Space-Time Standards Group

Japan Standard Time Project

National Institute of Information and Communications Technology, an Incorporated Administrative Agency

Japan Standard Time Project-the Generation, Comparison, and Dissemination of Japan Standard Time and Frequency Standard

NiCT National Institute of Information and Communications Technology

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 the life of the people. At first, International Atomic Time and Coordinated Universal Time are described. The standard time all over the world, including Japan Standard Time, is generated base on them. Then, three major functions of Japan Standard Time project -- Generation, Comparison, and Dissemination of Japan Standard Time-- are introduced.

What is the Time?

Definition of a Second

Definition of a second: The duration of the unit "second" was first defined based on an ephemeris time, which is tied to the rotation and the orbital motion of the earth. The definition in terms of frequency of atomic radiation was replaced with the International System of Units (SI) in 1967.

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 the atomic clocks is referred to as atomic time.

TAI was inaugurated its origin at 0:00, January 1, 1958, at 0:00 by synchronizing to UT2.

The TAI is decided by calculating a weighted average of the times of atomic clocks in the world.

Coordinated Universal Time (UTC) and Leap Seconds

Our daily lives are deeply related to the motion of the Sun. Time scale used in daily life is atomic time. Therefore, Atomic time should bring close to Universal Time (UT).

This is called the Coordinated Universal Time (UTC).

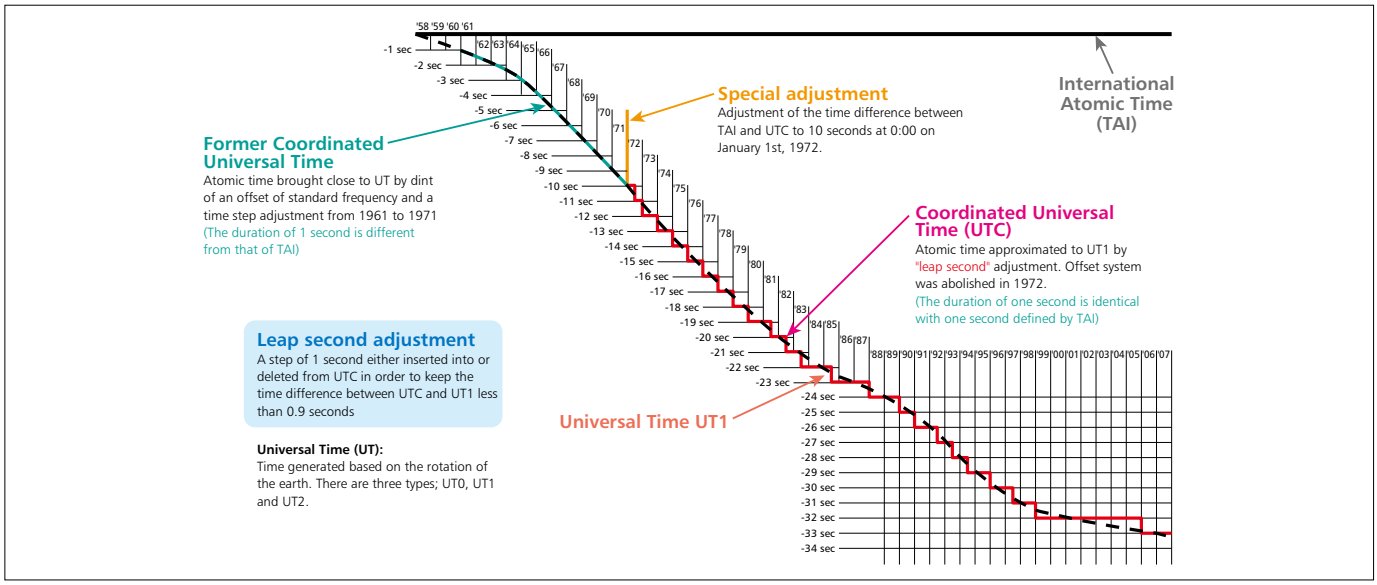
Since the rotation of the Earth is influenced by natural phenomena such as tidal friction, time difference between UT and UTC is apt to occur. Therefore one second is either inserted into or deleted from UTC in order to keep the time difference between UTC and UT below 0.9 seconds.

This is referred to as a "leap second."

Leap second adjustment was introduced to UTC after the special adjustment carried out in 1972. Leap second adjustments were performed 23 times from 1972 to January 2006. All adjustments were done by inserting a second to the UTC so far, and now the UTC lags 33 seconds behind the TAI.

Japan Standard Time (JST)

JST is set forward 9 hours (time difference due to the location at 135° east longitude) to UTC (NICT).



Generation of JST

The Atomic Clock

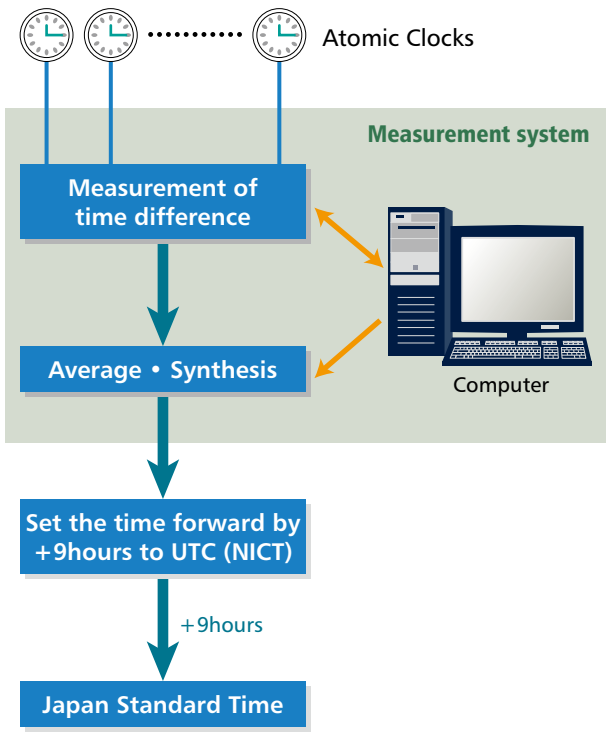
Japan Standard Time (JST) is generated by using a maximum of 18 sets of cesium atomic clocks and 4 hydrogen masers in accordance with the definition of one second mentioned above.

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

The frequency (the number of oscillations per second) of each atomic clock is easily influenced by the environmental conditions such as temperature, geomagnetic field and others.

To prevent the frequency from changing, the atomic clocks are mounted in temperature- and humidity-controlled "Clock Rooms" with electromagnetic shielding. Furthermore, each atomic clock connects with an uninterruptible power supply unit in case of a power outage.

Flow of Time Generation



(Left) Hydrogen maser (Right) Cesium atomic clock

Generation of JST

The mutual time differences of the cesium atomic clocks and hydrogen masers mounted in 4 "Clock Rooms" are measured regularly with a specific measurement system. UTC (NICT) is generated by averaging and synthesizing (frequency control) the times of atomic clocks once a day.

This series of procedures for generating JST is fully and automatically performed by several computers. Redundant units (main and backup) work in parallel to generate the time, ensuring continual measurement of JST even in the event of an incident such as equipment trouble.

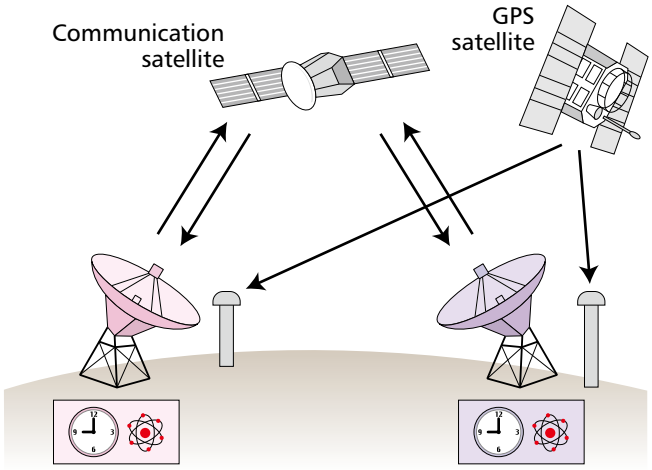
TAI (International Atomic Time)
determined by the International Bureau of Weights and Measures (BIPM)

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)

Comparison of JST



Comparison with International Time

There are two methods to compare International Time: One is performed by GPS satellites constructed in the U.S.A. Another is by communication Satellites.

GPS satellites mount highly accurate atomic clocks and are used all over the world. Car navigation systems are typical and popular for the general user. The radio waves transmitted from GPS satellites contain time information, and this is the GPS time. By receiving this GPS time and comparing it with the clocks settled in each station, the time difference between the GPS time and the local station time can be measured.

Standard organizations in the world perform these GPS time comparison by common-view method.

Calculating the data obtained by each standard station makes it possible to measure the time difference between GPS time and each standard clock.

With the use of simultaneously observed data, time comparison between two standard stations is made with a precision of one hundred-millionths or even billionths of a second.

Another time comparison is done by the communication satellite. Our project collaborates with other standard organizations, National Institute of Advanced Industrial Science and Technology (AIST), Germany, Australia, U.S.A, China, Taiwan, Korea, and Singapore, in continuous experiments on regular Two-Way Satellite Time and Frequency Transfer (TWSTFT) using commercial communication satellites.

Each station sends time information respectively through communication satellite and uses it to calculate time difference between stations.

With the above method, time comparison is made with a precision of one billionth to ten-billionths of a second.

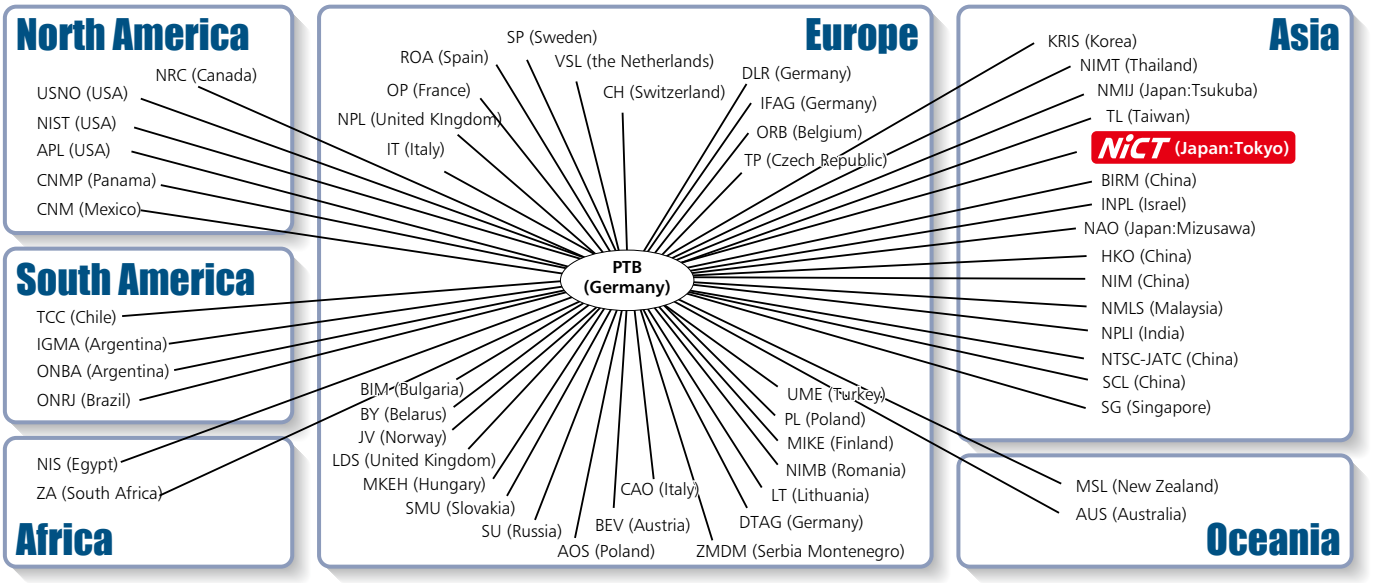
International Comparison of UTC

The both data of the time comparison between GPS time and UTC (NICT) obtained regularly, and that of TWSTFT are sent to the International Organization of Weights and Measures (BIPM) in France.

At the BIPM, International Atomic Time (TAI) and Coordinated Universal Time (UTC) are determined based on the time comparison data obtained, with the same method, by the organizations all over the world..

The UTC (NICT) is generated and maintained in order to keep the difference between the UTC and the UTC (NICT) below ± 10 nanoseconds (1 nanosecond = 1/1,000,000,000 second).

Network of International Time Comparison to establish International Atomic Time (as of April 2006)



Dissemination of JST

Low-Frequency Standard Time and Frequency Transmission Stations

The standard time and frequency transmission (JJY*) is a radio wave to supply the standard frequency and JST throughout Japan.

The primary clock of broadcast stations and telephone is synchronized with JST by reception of this standard radio wave.

Ohtakadoya-yama LF Standard Time and Frequency Transmission Station has transmitted the standard wave (40 kHz) since June 1999.

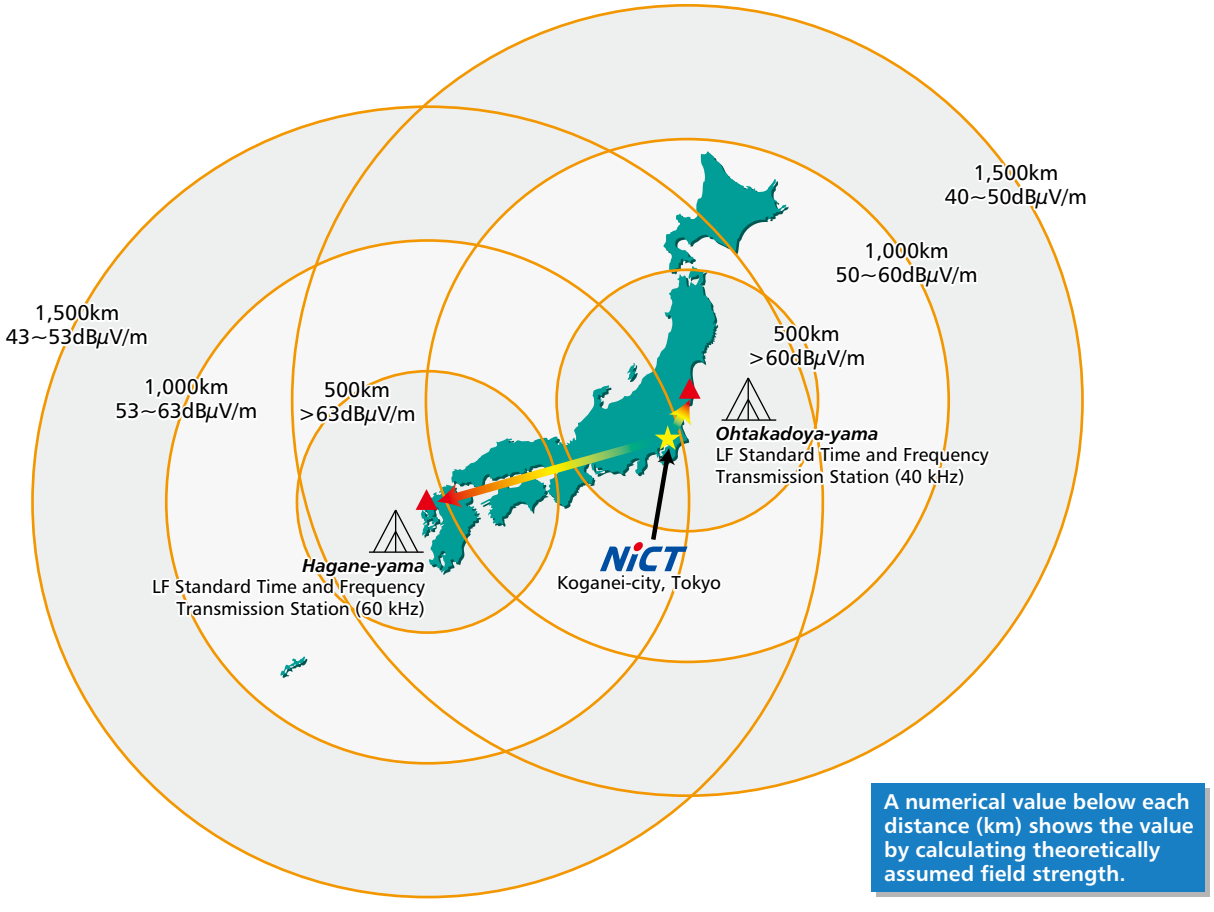
Hagane-yama LF Standard Time and Frequency Transmission Station has transmitted the standard wave (60 kHz) since October 2001.

The LF standard time and frequency transmission signal includes a time code which contains the following information; minute, hour, annual date (counted from January 1), year (last 2 digits of the dominical year), and day of the 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 contribute to a wide range of applications, such as clocks in home electronic appliances, cameras, automobile clocks, 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: measuring instruments, communication devices, standards for the master standard devices of electronic manufacturers, standard oscillators of ground-based digital broadcasting, and highly precise frequency standards.

For your reference: although the LF standard time and frequency transmission signal has ordinarily been transmitted for 24 hours a day, it may temporarily be interrupted because of maintenance work on devises and antennas, or measures against lightning storms.

* JJY is a call sign of the radio station and forms a registered trademark (T4355749) of NICT.



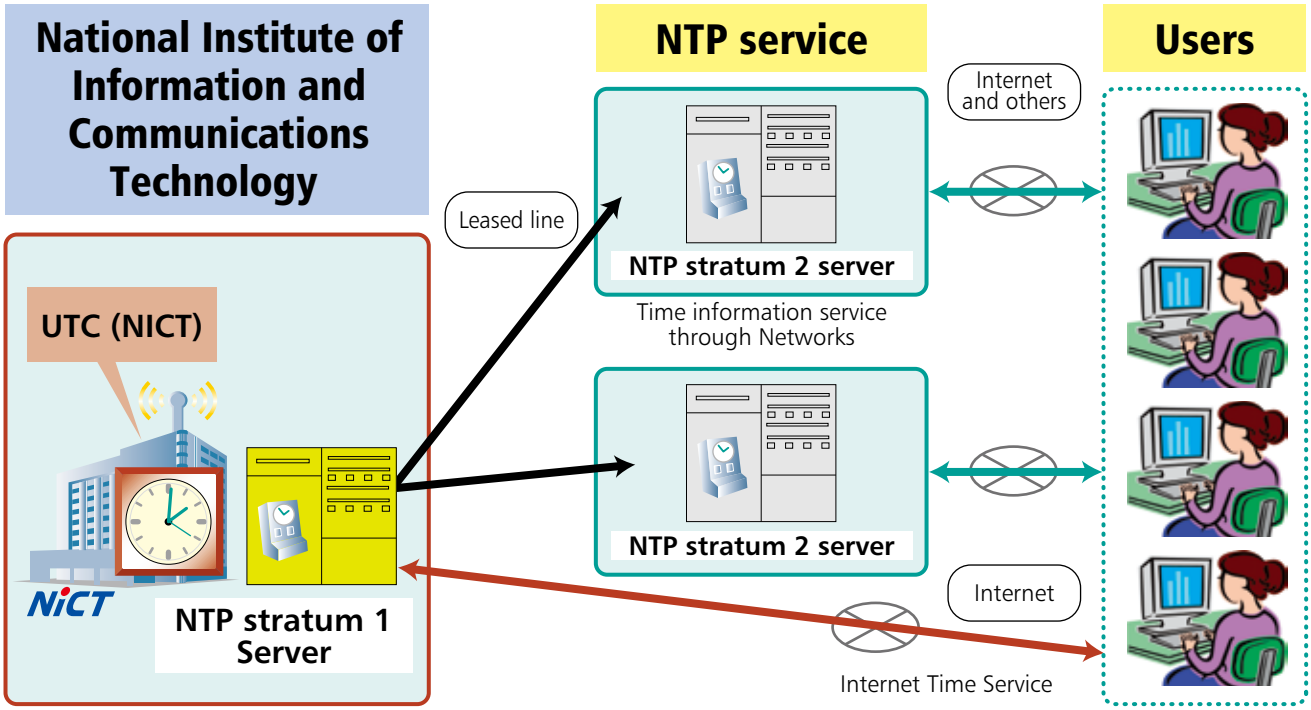
A numerical value below each distance (km) shows the value by calculating theoretically assumed field strength.

Internet Time Service

In today's computerized society, most computers transfer every data via networks. During these processes, file update times are usually defined by the built-in clocks of the individual computers. However, these built-in clocks of PCs are not highly precise, and so, without regular periodic time synchronization, inconsistencies are bound to occur in file information. Therefore, the use of NTP (Network Time Protocol) has spread so as to synchronize the time of networked computers.

Our project offers "Time Information Service by Networks" to time-dissemination enterprises authorized as Time Business, and internet related corporations.
Through this service, stable time information is provided by directly connecting users' servers with NTP server linking to JST.
We offer Internet Time Service so that the public are also available to use NTP server.

Architecture of Time Information Service through Internet



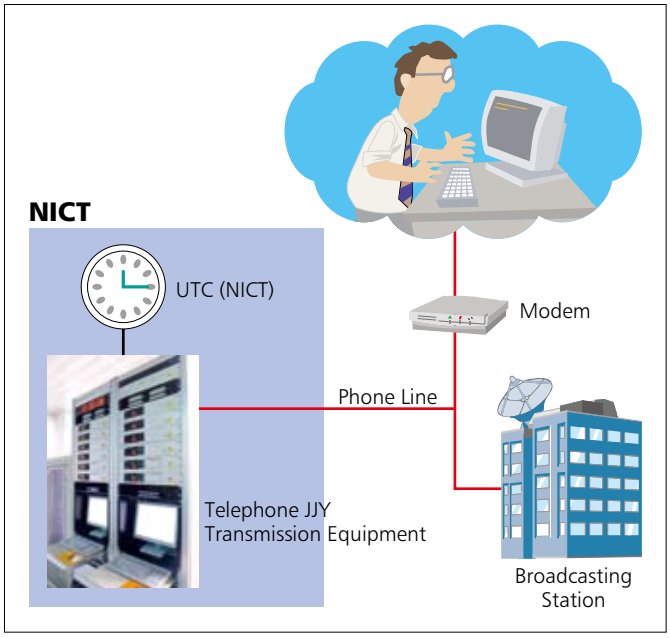
Telephone Time Service

Conventionally, HF standard transmissions were widely used to synchronize clocks for business applications, such as the master clocks of broadcasting stations. However, on Aug. 1, 1995, a new system came into operation, supplying a high-precision time signal electronically via analog telephone lines (telephone JJY).
A personal computer, a modem, and commercial communications software are all that a user needs to acquire time information with precision adjustment for delays in the telephone line.

Dedicated receivers for business use perform time synchronization using JST with a precision of less than one millisecond, equivalent to the precision of conventional business-use HF receivers, by measuring and correcting the delay in communication lines using the bi-directional telephone connection. Dedicated receivers are widely used in business, especially at broadcasting stations.
Instructions are given on the next page.
Nothing is required to register for using. The service is free of charge.

Parameters for Telephone JJY

- **Telephone number of the accessed site:**
  +81-42-327-7592
- **Communication rates, etc:**
  300/1200/2400bps, 8bit, non-parity, SJIS
- **ID (Name?):**
  TJJY
- **Information:**
  Time information and year, month, day, etc.
  (in JST or UTC)
- **Function:**
  Communication line delay measurement using the loop-back function
  (to be performed by the user)
- **Reference:**
  After authentication, type HELP [Enter] to view the available commands and functions.



Calibration of the Frequency Standard

As part of our duty of providing the standard frequency, our project performs the frequency standard calibration. The frequency deviation of the frequency standard is measured against the national frequency standard.

Calibration of frequency standard

1) Calibration in compliance with the Radio Law

2) Calibration in compliance with the Measurement Law (jcss calibration)

3) Commissioned calibration

a) Calibration of frequency standard (carried in)

b) Remote calibration (conducted by time comparison through GPS satellites)

As for calibration in compliance with the Measurement Law (2), our project is a designated calibration organization authorized by the Minister of Economy, Trade, and Industry, and we issue calibration certificates required by our clients to operate as certified business.

In terms of (3), commissioned frequency calibration, our calibration system was certified to be accordance with the ISO/IEC 17025:2005 (JIS Q 17025:2005) international standard and so is capable of issuing calibration certificates for global Mutual Recognition Arrangements (MRA). (Except for the disciplined oscillators; which transmit frequency by means of synchronizing with external signals.)

As for (3), in addition to commissioned frequency calibration, measurements will also be made of short-term stability.

	Radio Law	Measurement Law	Commissioned
Calibration of frequency standard	Carried-in	Carried-in Remote	Carried-in Remote
Measurement of shot-term stability	N/A	N/A	Carried-in

• "Carried-in" calibration is available • "Remote" calibration is available • "N/A"

Frequency Standard Calibration System

New Initiatives for an IT Society

Electronic Time Authentication

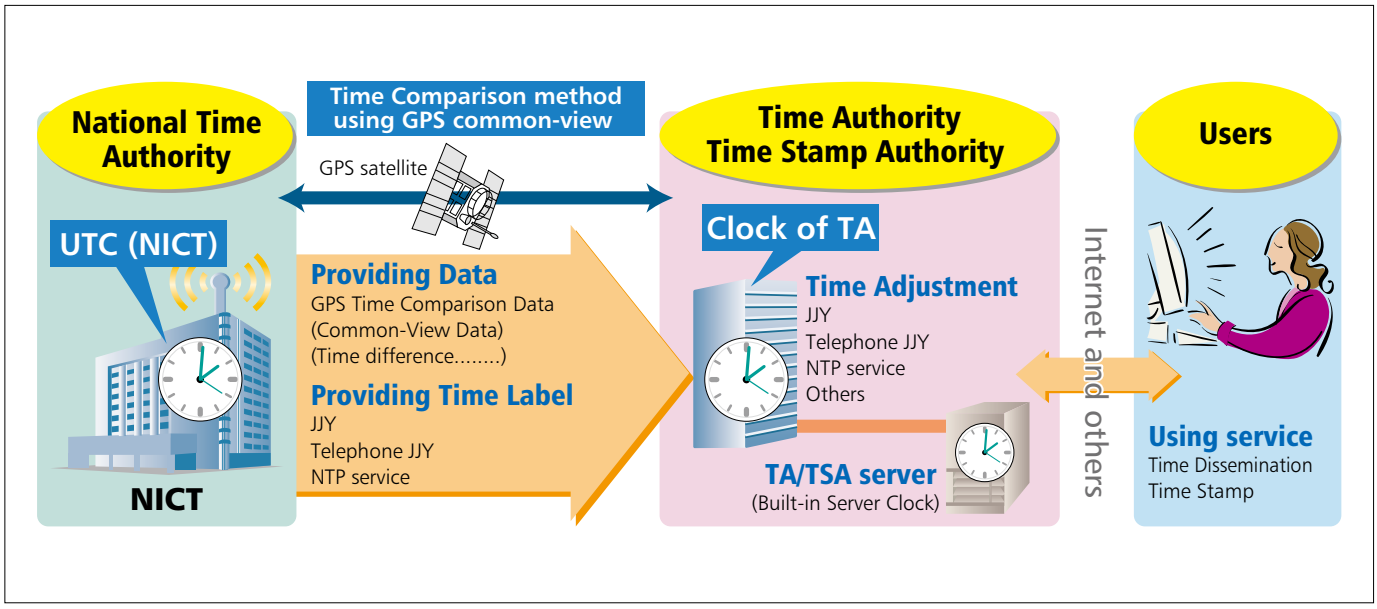
Dramatic progress in electronic commerce and electronic fund transfers, in addition to the launch of the electronic government project beginning in FY 2003, has led to a demand for a precise, publicly authorized time standard for electronic procedures.

The concept relating to time in the IT society is defined as new words "Time Business." Consequently disseminating precise time to the IT society and spreading its use for time stamp and others have been encouraged. The E-documents law, put into operation from April 2005, require time stamps to be put on electronic documents to certify that there is no alteration, on them, and the precise time information is inevitable for the time stamps

Our project started to disseminate Japan Standard Time to the general public from Feb 2005, which is traceable with the Coordinated Universal Time (UTC). This makes it possible to use precisely-and-socially authorized electronic time information.

A system, in practice, is constructed as shown in the figure below: NICT, as the National Time Authority (NTA), publishes the measured data using GPS common-view method on the web, and then provide users the precise time which is traceable to Japan Standard Time via Time Authority "TA" and Time Stamp Authority "TSA."

Since the time comparison method using GPS common-view is possible to measure 1 second with accuracy of 10 nanoseconds but not possible to measure time label itself, Telephone JJY, NTP, and JJY which are performed by NICT are used in order to adjust time label.



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