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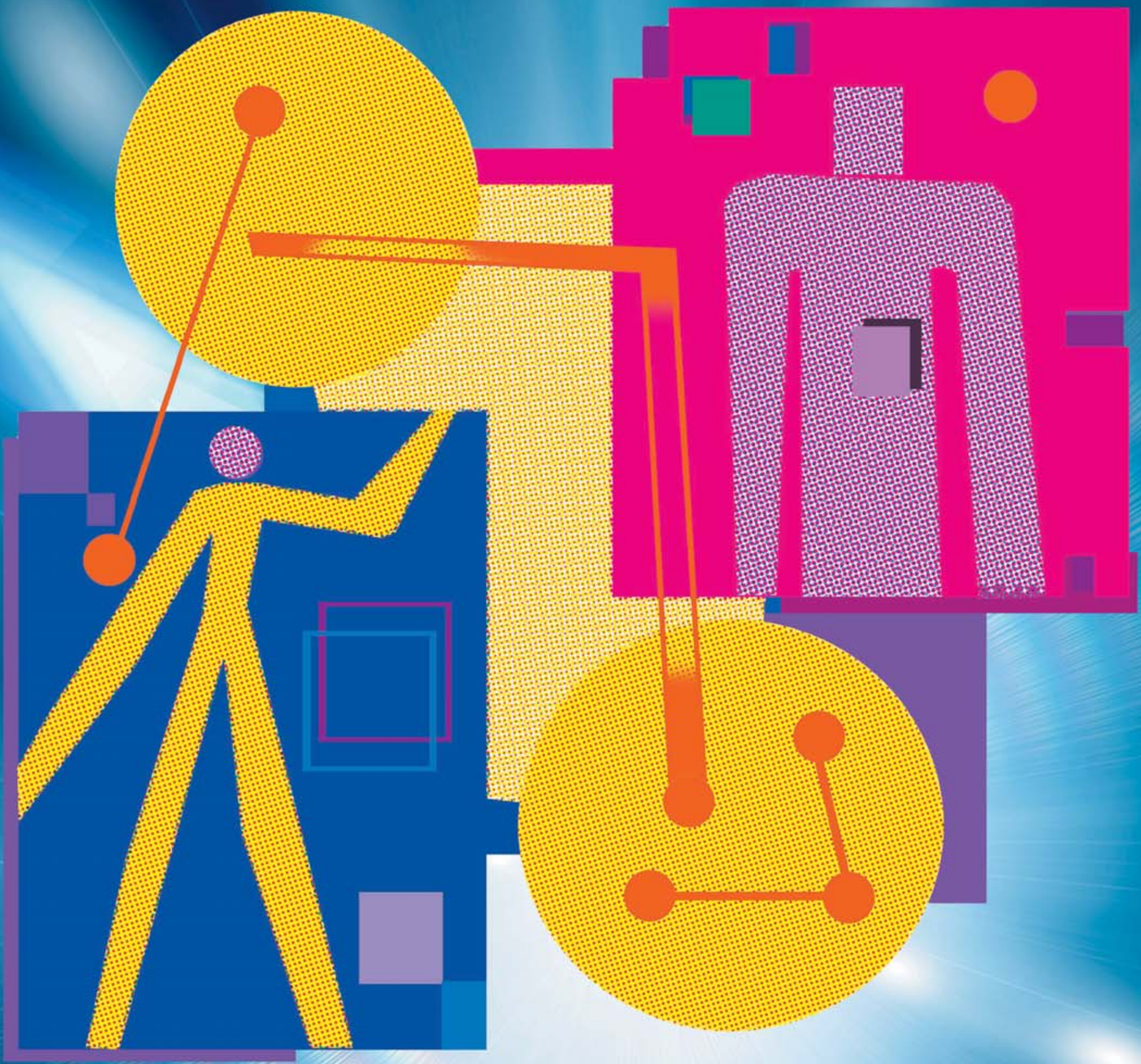
NICT NEWS

National Institute of Information and Communications Technology



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Review of the First Phase Medium-Term Plan

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Conclusion of the First Phase Medium-Term Plan

In March 2006, the five-year First Phase Medium-Term Plan will come to an end. In the next issue of NICT NEWS we will introduce the Second Phase Medium-Term Plan; here I would thus like to offer a review of the First Phase Medium-Term Plan.

The Communications Research Laboratory, the predecessor of the National Institute of Information and Communications Technology, was reorganized as an Independent Administrative Institution in 2001. The Minister of Internal Affairs and Communications proposed a set of medium-term goals in that same year, and the Communications Research Laboratory put together its own medium-term plan to help realize these goals. Following approval by the Ministry of Internal Affairs and Communications (MIC), the CRL published its official Medium-Term Plan. The Evaluation Committee for Independent Administrative Institutions was then formed in the MIC to evaluate the achievements of the Medium-Term Plan on an annual basis.

At the time of its reorganization as an Independent Administrative Institution, the CRL also reorganized its entire structure. Its eight former research divisions were reorganized into four new research departments corresponding to its four major fields of research. These remain as the four current departments: the Information and Network Systems Department, the Wireless Communications Department, the Applied Research and Standards Department, and the Basic and Advanced Research Department. At the time, CRL abolished the laboratories and adopted approximately 30 Research Groups. The CRL also established new systems to spur research and development, such as the Dynamic Projects, which focus research resources on particular topics within a limited span of years; as well as the President's Fund, aimed at generating promising new research topics.

Establishment of NICT

The most significant event during the period of the Medium-Term Plan was the integration of the Communications Research Laboratory (CRL) and the Telecommunications Advancement Organization (TAO) to establish a new independent administrative institution, the National Institute of Information and Communications Technology (NICT), with Dr. Nagao as the President. The new organization was established as the only public research institution in Japan specializing in the field of information and communications. The objectives of NICT are to conduct basic to cutting-edge research and development related to ICT (information and communications technology), widely recognized as the source of the international competitiveness of Japan and the key to future sustainable development throughout society at large. NICT was also assigned to promote comprehensive, strategic funding to support research and development in universities and the private sector and to develop the communications and broadcasting business. Under the banner of the NICT Vision—"Providing the engines of tomorrow's society through ICT"—NICT has published the four strategic programs indicated in Figure 1 and the six intensive action plans indicated in Figure 2.

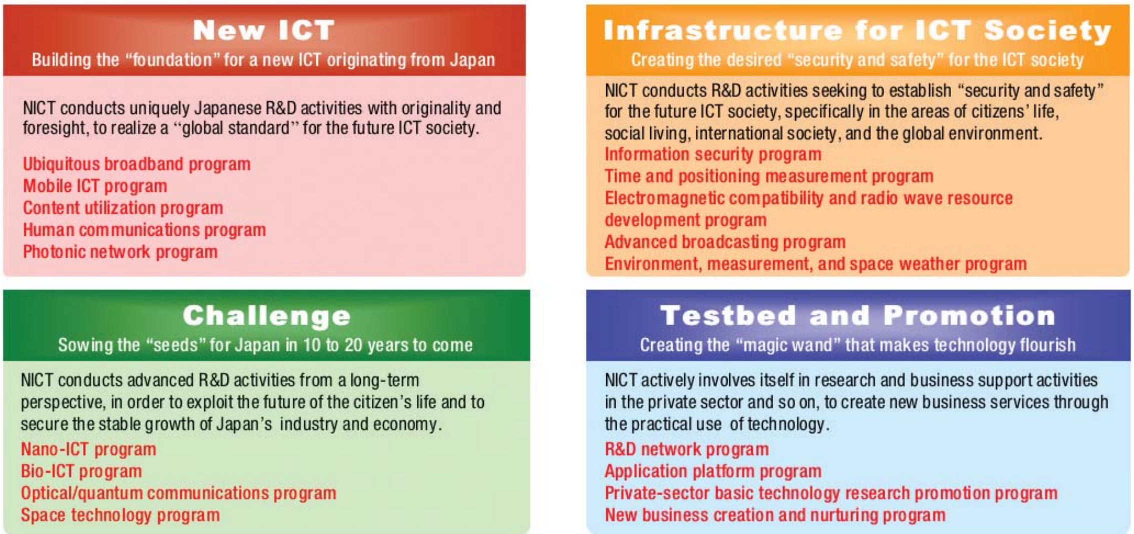

Figure 1: NICT's four strategic fields and their associated programs

First Phase Medium-Term Plan

Research and development in the First Phase Medium-Term Plan involved the Network, Application, and Fundamental research fields.

Research and development in the Network Field included investigation of photonic network technologies to realize tera-bit and peta-bit transmission speeds, telecommunication security technologies to ensure security in advanced telecommunications networks, multimedia wireless communications technologies, broadband wireless communications technologies on the stratosphere platform, measurement technologies related to the electromagnetic environment, and ultra-high-speed satellite communications technolo-

Figure 2: **Six intensive action plans**

gies using satellites such as ETS-VIII and WINDS.

Research and development in the Application Field includes investigations of diverse applications using advanced information and communications technologies: research and development into highly reliable technologies for creating, distributing, retrieving, and providing a variety of content and information, as well as research and development of technologies for collecting, displaying, transmitting, storing, and analyzing images, with the aim of approaching the functions of natural vision.

Research and development in the Fundamental Field includes the development of various basic and cutting-edge technologies to support advanced information and communications: research and development of photonic devices, new functional devices, quantum communications, and high-precision time, space, and frequency standard technologies.

Research achievements in these areas include the development of the world's most advanced technologies for future ultra-fast photonic networks, such as the 160-Gbps optical packet switch, which enables ultra-high-speed processing without converting the optical signals. In addition, some of these research achievements have already visibly contributed to daily life, as in the example of the standard frequency long-wave broadcast, which has led to an explosion in the spread of radio clocks. Experiments were also conducted using the JGN II optical testbed in collaboration with industry, government, and academia, leading to a variety of significant achievements. Unfortunately, I cannot introduce the details of these individual research achievements here due to the limited space of this article. However, I will continue to discuss these achievements in future issues of this newsletter, as in the past.

The integrated National Institute of Information and Communications Technology conducts research and development in three sections: Core R&D, Collaborative R&D, and Funding and Promotion. The Core R&D Section conducts basic and fundamental research and development in high-risk areas from a medium- to long-term perspective. The Collaborative R&D Section manages entrusted research in view of commercialization and promotes joint research and development among industry, government, and academia. The Funding and Promotion Section supports new ventures and infrastructural improvements to speed the creation of new businesses.

Further, we have organized the R&D Promotion Unit to promote the organic collaboration of these three sections—from basic research through application research to practical application—in a series of demonstration experiments. By selecting research fields in which collaboration between different departments will be particularly effective, we have organized the New Generation Mobile Unit, the Photonic Network Unit, the Information Security Unit, the EMC (Electromagnetic Compatibility) Unit, the Photonic Quantum Communication Unit, and the R&D Network Unit. We have also conducted joint experiments with private enterprises and universities and held a range of symposia, with each of these activities attesting to the effectiveness of this collaboration. In the Second Phase Medium-Term Plan, we intend to adopt a systematic program across research departments to promote such interaction even further.

Future perspective

Relative to the moment the CRL launched the First Phase Medium-Term Plan in April 2001, our research topics, research methods, organization, and operational management have changed significantly. Today we are developing a new research and development plan that will incorporate our four basic policies: further contribution to national information and communication strategies, thorough selection and concentration of research and development fields, continued strengthening of our fields of expertise and exploration of new fields, and enhanced collaboration with industry and academia. As a target for 10 to 15 years down the road, we are developing the concept of universal communication, which will enable cross-cultural and cross-generational communications—embracing different countries and generations. We are also establishing research plans and a new organizational system to help bring this concept to fruition. The next issue of NICT NEWS will discuss these topics in more detail.

Development of New Japan Standard Time system

Toward more advanced standard time

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Dr. Yuko Hanado entered the Communications Research Laboratory (the current National Institute of Information and Communications Technology) in 1989. After working in the Kashima VLBI Group, Dr. Hanado moved to work on standard time. Today her work is focused on improving Japan Standard Time and the development of time system algorithms.

Introduction

We use the time signal services provided by TV, radio, and NTT almost unconsciously. These services are based on Japan Standard Time (JST), which is a product of NICT. The term "product" may seem strange in this context. However, JST is indeed manufactured, through the measurement of signals from atomic clocks, calculations based on measurement results, and adjustments to equipment based on these calculations. To generate accurate time of day, we naturally need high-quality atomic clocks as well as a time-generation system featuring high stability, measurement precision, and reliability. While NICT has been providing JST for a long time, it has continually updated its system to incorporate improvements in the performance of atomic clocks and other devices. The newly developed New Japan Standard Time system (NJST system) has been implemented to feature a number of significant improvements, including the first built-in hydrogen maser frequency standards in addition to conventional cesium atomic clocks. Here, I will briefly explain the mechanism by which JST is generated and report on the points of improvements in the NJST system.

Mechanism of generating Japan Standard Time

Figure 1 shows a flow chart of the generation of JST. We generate JST using a group of cesium atomic clocks (now numbering 18) installed at NICT's Koganei Headquarters. The time differences between the clocks are measured regularly and the frequency (the relative degree of difference in time) of each clock is calculated. By averaging these frequencies, a synthesized frequency is computed. Based on this synthesized frequency, an actual clock is operated. The blue lines in the chart indicate the signal-generation flow. The frequency adjuster, operated with a single atomic clock as the signal source, is controlled to match the synthesized frequency and to generate a 5-MHz signal, which serves as the basis for the frequency standard, and the 1-second signal, which is used as the basis for timing synchronization. These signals tick off the time for JST. We manage JST through adjustments based on satellite-assisted time comparison to ensure synchronization with Coordinated Universal Time (UTC), the global standard.

NJST system

The mechanism of generating JST is simple. However, many difficult problems arise in its implementation, as countless factors influence the quality of standard time—from the performance of the atomic clocks and other equipment used to the methods of data processing. It is a daunting task to make changes to the standard time system, which of course cannot simply stop for repairs. Nevertheless, we must upgrade the system if we wish to improve the overall quality of standard time. Thus, we have developed the NJST system, adopting bold modifications throughout all operations in order to provide more reliable, advanced JST. The following are the major modifications from the past system.

- **Improved short-term frequency stability**

  The past system used a cesium atomic clock as the source signal for the frequency generator; this was changed in the new system to a hydrogen maser frequency standard. The concurrent use of cesium atomic clocks, with superior long-term stability, and the hydro-

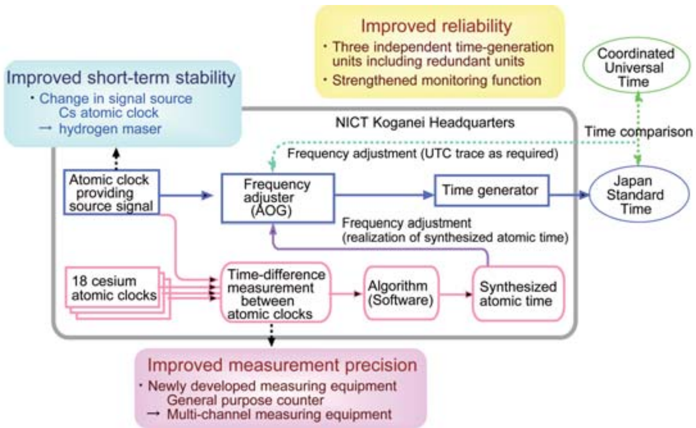
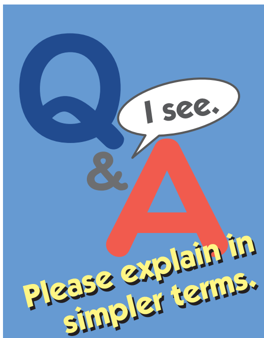


Figure 1: Flow of JST generation and areas of improvement in NJST system



Q Please explain the features of the New Japan Standard Time system.

A The new system can be synchronized with world standard time with five times the precision of the previous system. Specifically, this synchronization was within ±50 nanoseconds (a nanosecond is a billionth of a second); accuracy now stands at ±10 nanoseconds. This improvement was enabled by the addition of three hydrogen maser frequency standards to the 18 cesium atomic clocks used for the source signals of Japan Standard Time.

Q What are some examples of the new infrastructural and security measures?

A Measures have been implemented for the main chamber of the new system to ensure more stable operation, including electromagnetic/magnetic shielding, high-precision control of temperature and humidity, fully uninterruptible power supply, and reinforced security. The system is also housed in a building featuring high-grade seismic isolation.

gen maser frequency standard, with superior short-term stability, leads to the generation of JST with the benefits of both. In particular, this modification improved the frequency stability within a day by the degree of one decimal place (Figure 2).

Figure 2: **Four cesium atomic clocks (in the rack on the left) and a hydrogen maser frequency standard (on the right) installed in shielded Room 3**

- **Improved precision in time-difference measurement**
  In the past, we measured the time differences between the atomic clocks with a time interval counter by toggling between single-second signals generated from two clocks at a time. Thus, it took over 10 minutes to complete measurement. The new system uses newly developed multi-channel measuring equipment that can measure and compare 5-MHz signals from all clocks simultaneously. This simultaneous measurement eliminates errors due to differences in the timing of measurement. Measurement precision was also improved by a factor of approximately 100 relative to the old system.
- **Improved reliability through multiple redundancies**
  The old system featured two signal-generation units, whereas the new system is expanded to incorporate three. One of the units is used as the JST master unit and the remaining two units are continuously operated in stand-by mode. Three separate units are similarly installed for time-difference measurement. The new system is fitted with a new outlier identification mechanism that enables the acquisition of data as long as one of the three units is operating normally.

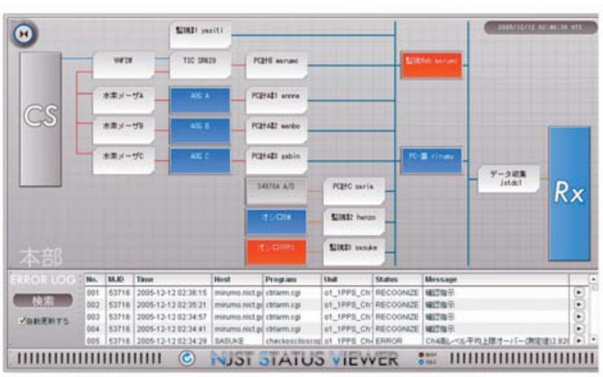


Figure 3: **Web-based monitor screen of the New Japan Standard Time system**

- **Enhanced monitoring function**
  A real-time output-waveform monitor has been installed for direct monitoring of the actual JST signals. We have also developed a web-based monitoring system (Figure 3), which makes it possible to check on the status of the system instantly from a remote location. If an abnormal event should occur, an alarm email is immediately sent to the person in charge.
- **Reinforced security**
  We have also taken measures to reinforce security in the building itself, to protect against earthquakes, power failures, and criminal acts. These measures have improved overall reliability in the operating environment. Our aim is to suppress any possible damage by external factors to the full extent possible to maintain the stable generation and supply of JST.

Summary

The NJST system formally began operations on February 7, 2006 (Figure 4). Problem after problem emerged during the developmental stage, but thanks to extensive troubleshooting, the system is now improved. The system is designed to maintain time synchronization with UTC within ±10 nanoseconds (as compared to the ±50-nanosecond precision of the past). We confirmed synchronization within 4.1 nanoseconds as of February 2006, according to a report published by the Bureau International des Poids et Mesures (BIPM, Paris).

Figure 4: **External appearance of the New Japan Standard Time system**
The cesium atomic clocks and the hydrogen maser frequency standards are operated in separate shielded rooms."

It is a great achievement that we can now generate JST with the world's highest precision and reliability, and we have now acquired the technologies to implement this achievement. Standard time and the standard frequency are, simply put, types of measures. Precise, reliable measures are essential whenever we construct something. However, technology advances rapidly; if we begin to devise a new measure after it the need for it becomes apparent, we are already too late. High-precision standard time and the technologies that enable its realization will form the foundation of a diverse range of future technological innovations.

Our next goal is to establish an autonomous time system linked with the "primary frequency standard," which NICT has developed and continues to operate. Our research and development in this area will be based on the compilation of records of stable operations.

Life & Tech-nology

● Standard time with higher precision at the core of the new ICT society

The ICT (information communication technology) society is growing, extending to "electronic government" and "electronic municipalities." Given this growth, the significance of Japan Standard Time continues to increase; for example, in certification of the time that a document is created or data is generated. While time services offered by "timestamp providers" have recently gained attention in a range of applications — official documents and data, patent applications and intellectual property, online trading, and electric medical charts — the switch to the New Japan Standard Time system will increase the importance of JST even further in these time businesses.

Signing of research collaboration MOU with Technical Research Center of Finland

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Yokosuka Radio Communications Research Center, Wireless Communications Department

On February 2, 2006, NICT signed a research collaboration MOU in the field of information and communications with the Technical Research Center of Finland (VTT). President Leppavuori from VTT and Vice President Shiomi from NICT signed the MOU at NICT's Koganei Headquarters. The two organizations will deepen their mutual cooperation and friendship through the exchange of information and personnel and through co-hosting of symposia; more generally these partners will also promote research collaboration over the fields of information and communications.

Signing ceremony
[VTT President Leppavuori (right) and Vice President Shiomi (left), front row]

VTT (the abbreviation for the Technical Research Center of Finland) is a national research institution established in 1942 under the supervision of the Finland Ministry of Trade and Industry. The organization employs approximately 2,700 people and is one of the largest research institutions in northern Europe. This specialized agency conducts research and development in the fields of engineering and the economics of engineering from a neutral and impartial standpoint. Its headquarters are located in the Otaniemi Science Park in the City of Espoo, near Helsinki. The agency's major activities involve application research directly related to commercial activities, with a main focus on developing new businesses (particularly in the field of informatics) and research tailored to the continuously monitored needs of the private sector. (As an illustration of the structure of these priorities, 28% of the budget is allocated to governmental activities and 72% is earmarked for private enterprises.)

Tour of NICT facilities after the signing ceremony
(Setting wristwatches to Japan Standard Time)

Scene of joint workshop held in Espoo in February 2006
(ESA Workshop/TSMMW'06/MINT-MIS'06)

Research and development through collaboration between NICT (with its basic and broad wireless technologies) and VTT (with a strong reputation in application research) will combine the advantages of the two organizations and is expected to lead to the establishment of a variety of new systems. In particular, in the field of wireless communications based on millimeter waveband radio waves, NICT and the VTT Millilab have already been cooperating in a research partnership through the Millimeter-Wave Promotion Project of the NICT Yokosuka Radio Communications Research Center. The current MOU will further strengthen this ongoing relationship.

As part of this research collaboration, a joint workshop was held in the joint symposium held in February 2006 that brought together ESA'06 by VTT Millilab, MINT-MIS'06 by Dongguk University in Korea, and TSMMW'06, which is an international symposium on millimeter-wave technologies co-hosted by NICT. Around 100 presentations took place, including lectures by specially invited guests. Some 140 participants took part in the workshop and joined in the intense discussions on millimeter-wave technologies.

Report on presentation at “Nanotech 2006: International Nanotechnology Exhibition and Conference”

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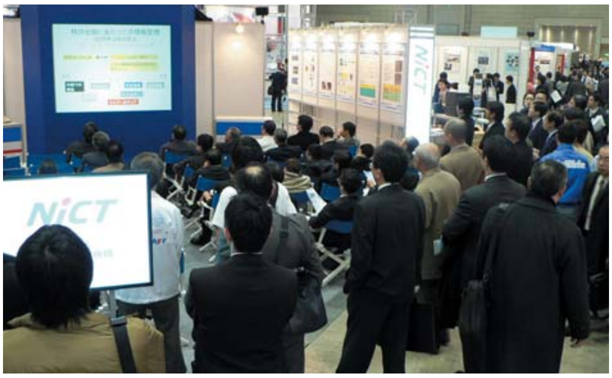
Basic and Advanced Research Department

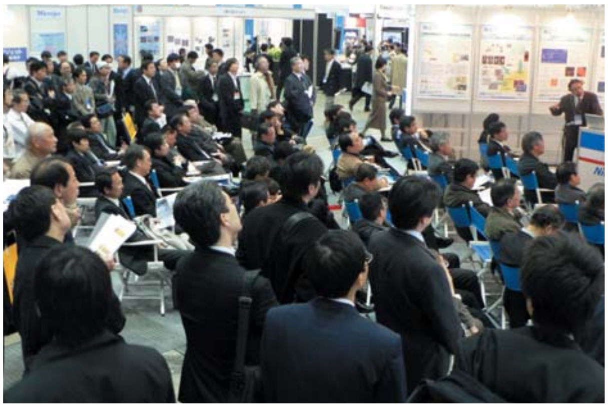
During the three days from Tuesday, February 21st through Thursday, February 23rd, 2006, the “Nanotech 2006: International Nanotechnology Exhibition and Conference” was held at the Tokyo Big Sight. This Exhibition and Conference is the world’s largest international exhibition on nanotechnology, and is sponsored by a range of ministries, including the Ministry of Internal Affairs and Communications, the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Economy, Trade and Industry; many overseas government organizations also took part, including the embassies of the US, the UK, France, and Germany; as well as numerous research institutions—including NICT, the National Institute of Advanced Industrial Science and Technology (AIST), the Institute of Physical and Chemical Research (RIKEN), and the National Institute for Materials Science (NIMS). This year, 243 enterprises and organizations from Japan and 95 enterprises and organizations from 17 foreign countries and regions participated in the exhibition. Essentially the exhibition was a trade show for products and technologies as well as a demonstration site for these cutting-edge technologies. Each booth competed with the others to show off the latest technological development. Dr. Mashiko, Director of the Kansai Advanced Research Center is a member of the exhibition’s executive committee and served as one of the judges for the awards presented during the event.



Scene of joint workshop held in Espoo in February 2006

NICT has been participating in this Exhibition and Conference for the past several years. This year NICT mainly displayed the achievements of the research groups of its Kansai Advanced Research Center, with its focus on nanotechnology. NICT presented a range of research achievements, various results, and patent information, through lectures by the researchers in charge. NICT’s booth also featured DVD and PowerPoint presentations providing overviews of its research topics and introducing the organization’s activities; demonstrations were also provided on the details of each research achievement, posters and models were displayed, and a “patent consulting corner” was hosted by the NICT Incubations team. This year in particular we featured our efforts to provide information on venture businesses and NICT-supported product commercialization, as some of the various outcomes of our research.

Scene of joint workshop held in Espoo in February 2006



Scene of joint workshop held in Espoo in February 2006

Scene of joint workshop held in Espoo in February 2006

The Exhibition and Conference attracted a total of 45,868 visitors, many of whom stopped by at NICT’s booth. The display was presented through collaboration between the Intellectual Property and Alliance Division and the Public Relations Division of NICT. We would like to thank all those who participated, supported, and collaborated in these activities.

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