Space-Time Standards Laboratory

# Japan Standard Time Service Group

Radio Research Institute, Electromagnetic Advanced and Infrastructure Research Center

## *Japan Standard Time Service Group—Generation, Comparison, and Dissemination of Japan Standard Time and Frequency Standards*



NICT National Institute of Information and Communications Technology

National Institute of Information and Communications Technology

*The National Institute of Information and Communications Technology (NICT) is responsible for the important tasks of Generation, Comparison, and Dissemination of Japan Standard Time and Frequency Standards, which have a direct impact on people's lives. In this brochure, we first explain how International Atomic Time and Coordinated Universal Time are calculated. We then look at how the standard time all over the world, including Japan Standard Time, is generated based on them. Finally, we introduce three major functions of the Japan Standard Time Service Group: Generation, Comparison, and Dissemination of Japan Standard Time.*

# What is the Time?

## ■ Definition of a Second

Definition of a second: The duration of the unit "second" was first defined according to ephemeris time, which is tied to the rotation and orbital motion of the Earth. Since 1967, however, the second has been defined in terms of the frequency of atomic radiation under the International System of Units (SI). The second is defined in the SI as "the duration of 9 192 631 770 periods of the radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom."

## ■ International Atomic Time (TAI)

The time scale created by atomic clocks is referred to as atomic time.

The International Atomic Time (TAI) was synchronized with (Universal Time 2) (UT2) at 0:00 on January 1, 1958, and the two have since drifted apart. TAI is decided by calculating a weighted average time of atomic clocks around the world.

## ■ Coordinated Universal Time and Leap-Second Adjustment

Our daily lives are governed by the apparent motion of the Sun. Since the time scale used in measuring time is atomic time, there is a need for an atomic time that is close to Universal Time (UT).

This atomic time is called Coordinated Universal Time (UTC).

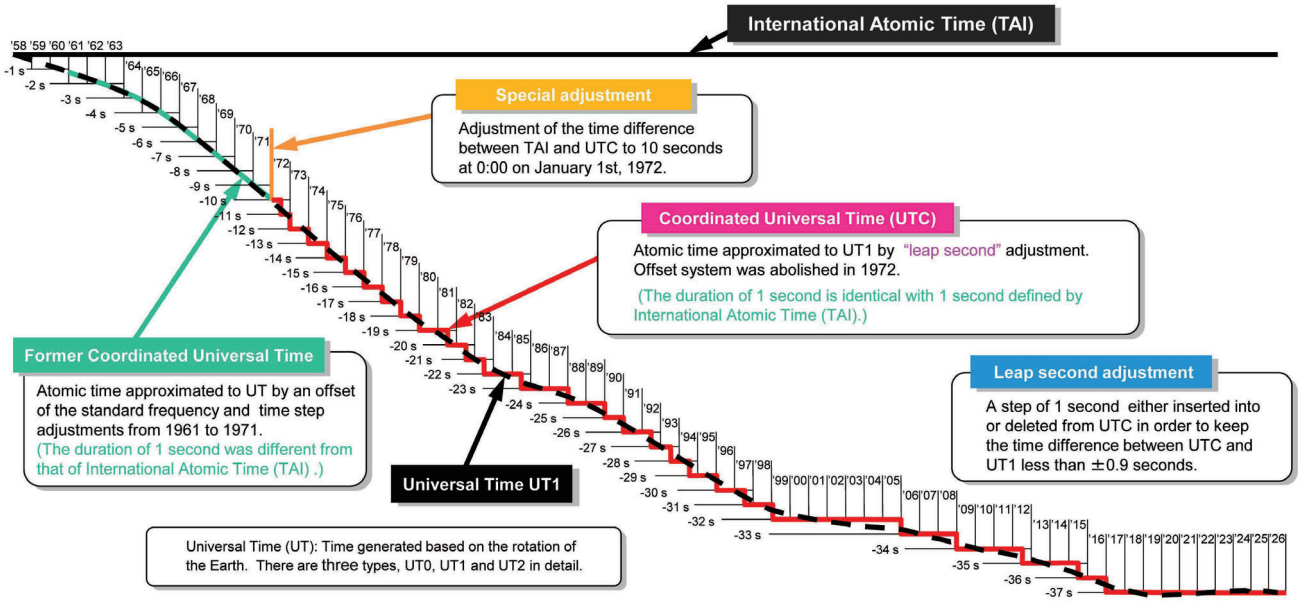
As the angular velocity of the Earth is affected by natural phenomena such as tidal friction, the mantle, and the atmosphere, a time difference between UT and UTC is fluctuated. Therefore, to keep the time difference between UTC and UT within 0.9 seconds, "one second" is either inserted into or deleted from UTC.

This one second is referred to as a "leap second."

Leap-second adjustment was introduced after a special adjustment was carried out in 1972. Leap-second adjustments have been performed 27 times from 1972 to January 2017. All adjustments so far have involved inserting one second to UTC, and UTC is now 37 seconds behind TAI.

## ■ Japan Standard Time (JST)

Japan Standard Time (JST) is defined to set 9 hours forward of UTC(NICT); the meridian line of Japan is at 135 degrees eastern longitude.



# Generation of JST

## Atomic Clock

JST is obtained using about 18 cesium atomic clocks and four hydrogen masers in accordance with the definition of the second as mentioned above.

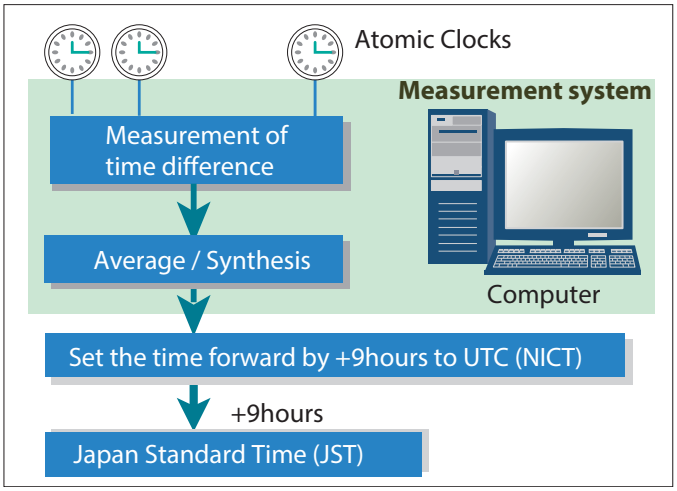
Cesium atomic clocks are good for long-term (longer than 5 days) stability and hydrogen masers are good for short-term (shorter than 5 days) stability.

The frequency (i.e., the number of oscillations per second) of each atomic clock is easily affected by environmental conditions such as temperature, humidity, and the geo-magnetic field.

To stabilize the frequency, atomic clocks are mounted in temperature-and-humidity controlled "Clock Rooms" with electromagnetic shielding. Furthermore, each atomic clock is connected to an uninterruptible power supply unit in case there is a power outage.

NICT has developed a strontium optical lattice clock which is more accurate than microwave-based clocks.

From 2021, the lattice clock contributes to the JST generation.




**TAI [International Atomic Time]**

determined by the International Bureau of Weights and Measures (BIPM)

**UTC [Coordinated Universal Time]**

determined by the BIPM

**UTC(NICT)**

determined by the NICT

**JST [Japan Standard Time]**

set 9 hours forward to UTC (NICT)

(Left) Hydrogen maser clock (Right) Cesium atomic clock

## Generation of JST

Mutual time differences of cesium atomic clocks and hydrogen masers installed in the headquarters in Koganei, the sub-station in Kobe, and LF stations are regularly measured every second by a specific measurement system. (The sub-station and LF stations are described in later.) UTC(NICT) is UTC generated by the National Institute of Information and Communications Technology (NICT) from averaging and synthesizing data obtained from atomic clocks once an hour. This series of procedures for generating JST is fully and automatically performed by computers. Three redundant units (the main unit and backups) work in parallel, ensuring the continual generation of JST in the event of equipment failure.

## Establishment of Distributed Structure

Until 2018, the generation of JST was carried out only at the NICT headquarters in Koganei, Tokyo. However, at the time of emergency, such a serious natural disaster, in Tokyo, the operation of JST in headquarters might be stopped due to infrastructure damage.

To increase reliability, therefore, we are promoting research and development for decentralization of the JST facilities. As the first step, JST substation was established in Kobe, Hyogo on June 10, 2018.

The equipment for JST substation, including cesium atomic clocks and high precision satellite time and frequency transfer systems, were installed there. The two accurate time scales generated in Tokyo and Kobe are always compared. At the emergency of Tokyo, Kobe Substation can function as the main JST station instead of the NICT headquarters.

We also developed a technology to consolidate multiple time scales from clocks in all JST facilities including LF stations. The new technology improves the reliability of JST time scale in emergency situations.

# Comparisons with JST

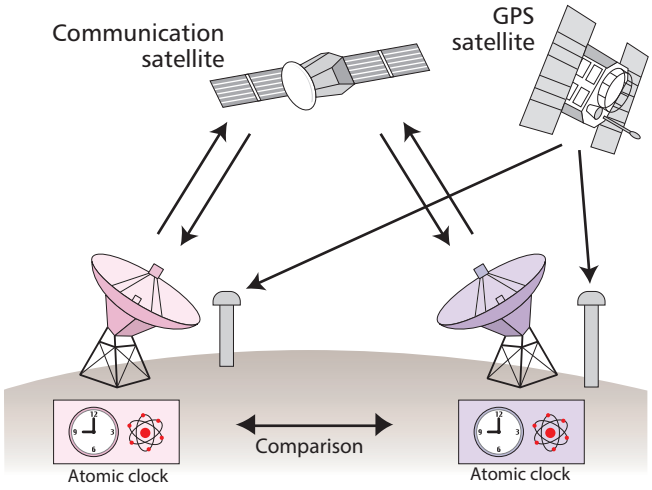
## Comparison of UTC and JST

The NICT manages UTC(NICT) to approximate UTC and decrease the time difference between UTC and UTC(NICT) within ±10 nanoseconds (1 nanosecond = 1/1,000,000,000 seconds). To make this adjustment, highly precise international time comparison methods using Global Navigation Satellite Systems (GNSS) such as Global Positioning System (GPS) and communication satellites are implemented.

Standards institutes around the world manage their standard times, and each institute reports time information for each atomic clock in terms of time differences to Bureau International des Poids et Mesures (International Bureau of Weights and Measures) [BIPM]. BIPM decides the TAI and UTC on the basis of the data collected from each country.

## International Comparison

The NICT adopts two methods in making precise international time comparisons.

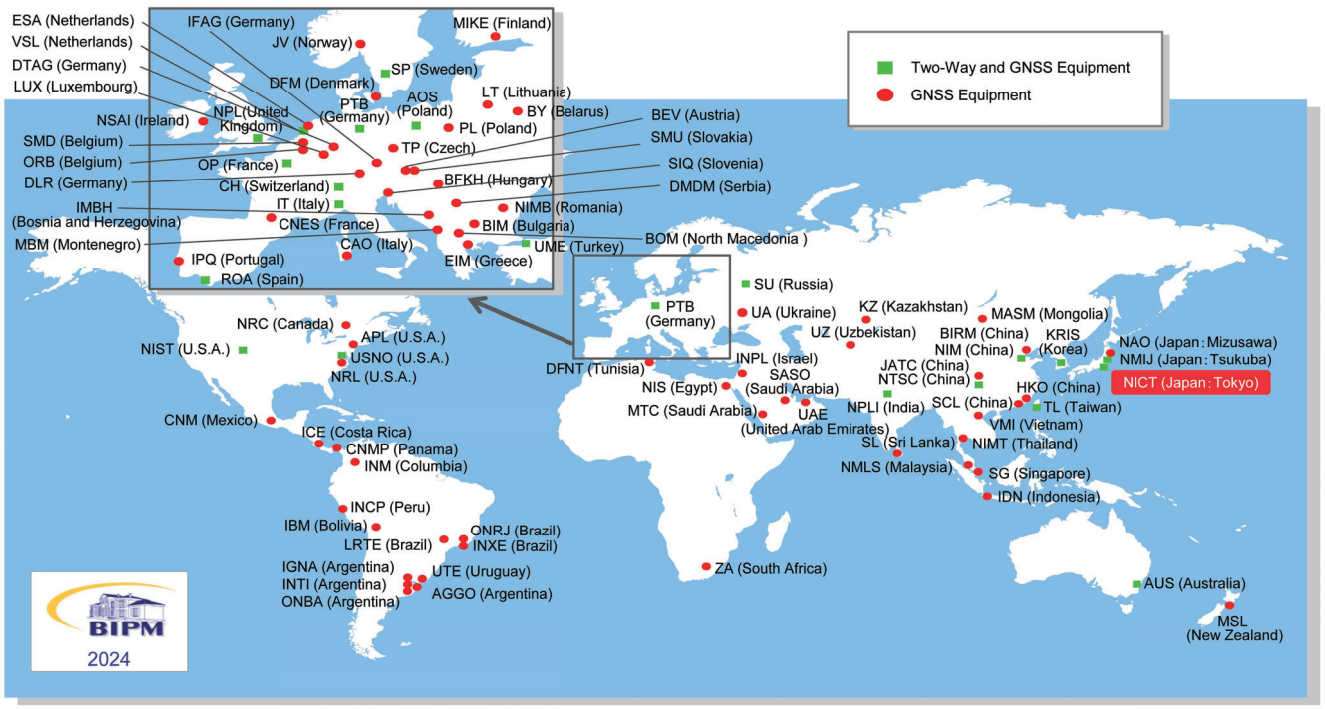



(1) Time comparison using GNSS:
It is possible to obtain the difference between time information transmitted by positioning satellites such as GPS and UTC generated by each institute maintaining atomic clocks.
UTC(NICT) and UTC obtained by each institute are compared using time information of satellites as an intermediary in the calculations. The times reported by two standard stations are compared with precision of about one-hundred millionths of a second to even ten billionths of a second.

(2) Time comparison using communication satellites:
Two stations simultaneously transmit time information using communication satellites, and the time difference is calculated. The precision of this time comparison is about one billionth of a second to ten billionths of a second.

Nowadays, many highly precise time comparisons are made using the two methods.

Geographical distribution of the laboratories that contribute to TAI and time transfer equipment (2024)



# Dissemination of JST

## ■ Low-Frequency Standard Time and Frequency Transmission Stations

The standard time and frequency transmission (JJY*) is a radio wave used to supply standard frequencies and JST throughout Japan. Radio-controlled watches and clocks are now widely used by the general public and they synchronize with JST by receiving this standard radio wave.

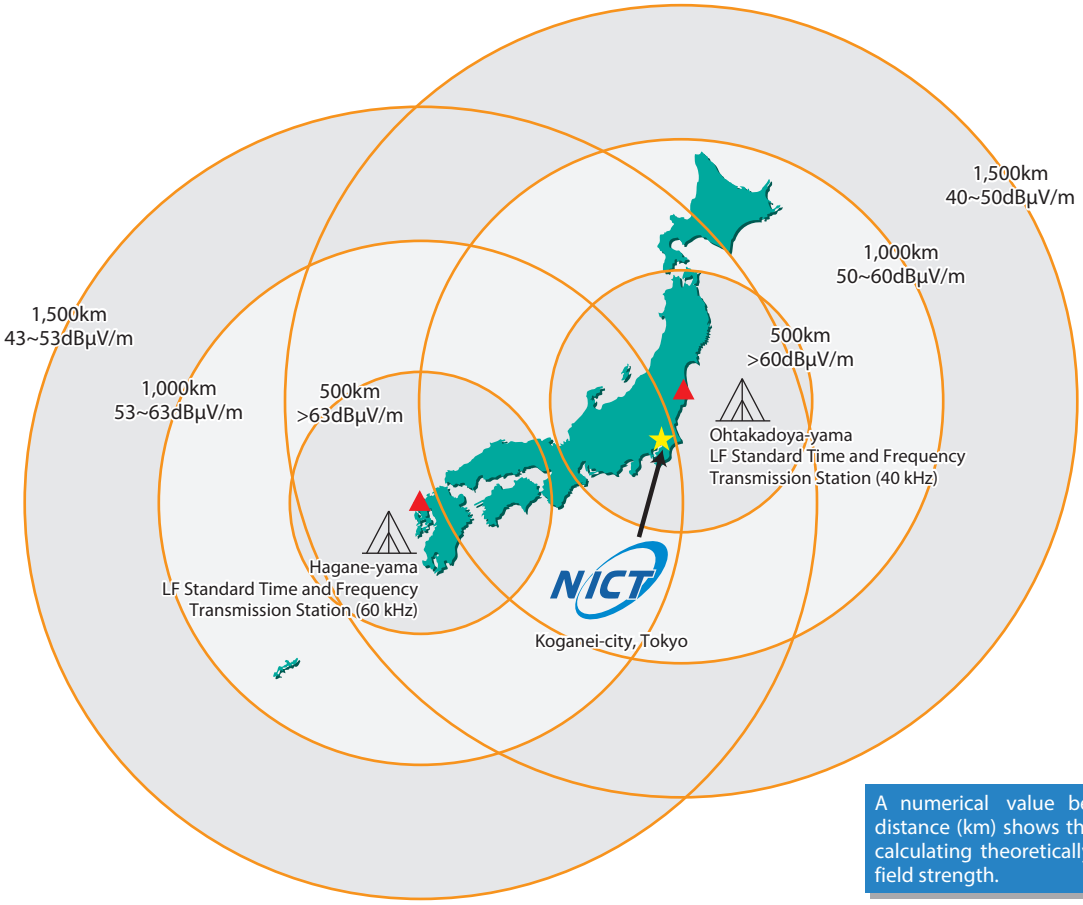
The first operational station, namely the Ohtakadoya-yama Low-frequency (LF) Standard Time and Frequency Transmission Station, started transmitting a standard wave (40 kHz) in June 1999. To provide a back-up and strengthen the signal in southwestern Japan, the Hagane-yama LF Standard Time and Frequency Transmission Station commenced transmission of a standard wave (60 kHz) in October 2001.

An LF standard time and frequency transmission signal includes a time code giving the minute, hour, day of year (counted from January 1), year (last two digits of the dominical year), and day of week. This time code is used for reception devices such as radio-controlled clocks with automatic time correction functions. The time code signal is expected to be used in a wide range of applications, such as clocks in home electronic appliances, cameras, and automobiles, and the built-in clocks of measuring instruments and seismometers. The standard frequency supplied by the LF standard time and frequency transmission signal is also expected to serve as a precise frequency standard for a variety of applications, such as measuring instruments, communication devices, master standard devices of electronic manufacturers, and standard oscillators used in ground-based digital broadcasting.

Although the LF standard time and frequency transmission signal has ordinarily been transmitted for 24 hours a day, it may temporarily be suspended because of maintenance checkups of devices and antennas, or in the event of possible lightning.

The status of transmission is announced on the websites.
**https://jjy.nict.go.jp**
**https://www.nict.go.jp/sts/**

*JJY is the call sign of the radio station and is a registered trade-mark (T4355749) of the NICT.




A numerical value below each distance (km) shows the value by calculating theoretically assumed field strength.

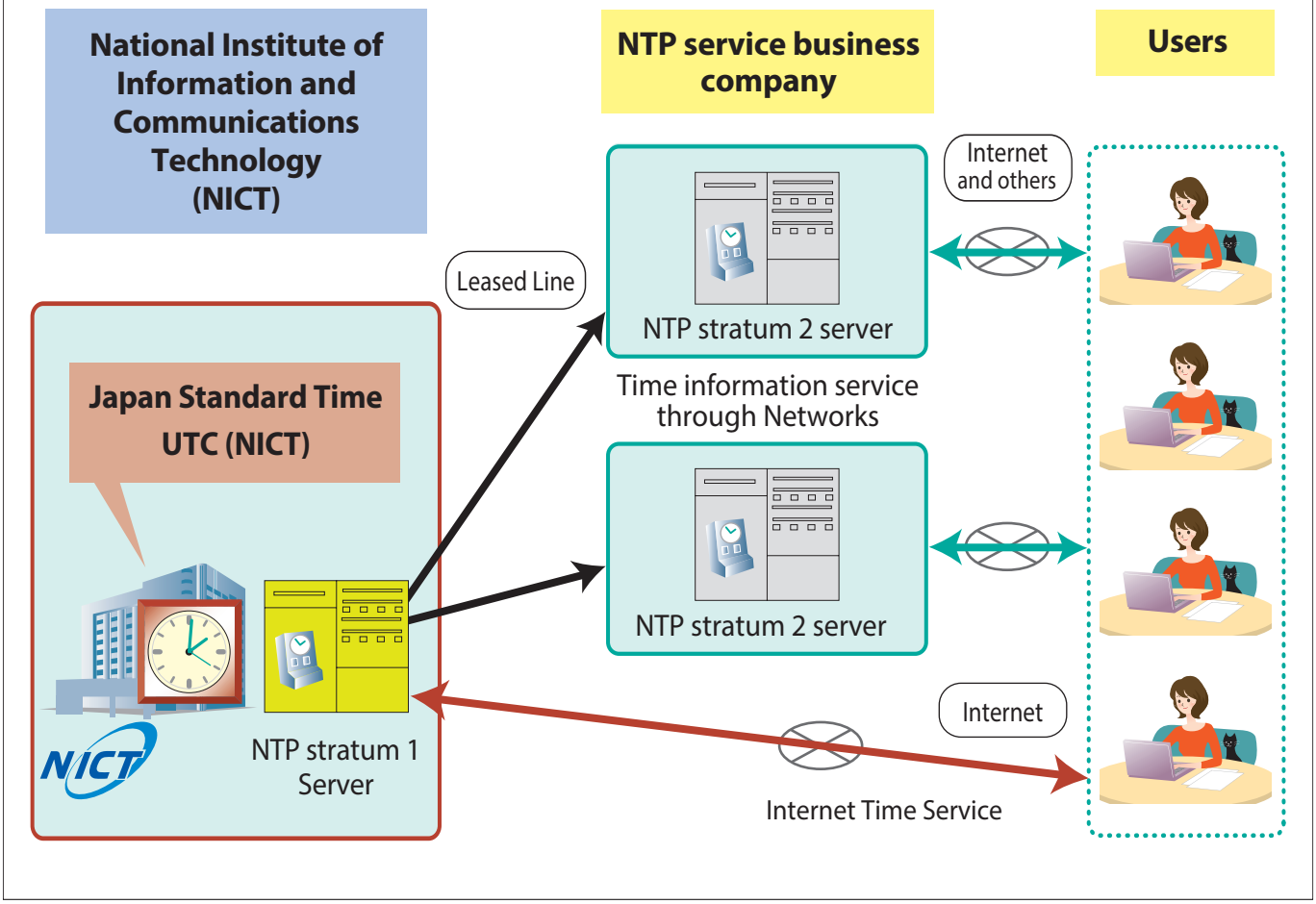
## Internet Time Service

In today's computerized society, most computers transfer many data via networks. During these processes, the file update time is usually defined by the built-in clocks of individual computers. These built-in clocks of personal computers, however, are not highly precise, and so, without regular periodic time synchronization, inconsistencies tend to occur in file information. Therefore, the NTP (Network Time Protocol) is widely used to synchronize the times of networked computers.

The Japan Standard Time Service Group (JSTG) offers "Time Information Service by Networks" to the time-dissemination enterprises authorized as Time Businesses, and Internet-related corporations.

Through this service, stable time information is provided by directly connecting users' servers with an NTP server linked up with JST. The JSTG also offers an "Internet Time Service" to general users so that they are also able to use an NTP server (ntp.nict.jp) that links up with JST.

### Architecture of Time Information Service through Internet



## Hikari Telephone JJY Service

For higher precision and stability of time dissemination, The NICT developed Hikari telephone JJY, and Hikari telephone JJY has been in official operation since February 2019.

Unlike the Internet, Hikari telephone JJY uses the Data Connect service of the Hikari Denwa Line, which enables secure communications by one to-one connection using phone numbers. It also uses high-speed data communication to stabilize the time supply accuracy and reduce communication charges. In addition, the installation of a host system at the headquarters and substation (Kobe City) suppresses the risk of service outages due to failures, disasters, etc. For the supply of standard time, a dedicated hardware NTP server developed by NICT is used, and by modifying the protocol, it has a function to provide daylight saving time and other information as needed in the future.

To use Hikari telephone JJY, you will need a Data Connect service, a Data Connect service-enabled router, and a time synchronization device. And an application is required to use Hikari telephone JJY.

For more information, please visit our website below.

**https://jjy.nict.go.jp** (Japanese version only)

**https://www.nict.go.jp/sts/**

Hikari Telephone JJY System

## Calibration Service of frequency standard

As part of the standard frequency dissemination activity, NICT provides calibration services of the frequency standard. Broadcasting stations and radio stations should broadcast and communicate with accurate radio frequencies, as stipulated in Radio Act.

By calibration of their frequency standards with respect to the national frequency standard maintained by NICT, we contribute to citizen's life.

The types of frequency calibration services are as follows.

1) Calibration based on the Radio Act
2) Calibration based on Article 135 of the Measurement Act (jcss* calibration)
3) Calibration based on CIPM**-MRA*** (ASNITE****calibration)
4) Commissioned calibration

*jcss : Japan Calibration Service System using National Standard
**CIPM : International Committee for Weights and Measures
***MRA : Mutual Recognition Arrangement
****ASNITE : Accreditation System of National Institute of Technology and Evaluation

In 2), NICT is a designated calibration organization authorized by the Minister of Economy, Trade and Industry. We issue calibration certificates to a client necessary for operating as a registered operator stipulated by the Measurement Law.

In 3), our calibration system is accredited in accordance with the international standard ISO / IEC 17025 : 2017 (JIS Q 17025 : 2018). Based on it, we issue a calibration certificate that supports international mutual recognition.

In addition to frequency calibration, short-term stability measurement service is also available in the type 4).

For more information, please visit our website below.

Calibration Service : **https://cal.nict.go.jp** (Japanese version only)

Frequency Standard Calibration System

# An Information Technology Society

## ■Electronic Time Authentication

The concept of incorporating precise time into advanced information society is referred to as new words “time business” which mainly consists of “time dissemination” and “time authentication” business. The IT community has been encouraged to adopt precise time; e.g., as a timestamp. A Japanese law concerning reliability of electronic documents (commonly called "e-documents law") which came into effect in April 2005, requires time stamps to be put on electronic documents to certify that they have not been altered, and it is inevitable for precise time information to be used for the time stamps.

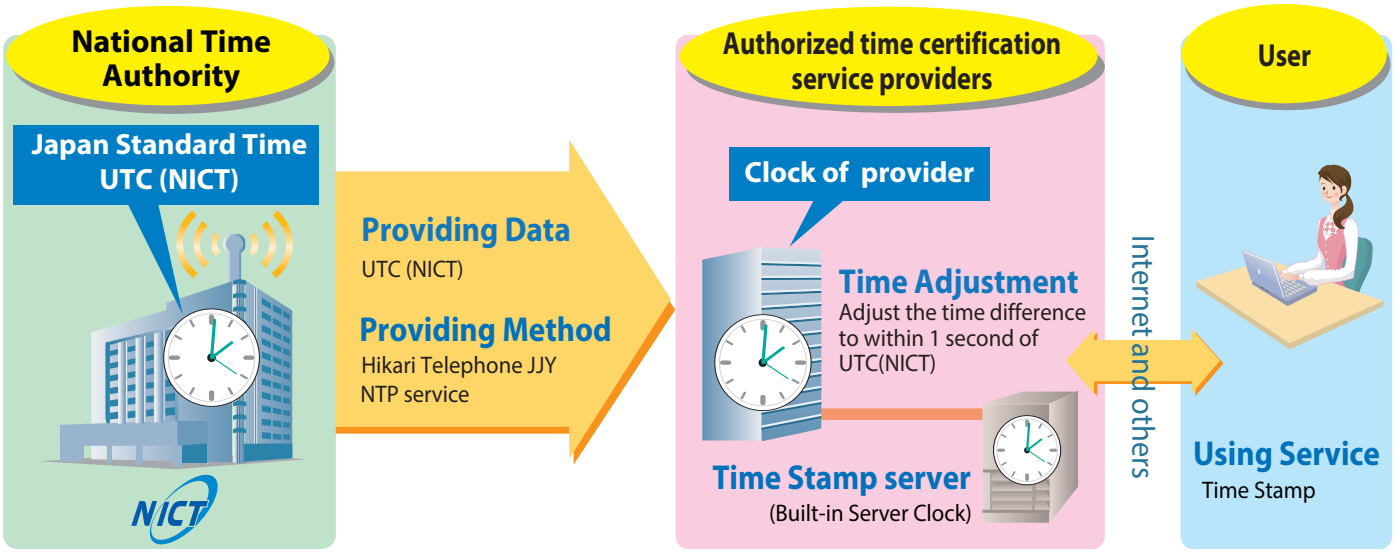
In response to the needs of society, the JSTG began disseminating JST, which is internationally traceable and widely available in the general public, in an easy-to-use format for issuing time stamps in February 2005. This has made it possible to use precisely and socially authorized electronic time information.

At the beginning of this service, time stamps were issued only through a certification system by a voluntary organization. However, the system ended in March 2024 and was replaced by a national certification system that began in July 2021 in response to trends in other countries.

As shown in the figure below, NICT, as a National Time Authority (NTA), disseminates JST to the authorized time certification service providers. The authorized time certification service providers maintain their timescale so that the difference between their own clocks and JST is within one second. As a result, a system has been built in which time traceable to JST is disseminated (time stamps are provided) to users.

Further, JST is disseminated to the authorized time certification service providers, using the Time Information Service by Networks and the Hikari telephone JJY by the JSTG.

And the JSTG has promoted the use of traceability chains of UTC(NICT) to the authorized provider and the structure of the time dissemination, and the audit carried out by the authorized provider. Technical requirements for the authorized provider have been established in Japanese Industrial Standards (JIS X 5094) and also established in ISO/IEC 18014-4 by the International Organization for Standardization.




National Institute of Information and Communications Technology
Radio Research Institute, Electromagnetic Advanced and Infrastructure Research Center
Space-Time Standards Laboratory, Japan Standard Time Service Group
4-2-1 Nukui-Kitamachi, Koganei, Tokyo 184-8795 Japan
URL: https//jjy.nict.go.jp E-mail: horonet@ml.nict.go.jp Tel: +81-42-327-6985 Fax: +81-42-327-6689

The 1st edition: October 2004
Revised: May 2026