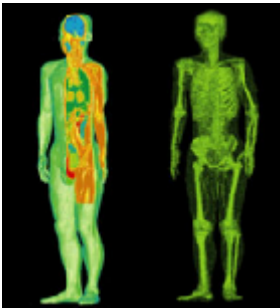


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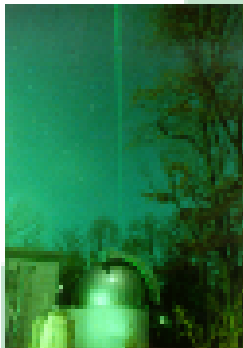
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Numerical modeling of average body shapes of Japanese male and female adults

Taro and Hanako – Human body models offering promising potential in simulating the effects of radio waves on the human body, plus other applications in numerous fields

World's first whole-body female model

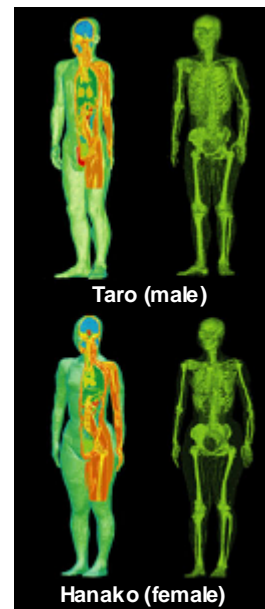
In partnership with Kitazato University, Keio University, and Tokyo Metropolitan University, the National Institute of Information and Communications Technology (referred to as "NICT" below) have created Taro (male; 173.2 cm, 65 kg) and Hanako (female; 160.8 cm, 53 kg) (Fig. 1), human body models generated by numerical modeling of the anatomical structures of volunteers reflecting the average body shapes of Japanese adult males and females. The aim of this development was to facilitate simulation of the effects of radio-waves radiated from mobile phones etc. on human bodies. A numerical female human body model featuring a spatial resolution on the order of a millimeter is unprecedented; [this is the world's first such model](#).

With the recent advance of technologies for radio-wave utilization, such as mobile phones, radio waves have rapidly come into more common use, and this [trend](#) is expected to accelerate in the coming ubiquitous society, including applications in various mobile radio communication instruments. As a result, interest is growing in the impact of radio waves on health. Accordingly, NICT is developing evaluation techniques to determine whether the Radio Radiation Protection Guidelines* are met in various environments in which the human body is exposed to radio waves, and is researching methods of increasing the accuracy of such techniques.

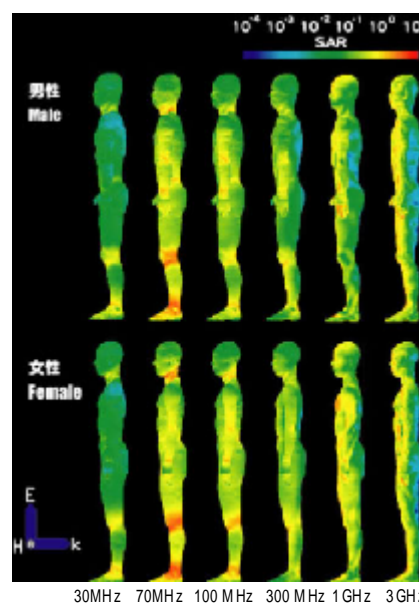
To evaluate radio-wave safety, we must first clarify how much radio-wave energy [is absorbed, and](#) by which part of the human body. [Though](#) embedding sensors in an actual human body is problematic, it is effective to make estimations through simulation using numerical models that imitate the human body. While numerical models of the entire human body had previously been developed by several groups, all of these models were based on anatomical data from Western populations; these models thus differed greatly from the body shapes of Japanese. Therefore, NICT obtained whole-body MRI (Magnetic Resonance Imaging) data from volunteers whose heights and weights matched those of average Japanese adult males and females, enabling the formation of a pair of numerical human body models having Japanese average body shapes. Further, NICT initiated the development of a female model, a task previously considered difficult (due, for example, to the long hours of MRI required). These efforts led to the creation of Hanako, the world's first numerical female human body model.

The numerical human body models Taro and Hanako represent the human body (tissues and organs) through an assembly of approximately eight million (6.4 million for the female model) stacked blocks, 2 mm on a side, comprising 51 tissues and organs (conventional models had provided approximately only 30 to 40). Each block is assigned a number indicating a tissue or organ, such as brain, bone, muscle, or fat. The manner in which radio waves are absorbed by the human body (Fig. 2) can be simulated by assigning to a block the electrical constant corresponding to the relevant tissue or organ. It has been confirmed as a result of [a medical editorial overview](#) and anatomical data analysis that the body-part sizes, organ weights, etc. roughly match those of the average Japanese.

At present, we are continuously improving these models, including the addition of tissue types. At the same time, development is underway [of an](#)



(Fig. 1) [Numerical Human Body Models](#)



(Fig. 2) [Color-coded distribution of radio-wave power absorbed by the human body exposed to radio waves at different frequencies](#)

advanced highly-functional human body model (Fig. 3) capable of being deformed into various body shapes (representing all age groups, from children to the elderly) and postures (e.g., sitting on a chair or talking on a mobile phone), enabling additional simulations etc. A pregnant female model is also under development through adaptation of the female model, in order to simulate the effects of radio waves on a fetus.

In addition to simulating the effects of radio waves on the human body, the numerical human body model holds promise for further applications in a number of fields, including analysis of damage to the human body in traffic accidents, or the creation of radiation therapy programs for cancer patients, through the establishment of the appropriate parameters (e.g., elastic coefficients representing the deformation of a substance in response to an external force, and radiation absorption coefficients) within the model. Consequently, NICT is pleased to release its database free of charge to universities and public research institutes for non-profit research purposes, in order to ensure the widespread use of the numerical human body models in a wide range of research. (For more information, visit <http://emc.nict.go.jp/menu.html>, a webpage offering guidance on the release of numerical human body model data within the NICT site.) Moreover, based on continuing consideration of the possible provision of the database at a fee to private corporations etc., such a service has been in operation since the end of March 2006. For more information, visit the following website: <http://www2.nict.go.jp/pub/whatsnew/press/h17/060328/060328.html>



(Fig. 3) Example of advanced highly-functional human body model

* The above figure shows the female model changing its posture from an upright position

* Radio Radiation Protection Guidelines

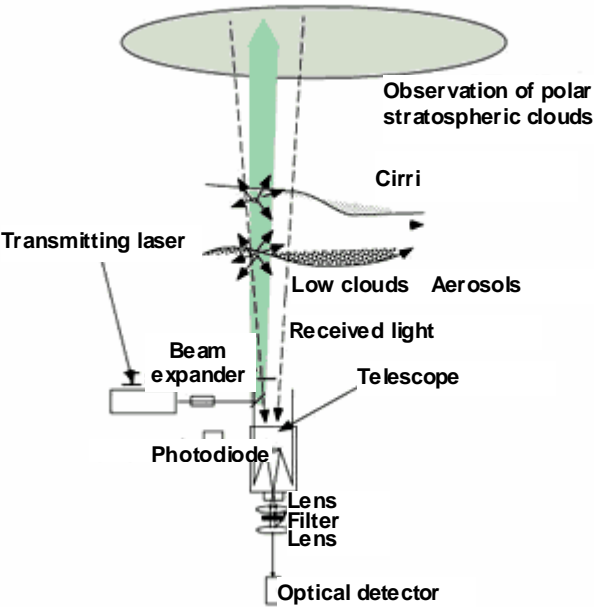
These guidelines define the basic concepts, reference values, etc. enabling judgment as to whether radio-wave emissions are safe. Initially established by the Ministry of Internal Affairs and Communications (formerly the Ministry of Posts and Telecommunications) in 1991, these guidelines were revised in 1997. Although they were originally used as voluntary standards for radio-wave-related industries, the codification of these guidelines into law is now underway in response to growing interest in radio-wave safety.

LIDAR, a laser-based, satellite-mounted atmospheric environment measurement system designed to yield higher precision in global warming prediction and weather forecasting

This system plays an active role in the observation of yellow sand, a phenomenon feared to affect agriculture

NICT is working on research on LIDAR, which measures the atmospheric environment using a laser beam. LIDAR, an acronym for Light Detection And Ranging, is also referred to as laser radar (i.e., optical radar). The system transmits a laser beam into the atmosphere; a telescope is then used to observe the scattered light reflected from fine particles (such as the water particles and aerosols comprising clouds (*1)), and atmospheric molecules and atoms. The system then measures such parameters as the sizes and densities of various substances in the stratosphere and troposphere, and the altitude distribution of wind directions and velocities (Refer to Fig. 1).

[Fig. 1] Measurement of aerosols and other particles with LIDAR



Laser-beam measurement principle

- (1) Distance**
A laser beam is transmitted into the atmosphere, and the time until the reflected light returns is measured, enabling calculation of the distance to the substance that reflected the light. As light propagates through the atmosphere at the speed of approximately 300,000 km per second, the distance to a given substance is 15 km if it takes one ten-thousandth of a second for the reflected light to return after the laser beam transmission.
 - (2) Wind direction and velocity**
Wind velocity measurement using a laser beam is performed based on the optical Doppler Effect (*2). A laser beam is radiated to aerosols or clouds in the atmosphere. The spectra (i.e., light separated by a spectroscop into different wavelengths) of light scattered by substances receding from the observation point show redshifts, whereas those from substances approaching the observation point are blueshifted. Such spectra are measured in three or more directions, thus providing values for the direction and velocity at which the target substances are traveling.
 - (3) Substance size**
The size of a substance is deduced by observing and analyzing the scattering of light when the transmitted laser beam irradiates the target substance. There are differences in scattering characteristics between Mie scattering (*3), caused by a substance comparable in size to the wavelength, and Rayleigh scattering, caused by particles much smaller than the wavelength.
- * In addition to the above, molecular density, temperature, humidity, etc. can also be measured.

■ Observation of wind directions and velocities in the troposphere and stratosphere, improving accuracy in weather forecasting and prediction of global warming

In relation to global warming, which is feared to lead to abnormal climate conditions worldwide as well as adversely affecting agricultural production and the ecological system, the IPCC (*5) provides future estimates and evaluates potential effects. The organization has predicted that the average global temperature in 2100 will rise by 1.4 to 5.8 degrees relative to 1990 levels. However, the accuracy of this prediction is insufficient, with the question as to whether or not warming has already begun remaining unanswered.

A variety of data is required to improve the accuracy of predicting global warming. Wind direction and velocity data, which varies complexly on a global scale, is one of the most important factors.

LIDAR is capable of measuring the altitude distribution of wind directions and velocities in the troposphere and stratosphere (*6, refer to Fig. 3) through observation of the movement of fine substances in the atmosphere. NICT is currently pursuing research in a bid to mount a LIDAR on a satellite and to measure these altitude distributions on a global scale. In such observations, a laser beam is transmitted from the satellite toward the Earth's surface. Here, the effects on humans must be taken into consideration, with the use of a laser beam that is safe for the human eye. Not only will this satellite-mounted LIDAR observe the distributions of clouds and aerosols on a global scale, but it

will also allow for measurement of carbon dioxide, a gas involved in global warming, raising hopes that this system will lead to significantly higher accuracy in the global warming model. Moreover, the LIDAR is capable of global observation of wind distribution from space, suggesting the feasibility of weather forecasting with unprecedented detail and accuracy.

■ **An active role in the observation of yellow sand**

Light reflected from substances not only informs us of wind direction, velocity, and temperature, but also can indicate the substances' sizes, properties, density, etc.

The LIDAR currently performing ground observations at NICT's Koganei Headquarters in Tokyo detects aerosols that strongly disturb the laser beam polarization (*7) in the period from March to April every year. These observations are characteristic of yellow sand.

Yellow sand consists of soil particles blown up to several thousand meters into the higher layers by winds in arid and semi-arid regions such as Taklamakan and Gobi deserts in the northwestern part of China, the yellow-soil zone in the Yellow River Basin; these sands are then carried throughout eastern Asia by the prevailing westerlies. Chiefly causing problems in Japan, South Korea, China, and Mongolia, yellow sand is observed occasionally in Japan from September through October as well as in the period from March to April.

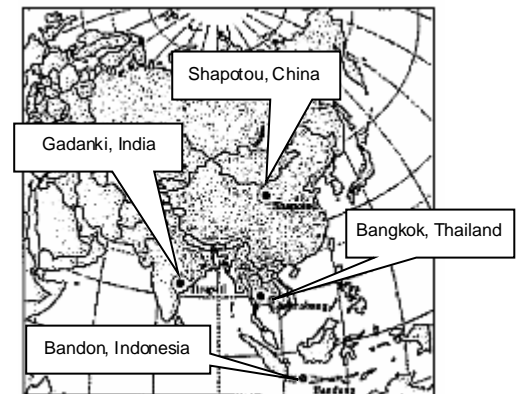
On one hand, substances contained in yellow sand are reported to neutralize acid rain. On the other hand, it has been pointed out that yellow sand adsorbs and carries atmospheric pollutants. Thus there are concerns that yellow sand may damage agriculture in addition to increasing atmospheric pollution, impairing visibility (*8), staining laundry, soiling vehicles, etc.

The Japan Meteorological Agency has created and released what it has termed Yellow Sand Information (*9) by combining observational data from domestic observation networks of its own and the Ministry of the Environment, as well as data from China and South Korea, with predictions on wind direction and velocity.

However, much of this data is indirect information obtained by a number of ground observation systems. To provide a more accurate Yellow Sand Forecast and to limit damage by yellow sand, as well as to establish judgment criteria for international countermeasures at various sources (e.g., planting trees at appropriate locations), we must collect data through direct observation of airborne yellow sand.

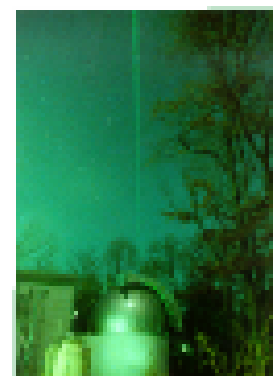
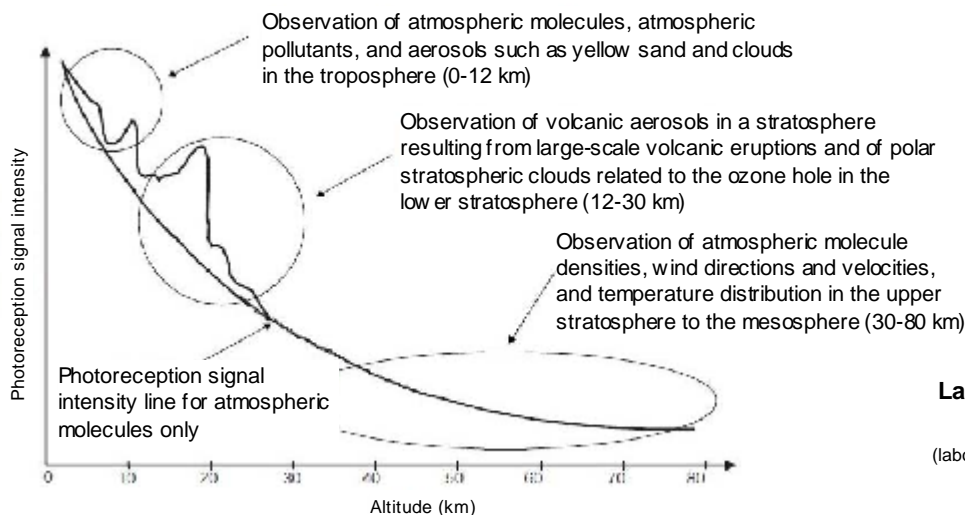
Today, LIDAR is the sole means of continuously and directly assessing the status of yellow sand. NICT set up a LIDAR observatory in 1994 in Shapotou, Ningxia Hui Autonomous Region in China near the Mongolian border, in partnership with the Lanzhou Institute of Desert Research of the Chinese Academia Sinica (currently the Cold and Arid Regions Environmental and Engineering Research Institute of the Chinese Academy of Sciences).

Including the above, there are four (4) observatories in operation in partnership between NICT and the research institutes of four (4) nations, collecting data for atmospheric environmental research.



[Fig. 2] LIDAR observatories deployed in partnership with the research institutes of different nations

[Fig. 3] Different observation targets of the LIDAR at different altitudes



Laser beam transmitted from the LIDAR on the ground

(laboratory at the NICT Koganei Headquarters)

*1 Aerosols:

Small particles floating in the tropospheric atmosphere of sizes from 0.001 μm to 100 μm (from one one-hundred-thousandth the thickness of a human hair up to its actual thickness). There are two types of aerosols: those of natural origin, such as sand dust and volcanic ash, and others of human origin, such as exhaust gases from factories and cars. Aerosols of human origin have shown a continuous increase since the industrial revolution in the 18th century. These aerosols are considered to have an adverse effect on the global environment as a result of solar radiation and chemical reactions in the atmosphere, with a significant impact on the processes associated with global warming.

*2 Doppler Effect:

A phenomenon in which the wavelengths of waves become shorter when the wave source and the observer approach each other and longer when they move away from each other. Although this effect is often described through the example of an ambulance's siren, it was the optical Doppler Effect that was discovered in 1842 by Doppler, who later pointed out that the Doppler Effect applies also to sound.

*3 Mie scattering:

A phenomenon in which the direction of travel of light changes (though its wavelength and energy remain the same) when passing through a medium containing particles of sizes comparable to the wavelength of light.

*4 Rayleigh scattering:

A phenomenon in which the direction of travel of light changes (though its wavelength and energy remain the same) when passing through a medium containing particles significantly smaller ($\lambda/10$ or less) than the wavelength of light (λ), such as atoms or molecules (e.g., the H_2O molecule, at approx. 1[nm]).

*5 IPCC:

Acronym for Intergovernmental Panel on Climate Change

The IPCC is an intergovernmental organization that surveys and evaluates the latest scientific, technical, and socioeconomic information on human-induced risks of climate change, providing advice to national governments. The organization was established by the WMO (World Meteorological Organization) and UNEP (United Nations Environmental Programme) in 1988.

*6 Troposphere and stratosphere:

The lowest layer of the atmosphere up to approximately 10 km in altitude is called the troposphere, and the next-higher layer--up to approximately 50 km—is the stratosphere. The temperature declines with increase in altitude in the troposphere and rises with increase in altitude in the stratosphere.

*7 Polarization:

Light is a transverse wave, and a laser light oscillates in a specific direction (i.e., it is polarized). In the scattering caused by a spherical water drop, the scattered beam oscillates in the same direction as the original laser light. In the scattering caused by a non-spherical particle such as yellow sand, some components in the scattered light oscillates in a direction perpendicular to that of the original laser light.

*8 Poor visibility:

Visibility is a measure of the distance at which an object or light can be seen. There are times when yellow sand lowers visibility, causing disruptions to air and other transportation systems.

*9 Yellow Sand Information:

<http://www.jma.go.jp/jp/kosa/index.html>

**Reaching 0.001-degree precision
for effective use of a finite stationary orbit**

Positional observation of stationary satellites using an optical telescope

<Crowded stationary orbit>

Stationary satellites are very useful, revolving around the Earth in the same period as that of the Earth's rotation, which makes them appear as if they are stationary from the point of view of someone on the Earth. A number of stationary satellites—including Japan's Himawari and BS satellites—play an active role in communications, broadcasting, meteorological observations, etc. throughout the world.

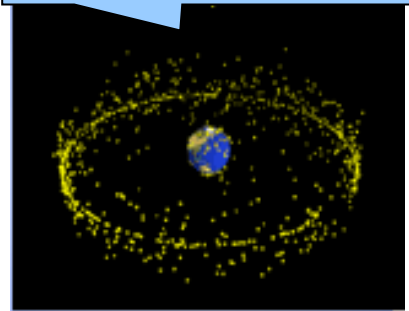
There is only one stationary orbit that can serve as the orbit for stationary satellites due to the laws governing the Earth's gravity and satellites' orbital periods. With about 300 stationary satellites reportedly operated by various nations of the world (as of May 2005), the parties concerned feel that the orbit is becoming increasingly "small" (refer to Fig. 1 at right; note that in this figure the orbit looks even more crowded as it includes those satellites drifting around the orbit after the end of their service lives). Concerns are beginning to be voiced as the number of satellites will continue to increase in the future. Orbital positions of stationary satellites are assigned to nations as a result of coordination through the International Telecommunications Union (ITU). No concerns would be raised over the increasing number of satellites if all satellites could remain precisely in their assigned positions. Unfortunately,

however, the satellites' orbits change gradually over time. This is because a satellite's motion is affected not only by the gravity of the Earth (which is not truly spherical in shape) but also by the gravity of the Sun and the Moon and the pressure of solar radiation. In the case of deviation from the assigned position, the satellite is controlled to return to its original orbit. As a result, however, all satellites unavoidably move around their assigned positions, which raises concerns that two satellites, both moving in this manner, may come too close to each other.

The coordination by the ITU is intended to avoid interference between the radio-wave frequencies used by the satellites. Rules have yet to be established as to how to avoid excessive convergence—and in the most extreme case, collision—between satellites. As it stands, satellites have surged in number while we **continue to fail** to establish rules.

What should we do? We must accurately measure and understand the present status, as can commonly be said to be necessary to address such problems. It is essential that we find out which satellites are located where in orbit, how much they move around, and how close they come to each other, all through observations.

Satellites dispersed out of their original stationary orbits are those that have been pulled out of these orbits for disposal at the end of their service lives.



[Fig. 1] Appearance of the stationary orbit (CG)

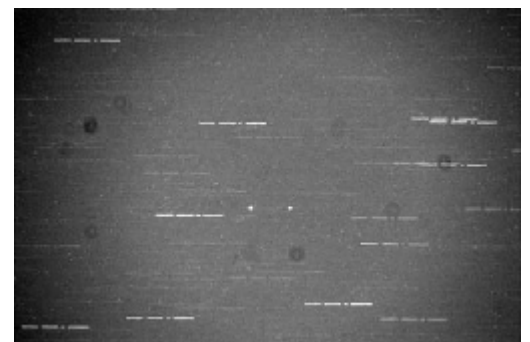
This shows how a limited orbital space is crowded with a host of stationary satellites.

<Optical observation facility>

There are two ways to measure the position of a stationary satellite: capturing the satellite radio waves or **capturing images of** the satellite through an optical telescope. Note that radio waves cannot be captured unless the satellite beam is directed toward Japan. Optical observation is better suited to the identification of all satellites without omission.

NICT has developed an observation technique for the stationary orbit using an optical telescope, making it possible to determine the position of a stationary satellite with high accuracy—with a margin of error of only 0.001 degree. The principle behind this technique is basically the same as that of the photographic camera; here a telescope (35 cm in diameter) is directed toward the target stationary satellite, and fixed in this position as the shutter is opened for a certain amount of time. As a result, as the Earth rotates, fixed stars move and appear as lines, whereas stationary satellites, reflecting solar radiation, appear as dots since they do not appear to move (refer to Fig. 2). As the accurate positions of fixed stars are known from long years of celestial observations, the positions of stationary satellites can be measured from the coordinate system based on fixed stars.

While the principle seems easy, practical measurement involves various



[Fig. 2] Observatory image of stationary satellites

Dots (two ● in the center) representing stationary satellites and lines (— ● —) representing fixed stars

innovations and developments. Motors and gears are used to point the telescope toward the target. Mechanical error is particularly detrimental to these observations. For this reason, the mechanical system was precisely adjusted, including gear mesh and drive shafts. In addition, the targeted directional data and mechanical error data were compared many times to create a correction table. This enabled us to train the telescope on the target at the center of its sight without fail within 1% error relative to the observational field of view (a width of one degree). The observation facility is situated at the NICT Kashima Space Research Center (Hirai, Kashima-city, Ibaraki Pref.). Since a high-altitude location is normally selected for celestial observations because of the minimal atmospheric fluctuation, there were concerns over observational accuracy at the Center, which is close to the seashore and thus at nearly sea level. After beginning the observations, however, it has become clear that satellite orbital positions can be observed from the Center without any problem. Instead, the location has proved to have an advantage in that the observation system's installation inside the research center allows for proper maintenance and a wider variety of experimental observations. Two telescopes are provided (refer to Fig. 3), allowing one to be operated while the other is maintained, thus ensuring continuous observation. At this research center, which is subject to salty wind and sandy dust, reliability comparable to that of a single robust system is ensured with a smaller budget.

[Fig. 3] Stationary satellite optical observation system
 The two (2) telescopes, front and back, are alternately operated and maintained.

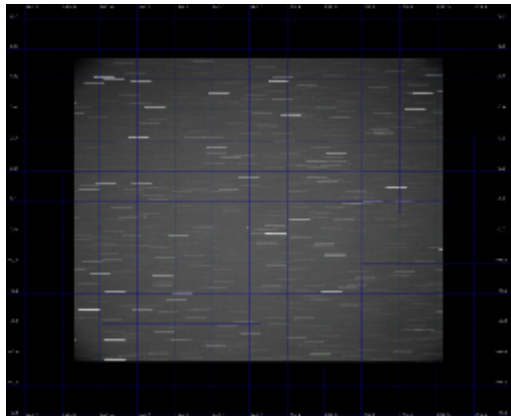


<Data processing and future challenges>

In terms of software, a program was developed that automatically matches the positional data of fixed stars with the observation image, thus improving the efficiency of observations. Further, we have made it possible for the current positions of stationary satellites to be directly read by showing their positions projected onto a world map with longitude and latitude lines in a coordinate grid (refer to Fig. 4). NICT is the sole organization in the world that has been able to process observation data into such easy-to-view images. A single survey of the entire stationary orbit viewable from Japan produces more than 200 photographed images. These images are released on the web after a few days of processing.

<http://www2.nict.go.jp/w/w122/control/geoscale/geoindex-j.html>

As future research targets, NICT will aim at faster data processing, the analysis of the six orbital elements (by determining the orbits of satellites exhibiting complex motion), and providing approach warnings regarding converging satellites several days in advance of any possible collision. It would be even more useful if one could search for information based on queries such as "Are there any satellites approaching each other to within a distance of X km in less than N days?" Thus we will continue to pursue higher accuracy and functionality in research and development.



[Fig. 4] Image with longitude and latitude scales directly under the stationary orbit
 This globally innovative manner of presenting observation data allows for direct reading of a stationary satellite's position.

* ITU, or International Telecommunications Union

One of the United Nations specialized agencies. This body defines the rules for assigning radio waves in wireless communication and registers and controls the assigned frequencies. This scheme is also applied to stationary satellites.

Outline of the National Institute of Information and Communications Technology (NICT)

● NICT Activities

The National Institute of Information and Communications Technology (NICT) began as a result of the integration of the Communications Research Laboratory (CRL) and the Telecommunications Advancement Organization of Japan (TAO) in April 2004.

NICT works to advance Japan's telecommunications sectors through consistent and unified operations of the CRL, an organization engaged in a range of research—from fundamental and basic research in information and communications technology to various applied research activities—and of the TAO, which provides multifaceted support to research and development projects (in partnership with industry and academia) aimed at the commercialization of information and communications technology, as well as R&D projects conducted by universities and the private sector.

● NICT Charter

NICT Charter

Mission

As the sole national research institute in the information and communications field, NICT will strive to advance the technologies and contribute to national policies in the field, by promoting our own research and development and by cooperating with and supporting outside parties.

Vision

We believe that the essential role of communication is the promotion of mutual understanding and the achievement of better relations between people and people, people and society, and between people and nature, by overcoming the various boundaries which may exist between generations, nations etc., thus realizing a world of universal communication.

NICT will make every effort to become a world leader in achieving this dream of universal communication.

Action Principles

1. Creating Technologies
We will undertake research and development by pursuing original technologies, world-leading technologies, and technologies that will directly benefit society.
2. Contributions to Society
We will use every available means to disseminate the results of our research throughout society.
3. Devotion to Self-Improvement
We will devote ourselves to self-improvement with an awareness of the weight of our social responsibilities, a strong sense of ethics, and a spirit of independence, so that we can demonstrate our maximum potential.

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