UPDATE ON THE NATIONAL INSTITUTE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY TIME AND FREQUENCY TRANSFER RESEARCH ACTIVITY

Mizuhiko Hosokawa, Yukio Takahashi, Shin'ichi Hama and Takao Morikawa

National Institute of Information and Communications Technology
Nukui-kita 4-2-1, Koganei, Tokyo 184-8795, Japan
Email: hosokawa@nict.go.jp

Outline

The National Institute of Information and Communications Technology (NICT), formerly known as the Communications Research Laboratory (CRL) has conducted the research and development on time and frequency transfer. The activity on time and frequency research and development in CRL has been fully succeeded by NICT. In this paper, we show the recent activity of the research and development on the time and frequency transfer. The main subjects are Global Positioning System (GPS) time and frequency transfer, two way satellite time and frequency transfer (TWSTFT), precise time comparison using Engineering Test Satellite (ETS)-VIII and the time management system in Quasi-Zenith Satellite System (QZSS).

GPS time transfer with geodetic receivers

NICT makes research on precise time transfer using dual frequency geodetic GPS receivers. In carrier phase method, we achieved a precision to 100 ps for a short baseline such as NICT-TL by making use of the precise orbit analysis software "CONCERTO" [1] developed by NICT. Since the number of visible satellites is not enough to resolve the carrier phase ambiguity for long baseline, we are trying to improve the precision by increasing the number of parameters to be estimated [2].

For P3 code time transfer, we are trying to improve precision of all-in-view method with IGS products in Asia Pacific region. All-in-view method is expected to have 1.5 times better precision than common-view method for a long baseline such as NICT-NMIA [3].

Two way Satellite Time and Frequency Transfer

Regular operation of multi-channel TWSTFT modems developed in NICT has commenced since February 2005 between NICT and KRISS (Korea), NMIJ (Japan), NTSC (China), TL (Taiwan), SPRING (Singapore) via JCSAT-1B satellite, and between NICT and NMIA (Australia), KRISS (Korea) via PAS-8 satellite together with GPS time comparison on those baselines. Results of an inter-comparison of TWSTFT by the NICT modem, TWSTFT by the Atlantis modem and GPS common view (CV) in some links have been analyzed and evaluated. An example of the inter-comparison between NICT and KRISS is shown in Fig.1.

A transportable TWSTFT station is under development for calibration in the Asia-Pacific Rim region. The performance evaluation shows that the NICT modem data is consistent with conventional model (Atlantis) and satisfactory for international time comparison. Differential delays between each station are determined and reported to BIPM [4]. We have been using the NICT modems for Asia-Pacific time comparison network from this June.

A plan to extend a TWSTFT link to PTB (Physikalisch-Technische Bundesanstalt, Germany) by using PAS-4 satellite has been proceeded. We are also going to put a relay station in Hawaii for NICT-USNO baseline since current relay station Vandenberg (USA) has low elevation for the satellite to NICT. After establishing both PTB and Hawaii stations, a round-the-world closure TWSTFT link will be achieved. We are now surveying an appropriate site in Hawaii.

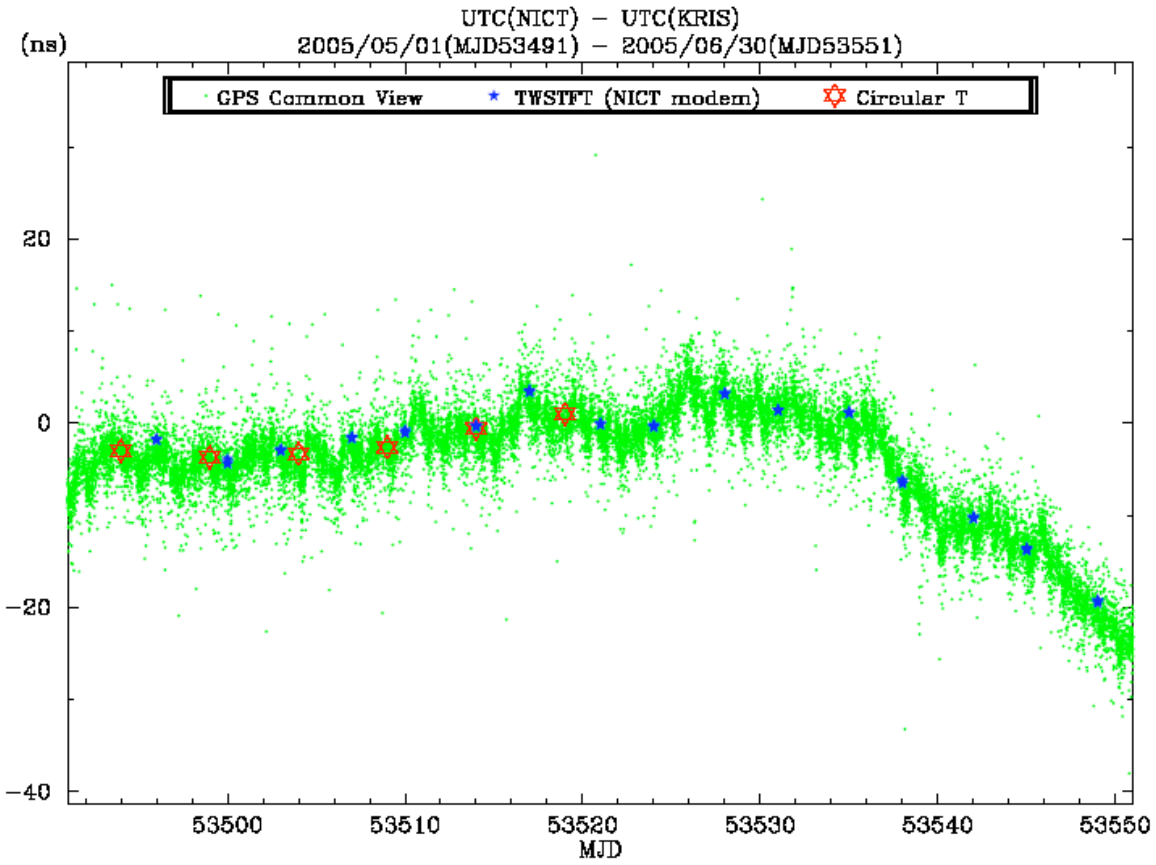

Fig.1 Time comparisons by various methods between NICT and KRISS

Engineering Test Satellite VIII

ETS-VIII is a Japanese geostationary satellite, which will be launched in FY2006. The missions of ETS-VIII are mobile communication experiments and positioning/navigation experiments using an atomic clock in space. NICT and JAXA (Japan Aerospace Exploration Agency) plan to conduct a precise time and frequency transfer experiment between an atomic clock on the satellite and a ground-reference clock. NICT has developed an on-board precise time and frequency comparison equipment which conducts two-way time transfer using both code and carrier phase measurement [5]. It also calibrates internal delays and delay variations of the transmitting and receiving paths

between the satellite and ground station. Precise time transfer between ground stations is also possible via ETS-VIII.

By using these methods, we expect to obtain a measurement precision of approximately 10 ps between the on-board clock and ground reference clocks. The development of the time comparison equipment, which went through electrical tests, was finished. We are constructing the ground stations and planning detailed experiments.

Quasi-Zenith Satellite System

Japanese government and private sectors decided to develop QZSS to provide navigation/positioning service and communication/broadcasting service with a high elevation. QZSS makes use of three satellites on inclined orbits separated 120 degrees each other to improve the visibility of satellites particularly in urban canyons in mid-latitude area. NICT is to develop time and frequency technology for this system such as space-borne hydrogen maser atomic clock and time management system [6]. QZSS satellite will have a precise time comparison unit and bent-pipe function to meet those requirements. Precise time comparison between on-board atomic clocks, between the satellite and the ground stations (time management station (TMS) and monitor stations), is performed by using the on-board time comparison unit in Ku-band. Two-way time transfer between TMS and the monitor stations will be conducted by using a geostationary satellite. As QZSS works as a supplement of GPS, the difference between QZSStime (referred to UTC(NICT)) and GPStime (referred to UTC(USNO)) will be measured with the precision of a few nano seconds and will be broadcast to users via navigation message of QZSS. We finished the basic design for the on-board equipments, and have started making the Engineering Models (EM) and designing the ground system for it.

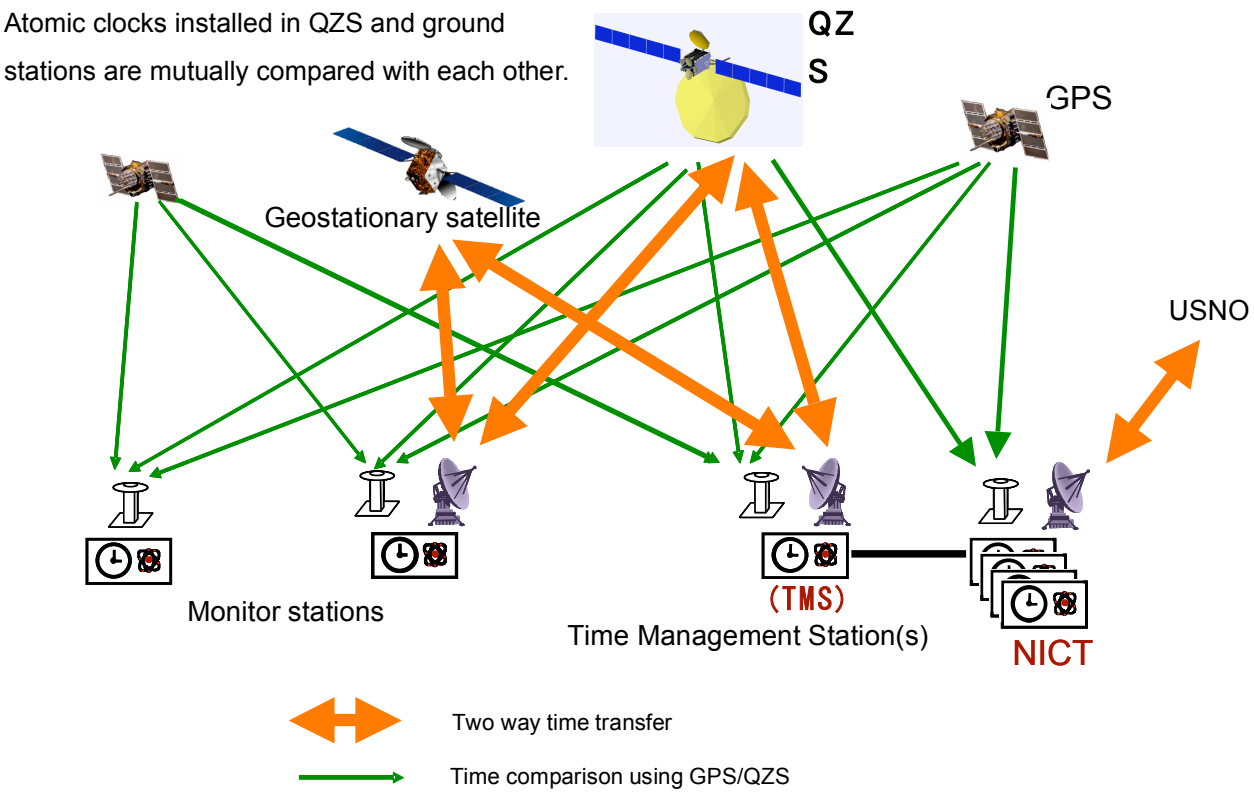

Fig.2 Time management system in QZSS

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