activities in TWSTFT at NTSC, especially the accurate time transfer between NTSC and other Asian national time laboratories, NMIJ (Japan) (NMIJ is not mentioned is this paper), NICT (Japan), SG (Singapore), KRIS (Korea) and TL (Chinese Taipei) as well as the NTSC-European time links. We compare the TWSTFT and GPS time transfer results, analyze the error sources in the measurements and discuss the uncertainties in the time transfers and in the calibrations.

I. INTRODUCTION

NTSC is the national time authority of China. NTSC takes the role of the national timing keeping and dissemination. NTSC have seventeen cesium clocks and three hydrogen masters which contribute for TAI (International Atomic Time). Currently, UTC(NTSC), the official real time realization of UTC, is generated from a high performance cesium clock.

TWSTFT link between NTSC and NICT was implemented in KU band through commercial satellite JCSAT-3(E 128°) in 1998 and changed to JCSAT 1B (E 150°) in 2000[1,2,3]. In order to improve the TWSTFT system, we purchased a new system and carried on a simultaneous time transfer with other five national laboratories in 2005. Multi-channel modem in use is provided by NICT (National Institute of Information & Communications Technology, Japan). The new system includes: HPA (high-power amplifier), LNA (low noise amplifier)，Up and down converter from Comtech company.

The topic of establishing an Asia-Europe link was discussed in the 14th TWSTFT meeting of CCTF Working Group in 2004. NTSC, VSL and OP were all immediately interested in setting up this link. First, the link with VSL implemented in 2006 and the link with OP employed in 2007. The performances of two links are still acceptable [4,5]. So, we set up the TWSTFT time transfer link with PTB in 2008 (Fig 3).

At NTSC, we have three different types of GPS receivers. A single frequency receiver employed in 2003 year; a dual frequency receiver Time Transfer System implemented in 2005 as well as an Ashtech Z12-T GPS receiver which however is not used due to some unexpected anomaly.

II. DATA ANALYSIS AND TIME COMPARISON RESULTS

A. Asia – Asia links

For analyzing the clock difference between NTSC and NICT, we compare the TWSTFT and Circular-T for the period of MJD 54800-54912. The GPS AV time transfer is used for generating the UTC-UTC(NTSC) values for this period. Figure 1 shows the results of UTC(NTSC)-UTC(NICT) obtained by using TWSTFT and by Circular-T methods during this period. The TWSTFT data of NICT and NTSC were collected from BIPM web site (http://www.bipm.org/en/scientific/tai/). The clock differences were compensated with calibration offset value provided by BIPM of which the uncertainty is about 1 ns. The Circular-T can be found at BIPM web site.

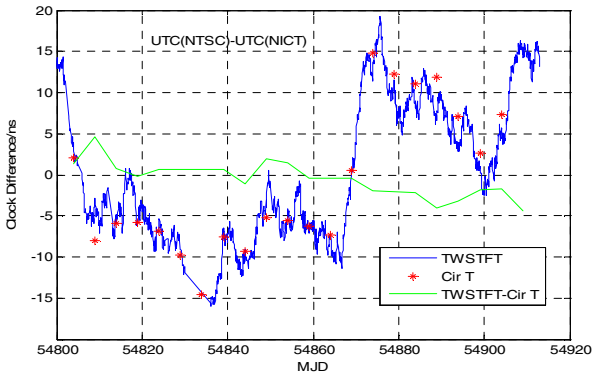

Figure 1. Comparions of [UTC(NTSC) - UTC(NICT)]by TWSTFT and GPS for the MJD period 54800-54912. The TWSTFT data have been calibrated.

The comparison results between Asia links obtained by TWSTFT for the MJD period 54700 to 54801 illustrated in Figure 2. The raw TWSTFT data, obtained from NICT web site (http://www3.nict.go.jp/w/w114/data/TWSTFT/), have

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been calibrated. Table I shows the RMS (Root Mean Square) value of five minutes raw data fitting. The row data means that RMS data received at a station (other four station transmitted signal). The column data means that RMS data received at four stations (other station transmitted signal).The RMS data of NTSC transmitted the signal and received at other Asia links is similar to the RMS data of other links.

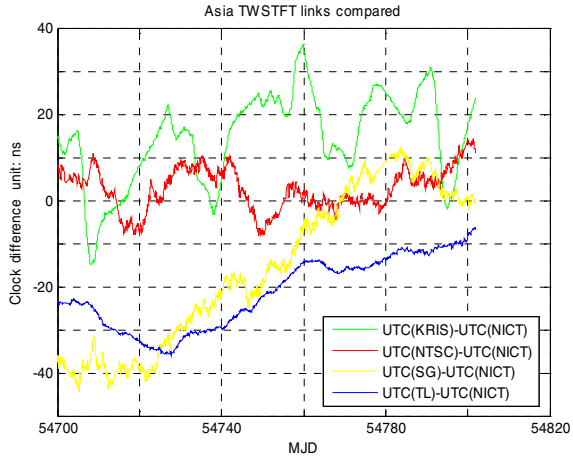

Figure 2. Clock differences between Asian links computed by TWSTFT

TABLE I. THE RMS VALUE OF ASIA TWSTFT LINKS / NS

Reception Station	Transmission Signal Station				
	NICT	KRIS	TL	SG	NTSC
NICT	-	0.472	0.746	0.344	0.366
KRIS	0.441	-	0.85	0.353	0.4
TL	0.366	0.437	-	0.307	0.336
SG	0.452	0.494	0.748	-	0.405
NTSC	0.497	0.516	0.889	0.378	-

B. Time links beween Europe and Asia

NTSC established TWSTFT link with PTB via IS-4 satellite in May 2008. The modem is SATRE modem from Timetech, equipped with a transmission channel, three receiving channels and internal time interval counter (TIC). According to the technical information of the allocated satellite transponder, each earth station must joint a 2.5MHz filter at transmission entrance. After the UAT (uplink access test) performed successfully in June 2008, the link with PTB functioned normally.

Because PTB adjusted the equipment, the TWSTFT link has interrupted and restarted in September 2008. Unfortunately the performance of this link was not completed continued. In the first period, the HPA power of NTSC is too low. The row data noise level of the received NTSC signal at the PTB station is about 0.9 ns. We considered increasing its power to improve the performance. With the PTB permission, we increased the transmission power by 3 dB. Then the row data noise level of received at PTB station reduced to 0.4 ns.

During the MJD period 54727-54877, PTB established simultaneously with NICT, TL and NTSC with the same earth station equipment. Figures 3, 4 and 5 show the clock difference results between PTB and Asia laboratories. The clock differences obtained by TWSTFT had not calibrated. All the raw data obtained from BIPM web site. The performance of NTSC-PTB is similar to NICT-PTB link.

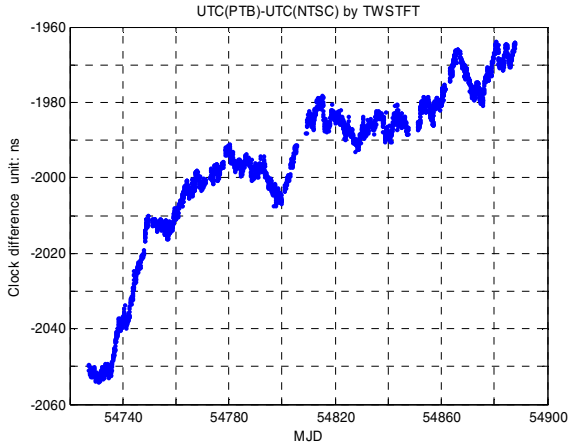

Figure 3. Results of [UTC(PTB)-UTC(NTSC)] by TWSTFT for the MJD period 54727-54877 with Satre modem. The raw TWSFT data had not been calibrated.

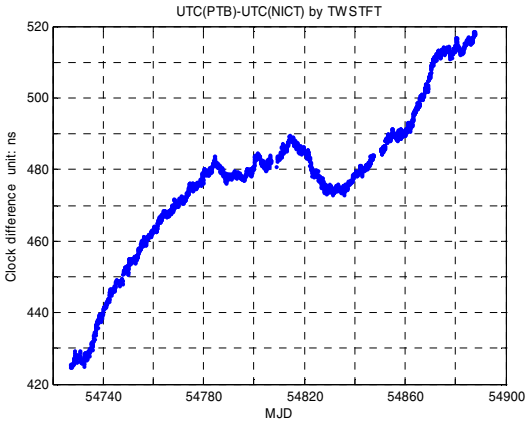

Figure 4. Results of [UTC(PTB)-UTC(NICT)] by TWSTFT for the MJD period 54727-54877 with Satre modem.The raw TWSFT data had not been calibrated.

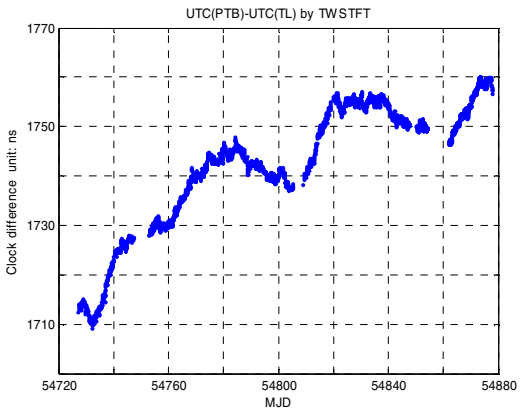

Figure 5. Results of [UTC(PTB)-UTC(TL)] by TWSTFT for the MJD period 54727-54877 with Satre modem.The raw TWSFT data had not been calibrated.

III. CONCLUSIONS

We presented the TWSTFT activities at NTSC and the TWSTFT time link results between the timing laboratories of Asia and Europe.

The TWSTFT results of NICT modem are compared with those computed using the Circular-T in this report.

The RMS data of NTSC transmitted the signal and received at other Asia stations is similar to the RMS data of other Asia links. The performance of the NTSC-PTB link using Satre Modem is improved when we increased the NTSC earth station's TX power value.

In the near future, it is expected that TWSTFT link will be used officially as the UTC time transfer between NTSC and PTB.

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