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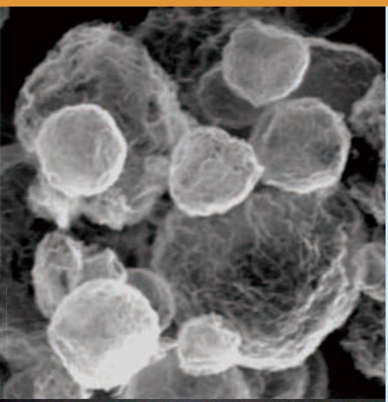


MESSAGE

Message to the Japanese Industry from the President

FEATURE

GEO Grid

– Integration and provision of earth observation data from the user's standpoint –

Research Hotline

UPDATE FROM THE CUTTING EDGE（April−June 2009）

In Brief

Message to the Japanese Industry from the President

Tamotsu Nomakuchi

President
National Institute of Advanced Industrial Science and Technology (AIST)

1. Preface

My first message in the previous issue was on my vision in assuming the post of AIST President. In this issue, I would like to share my findings and thoughts after joining AIST as the first president with an experience in the private sector. Though the title is addressed to industry, I would be delighted if it is read by not only company executives and R&D staff but also university members.

2. The reality of AIST

Nearly six months have passed since I joined AIST. During this time, I have received detailed briefings on its multiple kinds of activities while I have also talked with representatives of our collaborating companies, universities and public sector. The first thing that strongly captured my attention was the difference in the research motives among industry, academia and government. Or, I should rather phrase it as the “difference in the research perspectives.”

With ‘industry,’ the motivation or driving force of R&D is based on the necessity and demands arising from business management. Compelling pressure to comply with the demands is increasing year by year due to the severe industrial competition of global scale, and we know well that it has become hard for companies to tackle important but long-term research assignments.

With ‘academia,’ the missions are education, research and societal contribution, as stipulated in the Fundamental Law of Education. However, the actual driving force of R&D would be intellectual curiosity and academic necessity.

What about research with the “governmental and public sectors” ? Here, the motives and meaning of R&D should be the requests from the nation and society. There are many R&D issues that must be addressed for sustainable development, but these cannot be fully coped with by companies that have urgent business activities as their first priority, or by universities which respect academic freedom. It is exactly the 'governmental and public sectors' that should confront such issues steadily and discreetly. In AIST's case, such issues are geology, measurement standards, and other infrastructural, cutting-edge research in various fields. I believe that the so-called industry-academia-government collaboration can be carried out more efficiently and effectively upon mutual awareness of such characteristic features and difference in our respective research activities.

Now I would like to elaborate on an aspect of AIST's research. We now have 6 priority fields of Life Science and Technology; Information Technology and Electronics; Nanotechnology, Materials and Manufacturing; Environment and Energy; Geological Survey and Applied Geoscience; and Metrology and Measurement Science. 51 research units in total are engaged in research in the fields. Each individual unit sets the objectives of its research implementation and creates the strategy road maps. Researchers are very much aware of the importance of collaboration among units, beyond their own research areas, and this demonstrates the merit of AIST's merge of the former 15 institutes into one comprehensive institute. Also such collaboration circles are naturally extended to universities and industry. Their ultimate aim is to make their "outcome" of research be utilized in actual society. I appreciate their keen interest in "research outcome and product realization" though it should be naturally expected in a public institution. Although such interest might be regarded as still insufficient in the eyes of industry experts, I am confident that we can expect much from their efforts in *Full Research*, efforts to search beyond the level of basic research and explore the process toward product realization.

I also highlight here some research results of AIST, unspectacular but indispensable in society. AIST's research results come out in various forms. There are numerous results that appear in visible, audible, tangible forms as cutting-edge products, projects or technologies. AIST also produces considerable number of research results to fortify the infrastructure of industry and society. They are, for example, geological maps covering our entire land, measurement standards, safety evaluation database of chemical substances, database of gene-protein structures, and many more. The degree of contribution of any one of them cannot be directly evaluated, but should be appreciated by the effects of their services to reinforce the fundamental potentials of Japan, serving as the overall industrial infrastructure. Today technologies are diversified, such as life science technology, nanotechnology or bio-science technology, and the kinds of materials we handle are multiplying. Moreover, the global issues, such as environmental problems, are increasing. It is AIST's important role to send out such discreet but crucial knowledge that is indeed essential for the realization of sustainable development.

Next, I would like to introduce AIST's support for local industry and small and medium enterprises (SMEs). Though it may appear that AIST has closer relations with large enterprises, it also places great emphasis on collaboration with SMEs. Around half of our technology consultations, which annually run into more than 4,000 cases, are from SMEs. We cooperate in diversified cases such as analysis and testing for quality improvement, basic data-collection or process development for introduction of new materials, and production methods development corresponding to new standards or regulations. AIST has a network of regional research bases in Hokkaido, Tohoku, Tokyo Waterfront, Chubu, Kansai, Chugoku, Shikoku, and Kyusyu. In each regional center, we have a consultation service office for local industry. In case one center cannot give a proper solution at the site, AIST Tsukuba and other centers will cooperate. It has been also the tradition that they cooperate with prefectural industrial research institutes to strongly support the local industry. Before, advisees used to receive an impression that AIST gives technological instructions as the governmental authority to private sectors, but these days both sides cooperate on the same platform of joint research or technology consultation.

Here is a little by-talk. Having long served in industry until quite recently, I have seen or heard of many cases of restructuring and in some cases was responsible in decision-making myself. However, never have I known a more drastic case as the one of AIST, of merging the 15 institutes that possessed prestigious histories since the Meiji Period into one comprehensive institute. I believe that it owes much to the new-found spirit, sense of crisis, and sincere discussions of those who took responsibility in the re-establishment. I hear that there are often visits from abroad to investigate the AIST restructuring, when re-organization of national research institutes are considered and planned.

3. Further advancement of collaboration

While I was in industry, or even after I joined AIST, I have heard many criticism on or expectations for AIST: "AIST should listen to voices of industry in setting its goals," "We cannot easily consult AIST because they first talk about cost-sharing," "AIST has too rigid an idea on the value of their intellectual property that it discourages us to collaborate," "AIST still makes much of academic papers, and has little understanding of management in industry," and so on. Each comment has its reasons, and I sincerely think AIST should try its best to improve. On the other hand, however, I would like to ask for your kind understanding on the difficulties in our management due to the fact that AIST is a public institute.

In our improving the afore-mentioned points, it would be necessary to increase occasions of communication with industry to exchange our ideas frankly. I would do my best to explain AIST activities accurately to the public, and to introduce the voices of industry to AIST.

At present, AIST is now in the last fiscal year of its Second Medium Term, the First Medium Term being from 2001 to 2004 and the Second from 2005. We are now working to complete the Second Term and advancing in-depth discussions on core visions of the Third Term. We plan to contribute all the more to national policy-making, by promoting R&D focusing on the social needs toward the realization of a sustainable society. The main themes of our heated discussions are as follows.

- to break through the former vision of "AIST sending out the research results for the use of society" toward a new vision of "AIST itself acting to enhance competency of Japanese industry"
- to challenge issues responding to the governmental policies, while also reflecting the voice of industry
- to make AIST's value clearly visible and tangible from industry and academia, to encourage interaction in both quality and quantity

During and after the current discussions, we would like to share our visions with fellow leaders in industry and academia for our better future cooperation. I am very much looking forward to talking with you all.

An Overview of GEO Grid and Its Significance

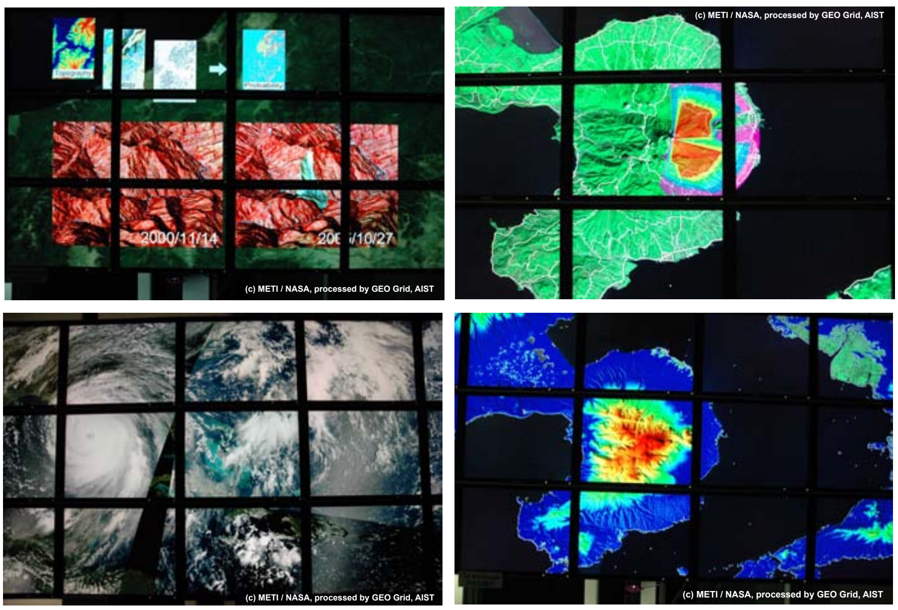
A user-oriented service for archiving earth observation data

The GEO Grid (Global Earth Observation Grid) project aims to provide existing earth observation data sets including satellite imagery, geological data, and ground sensed data with advanced IT platforms where wide variety of users can reach entire integrated data sets more easily.

Up to now, earth observation data have tended to be made available on AS-IS basis, where the providers simply published the data and let users worry about how to make use of it. Users have had to struggle to obtain the data needed for each particular application, prepare the necessary servers and develop software programs, and perform various kinds of data processing. On the other hand, with the advance of the Internet and growing Internet-based services of providing satellite imagery data and others, the number of potential data users have surged dramatically. The knowledge levels of users regarding the data have become extremely diverse, from experts possessing a full set of analysis tools to ordinary consumers with just having a PC or a mobile phone; moreover, the uses of the data vary widely as well. Many of the approaches to data provision, from the standpoint of the data producer alone, can no longer meet all these diversified needs. Some users, for example, simply want to be able to choose the necessary data on a menu, others need the computing resources and tools for processing data, and still others have a need for data obtained by complex computational programs on high performance computing systems. Greater use of the data cannot be achieved without meeting the needs of this diverse range of users. The system design concept of GEO Grid assumes that anyone will be able to make ready use of earth observation data and to create new value with it. The aim is to provide one-stop service from the user's standpoint meeting diverse needs.

As a first step of exploitation to achieve this concept, GEO Grid, started in 2005, has made more than 1.5 million ASTER* images available for online access. In 2008, a proper data protection function was added to the system, and currently a worldwide geological map (One Geology) and Japanese geological information providing services are being developed in 2009.

Regional problems are becoming global issues



GEO Grid processing results on super high-resolution displays
Clockwise from top left: Earthquake and landslide; simulation of pyroclastic flow from Mt. Unzen-Fugen; elevation map of Unzen-Fugen vicinity; hurricane

According to the 4th Report of the Intergovernmental Panel on Climate Change (IPCC), the rise in average global temperatures observed starting in the latter half of the 20th century is very likely due to an increase in human-caused greenhouse emissions. Concerns about the effects of human socioeconomic activities on the earth's environment have continued to grow. Scientists have further pointed out that as sea levels rise due to continued warming, regions that are no longer habitable or that have become vulnerable to tidal waves and other disasters will increase. Another issue under discussion lately is whether future introduction of a carbon tax will result in farmland being converted to forests. Modern society with its rapid advance cannot, due to the increasing complexity and globalization of city functions, take effective measures against disasters at the local level alone. Japan, with its overseas reliance for much of its resources, materials, labor and other capital needs, can no longer ignore the major disasters occurring frequently throughout the world, including from the standpoint of BCP (business continuity planning).

As these problems are expanding and becoming enormous, we need to grasp phenomena from a broad, whole-earth perspective and launch a many-faceted attack on the problem. To achieve it, all the many different kinds of data gathered from earth observations will need to be mobilized and applied to the problem-solving tasks. The big issues for technologies are (1) integrating different kinds of widely dispersed information with different data providing policy and (2) meeting the large-scale information and complex requirements. In the articles that follow in this special feature, we will introduce the technological approaches taken in GEO Grid toward solving these issues.

The GEO Grid System Architecture

In designing the GEO Grid, the emphasis has been on international cooperation and contribution. Central roles are being played in particular by such organizations as the intergovernmental Group on Earth Observations (GEO), the Open Geospatial Consortium (OGC) which is pursuing standardization of software handling geospatial information, and the Open Grid Forum (OGF) engaged in standardizing grid technology.

At AIST, GEO Grid is being managed under the GEO Grid Promotion Council as a project that intersects with and merges many different research fields, including information technology, electronics, geology, and environment and energy fields. Toward the achievement of sustainable growth on a global scale, GEO Grid is being built as a system for worldwide sharing of earth observation information that can help bring about sound policy-making, and is being provided to the Asian region as a Japan-originated initiative. The hope is that it will contribute to solving problems facing society on a global scale, from protecting the earth environment and making effective use of energy resources to reducing the harm of natural disasters and managing risks. At the same time, in combination with urban information, lifeline information, geospatial information, societal news and other such information, we hope to uncover needs and create services based on new business models.

Director, Information Technology Research Institute

Satoshi Sekiguchi

*Note:

ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). Developed by Japan's Ministry of Economy, Trade and Industry (METI), ASTER operates in 14 bands covering the visible through thermal infrared portions of the electromagnetic spectrum. It has a capacity to observe any place in the world at least once in daytime and nighttime during its 16-day revisit cycle.

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Integration and Utilization of Earth Observation Information

"Toward realization of a dream, in Japan, Asia and the world"

Research Coordinator for
Geological Survey and Geoscience
Eikichi Tsukuda

In order to make information on the earth's environment useful for exercising emergency judgments and making decisions on urgent action at the time of large-scale disasters, for dealing with climate change and other environmental changes, and for making decisions on where to develop resources or locate large-scale important facilities, the information needs to be of as high quality as possible and organized so it can be used immediately and conveniently. Often time is wasted because of failure to obtain the necessary national or international consent for use of the information. In many cases the sticking points may appear to be relatively minor matters, such as the failure to prepare or share underlying data for reaching an agreement. In reality, however, the volume of data involved is huge, and much of the time it is not centrally managed and therefore cannot be used readily. There are cases where the data can be accessed only after going through several layers of experts. Sometimes a decision cannot be made without superimposing data of many different qualities on top of each other.

Toward resolving such problems, the Global Earth Observation System of Systems (GEOSS) Ten Year Implementation Plan was adopted at the Third Earth Observation Summit held in Brussels, in 2005. In Japan, as well, based on the Earth Observation Promotion Strategy adopted by the Council for Science and Technology Policy at the end of 2004, needs-driven plans to integrate earth observation systems and coordinate the related organizations are being carried out under management of the Ministry of Education; Culture, Sports, Science and Technology (MEXT) serving as secretariat. A legal foundation is also being laid, with the passing in short order of the Basic Act on the Advancement of Utilizing Geospatial Information and the Basic Act on Ocean Policy in 2007, followed by the Space Basic Act in 2008. Under each of these laws, the government has drafted national blueprints on which to proceed. Corresponding to this background, AIST is carrying forward the GEO Grid project with researches aimed at integrating and utilizing satellite information, geological maps, and environmental information in order to take up the challenge of solving national and international problems.

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Geoinformation Center (See website at http://www.gsj.jp/HomePage.html)

GEO Grid System Structure and Database Integration

Beautiful satellite images and detailed geologic maps provide enough intellectual stimulation on their own, but by overlapping them we can gain new knowledge beyond what is possible from individual images. Satellite images from different observation periods show changes in topography. When these are combined with geological data, land usage patterns (coverage), rainfall and other sensor data, we can obtain scientific knowledge useful to society such as the cause-and-effect relationships among topography and soil, vegetation, weather and other factors. Not only images that are clear at a glance but also this kind of data integration can be extremely important for making discoveries. One important purpose of the database integration technology in GEO Grid is to see how effectively knowledge discovery and creation can be supported.

How can diverse types of widely dispersed information be integrated?

Much of the various information produced by diverse organizations throughout the world cannot be made freely available on the Internet because of its high value. When information is made publicly available but cannot be acquired without going to the original website and conducting a search, data integration across websites becomes impossible. Data formats and classifications also differ in many cases due to the differing backgrounds of the organizations producing it, further impeding data sharing.

To overcome these issues, standardization is being advanced in earth observation and other fields to achieve common data formats and access methods enabling mutual use. The GEO Grid project supports such efforts, including the standard access methods and data formats defined by the international OGC (Open Geospatial Consortium). One example of this support is the creation of a CSW (Catalog Service Web) service, addressing the question of which services and information are available where. CSW functions as the entry point to services in Japan and overseas that are tied into GEO Grid.

Meeting increasingly large-scale, complex needs

In the case of problems like global warming that require complex solutions on a global scale, here again the need is for large-scale data integration worldwide. Applications to the environmental and disaster prevention fields likewise are faced with the issue of increasing scale, so that existing geographical information systems can no longer handle the growing size and number of databases. Without a high-performance system that can deal with the wide dispersion of data, search functions are not possible. For solving complex problems, integration also with data of other scientific fields becomes necessary, giving rise to the problem of how to integrate different types of data transcending the standards for individual fields.

A key feature of the GEO Grid approach to these problems is high-performance, highly scalable distributed technology known as grid technology. Database access in GEO Grid, for example, is implemented based on OGSA-DAI (Open Grid Service Architecture Database Access and Integration), distributed database middleware being developed in the U.K. Using this technology, we conducted a successful trial integrating satellite image databases in Taiwan and Japan over the Internet while maintaining the security of data.

At AIST we are also carrying out research and development with international cooperation on a further extension of OGSA-DAI called OGSA-DQP/XML, WebDB[1] making possible access to XML, Web-based, and other types of databases. Moreover, in implementing the above-mentioned CSW, we are developing a system capable of standard searches for data of various structures (schemas) by making effective use of functionality of full-text searches without regard to structure. The overall

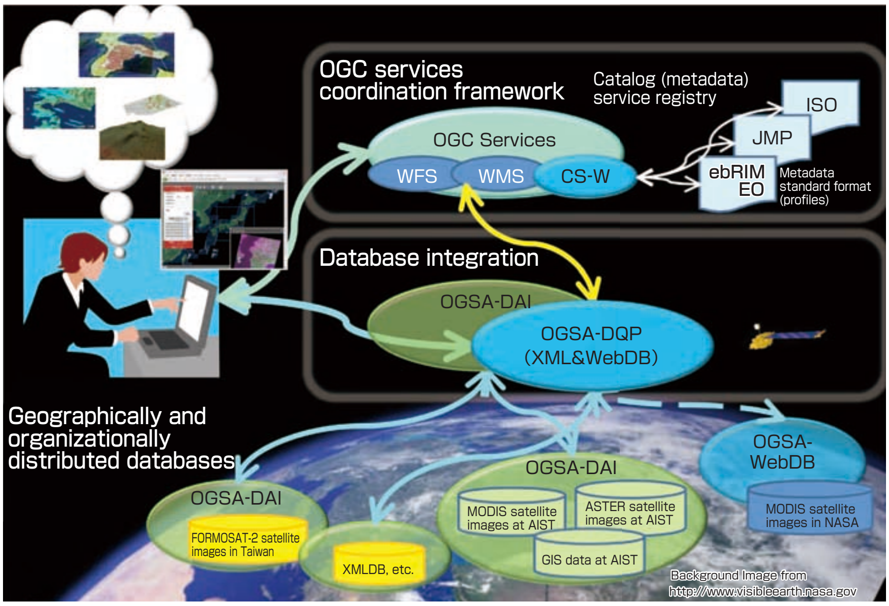

Fig.1 Database integration in GEO Grid
The portions in blue are middleware developed by AIST. We also developed the heterogeneous distributed database integration environment using grid technology, the catalog service (CSW) enabling searches for service definitions in different metadata formats, and the Web interface.

platform we are developing will be like that shown in figure 1, and will allow us to integrate large-scale heterogeneous distributed databases.

With future developments that achieve advanced computer processing on these data integration platforms, such as distributed data mining and distributed workflow, as well as making possible advances in metadata and other areas, we hope the technology will be able to contribute toward creating knowledge and expertise as an e-Science platform.

As an intellectual property archive

Databases of intellectual property, often called digital repositories or digital archives, are infrastructure that will be necessary for a long time for the advance of society and science. It is highly important that they be maintained and enhanced so they can be used effectively. In GEO Grid as well, we intend to continue with our technology development as part of the AIST innovation hub function in order to contribute to society.

GEO Grid system overview

Based on the above approach to integration, in GEO Grid we are proceeding with integration of geographically and organizationally distributed computing and storage resources (computing grid, storage grid) adopting an overall structure[2] like that shown in figure 2. The use of grid technology allows flexible configuration and provision of computational resources needed by users while achieving extensibility regarding geographical distribution and scale. As with the database integration we have been describing here, databases and application programs (workflows) built on these resources, functions for linking them, and a variety of other services are being realized. These services are designed in accord with standard protocols and interfaces based in the Web Services architecture, and realizing overall a Service Oriented Architecture (SOA). Another feature is the flexible security platform based on the Virtual Organization (VO) concept described on the following pages. The services as a whole conform to the OGC standard specifications. Besides supporting a variety of applications involving geographical information, this design enhances the interoperability with other systems.

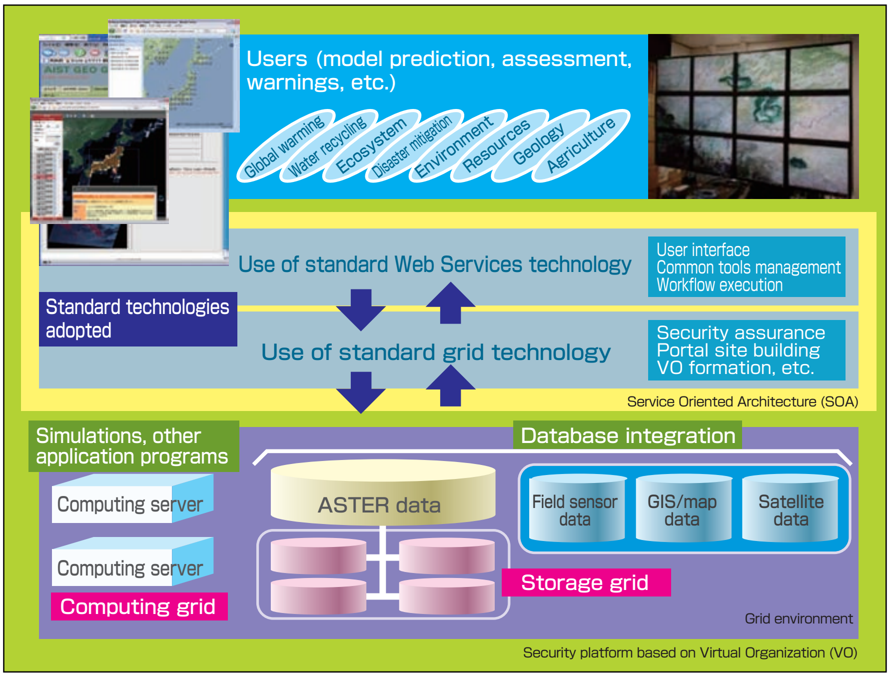

Fig.2 GEO Grid system structure
Distributed high-performance computing servers and large-scale storage systems are integrated by means of grid technology. On this platform, OGC-conformant services and workflows as well as other application support environments are built, facilitating application to global warming, water recycling, and other such areas. Another object of R&D is a visualization environment using multiple large displays.

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[2] S. Sekiguchi *et al.*: *IEEE Systems Journal*, 2(3), 374-389 (2008.09).

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The GEO Grid Framework

GEO Grid is aimed at sharing and integrating heterogeneous distributed data and providing it to users based on the policies of each data provider. We have analyzed the respective demands of users and data providers and are now working on designing and implementing a system that meets these demands. The objective is to allow users to perform a larger amount of useful data processing and computation more readily.

Demands of users

Users would like to refer to just the information they themselves need from the vast amount of available information, and to access it as if it were located inside their own organization without regard to its being geographically and organizationally dispersed. In many cases, moreover, being able to refer to the data is not the end of the matter. Data do not just produce value by themselves. Typical usage by applications includes simple and easy data transformation or marshaling to feed into the next service. GEO Grid must provide a research environment in which data and processing can be combined readily to meet such demands.

Demands of data providers

Due to restrictions concerning the protection of national security, intellectual property, privacy, confidentiality, and relevant ethical issues, the data owner is generally willing to permit only a range of data access and certain choices of data format. They wish to require the users to accept certain limits on the transfer of the rights, etc., and wish to reserve the authority to set and modify licensing rights and conditions. The management burden can also become unwieldy, as when each user is required to create an account, or access control settings are made per user, and the number of users grows into hundreds, thousands or more. Another need of data providers is therefore to be able to control access to data based on various conditions, with minimum administration cost. This requires high-performance, flexible, and highly scalable security functions.

Design and usage model

To meet these demands, GEO Grid is based on a Service Oriented Architecture (SOA) in which data and processing are configured and provided by means of standard protocols and interfaces as combinations of "services" (Fig. 1). Important in an SOA are security functions for managing who can access which services. GEO Grid is designed and implemented by introducing the concept of a Virtual Organization (VO). Services of multiple organizations are provided to users by enclosing them in invisible partitions and making them appear as if they exist in one organization, the VO.

The usage model of GEO Grid, alongside the roles of (1) user and (2) service provider making available data and computer processing as services, adds two more roles, those of (3) the VO manager and (4) the GEO Grid administrator. A VO corresponds to a project sharing policies

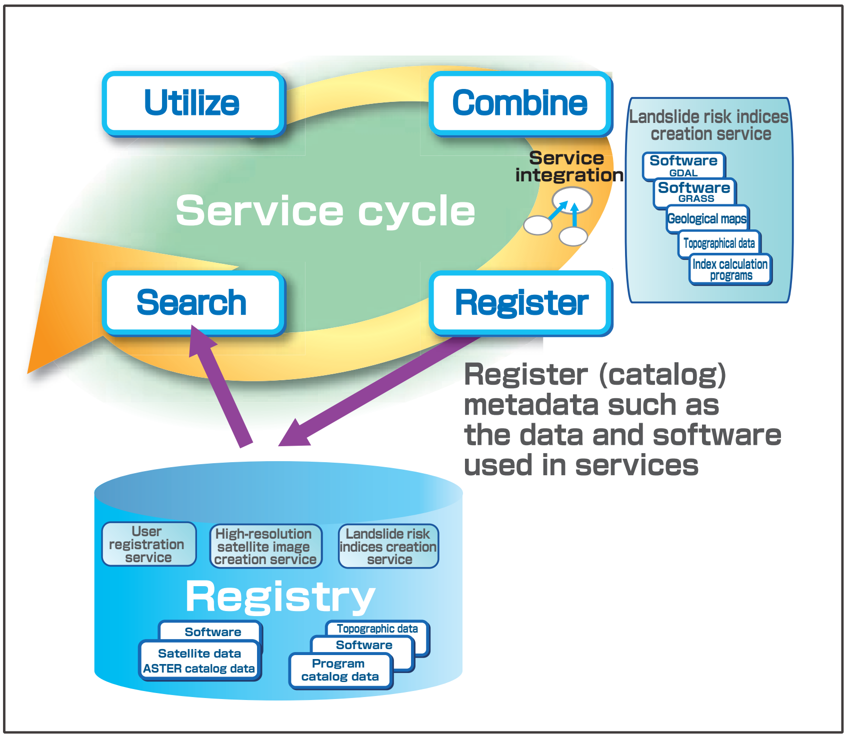

Fig.1 Concept of SOA

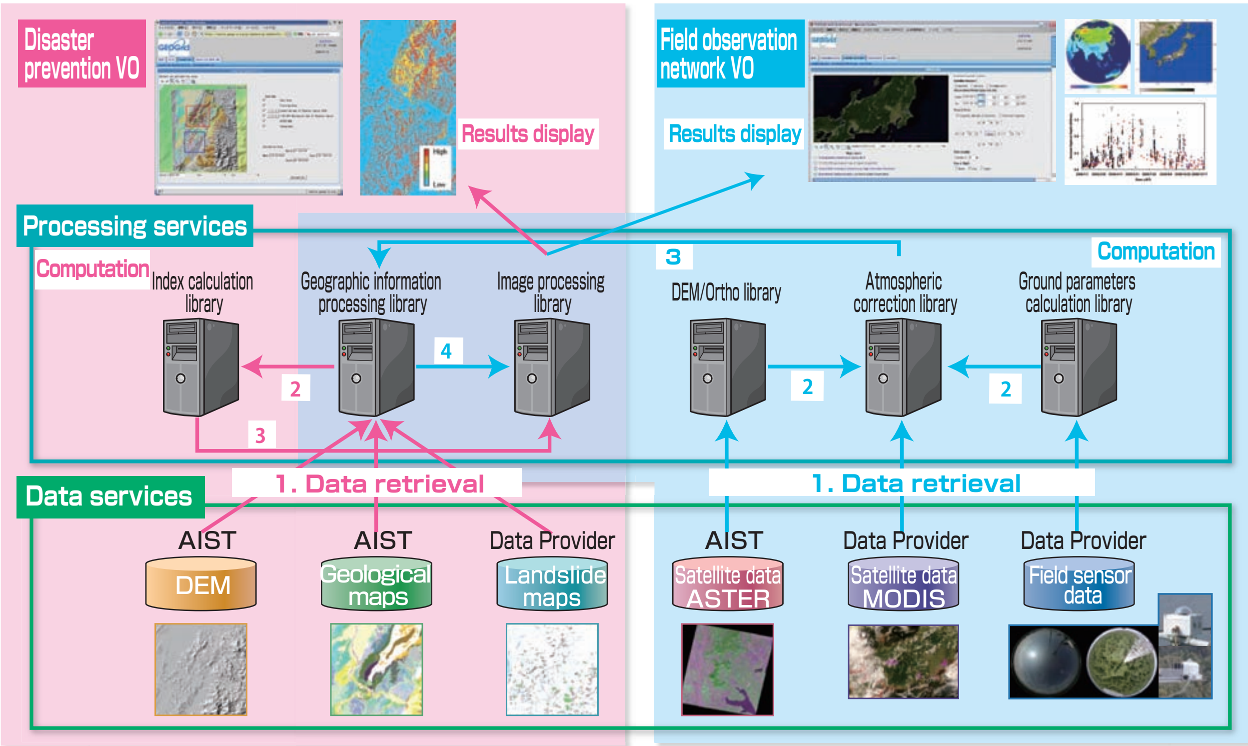

Fig.2 Workflow for integrating processing and data services in two Virtual Organizations based on the GEO Grid VO design

or a community sharing research data. Each of the roles is described briefly as follows.

(1) Users basically utilize services as members of one or more VO. Users that do not belong to any VO are allowed, but they have access only to very limited services.

(2) A service provider registers information for the provided services in a registry. Depending on the service provider's policy, access is controlled at many different levels, making information available throughout an entire VO, or only to certain groups in the VO, or only to certain users, for example. The VO information is used to realize simple access control, in which the management burden does not grow with an increase in users.

(3) A VO manager configures, modifies, and deletes VO settings, manages users belonging to a VO, and creates a Web portal for users. After determining the kinds of services that are available by searching the registry and deciding if there are users who would like to use the services, the VO manager negotiates separately with each service provider. If the negotiations succeed, those services are made available for the VO. The VO manager can provide users belonging to a VO with a list of available services. Users can combine and make use of the desired services from that list; once they log on to the VO, they do not need to log on again each time they use a different service.

(4) The GEO Grid administrator manages the registry in which available services are registered, and provides information on available services.

A test environment based on this VO design has been implemented and is being used successfully for trial service provision in the environmental and disaster prevention field, to be described later below (Fig. 2).

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Geological Data Preparation and Provision in AIST

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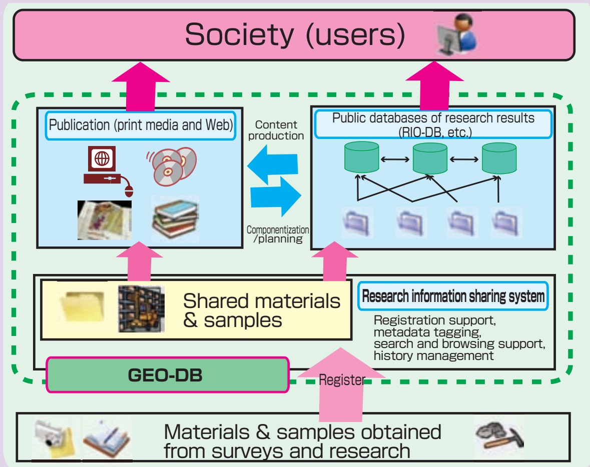
Keiichi Sakaguchi

The Geological Survey of Japan (GSJ) of AIST prepares geological maps, earth science theme maps, and various kinds of geoscience information and provides these to the public. Large amounts of data and expertise go into the preparation of one geological map, which requires field geological surveys and observations, analysis and testing of samples, and expert review of the results.

GSJ, using as platform the system being developed in GEO Grid, is working to build a comprehensive geological information database (GEO-DB) as an information management system covering services from internal sharing of survey and experimental data to management of research results and publications. Up to now, the information made available was limited, in part by technical restrictions. The new system is aimed at improving the quality and quantity of information provided to the public, by thoroughly preparing geological information as a public property, providing a scientific basis for policies and measures, and achieving research traceability. Internally, the GEO-DB can be used as a system leading to the further advance of researches.



Overall view of comprehensive geological information database (GEO-DB)

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Application of the Geographic Information System (GIS) in GEO Grid

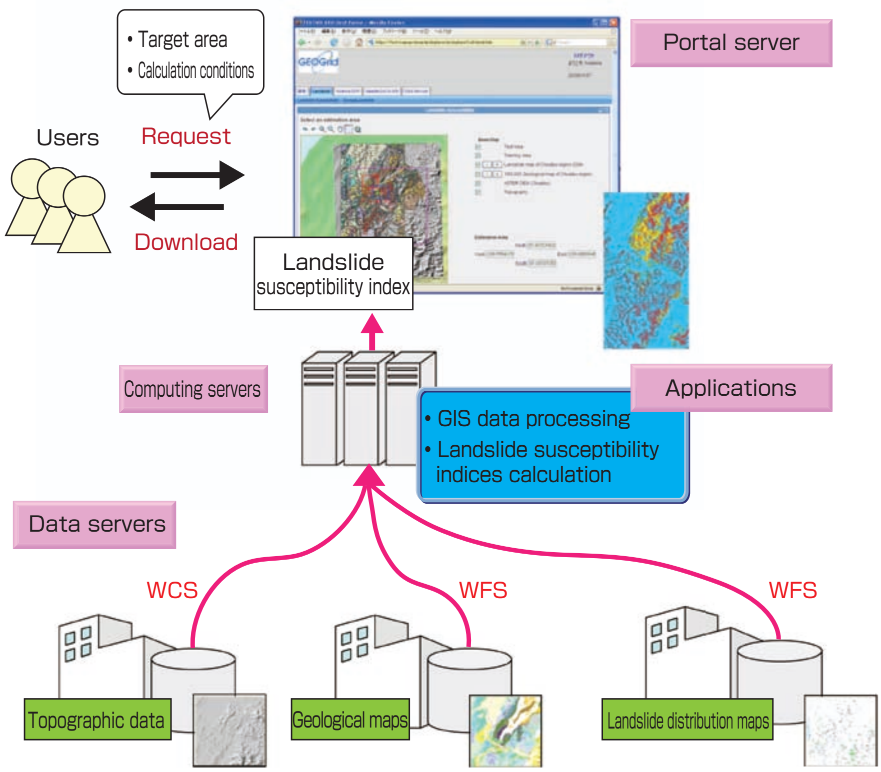
Map distribution services on the Internet

Map distribution services on the Internet have become increasingly common in the past few years. Especially, services using the Web Map Service (WMS), the standard service established by the Open Geospatial Consortium (OGC), allow users to derive map information from multiple sites and superpose them on a web browser or a WMS client software. In Japan, the National and Regional Planning Bureau of the Ministry of Land, Infrastructure and Transport has drawn up guidelines for sharing of geographic information, based on the WMS implementation specification adopted as international standard (ISO 19128). A variety of thematic maps are now distributed from many research organizations using WMS. In other countries, satellite images such as MODIS, Landsat7ETM+ are provided as well as geological maps of the world. AIST also uses WMS to distribute the 1:1,000,000 scale geological map of Japan.

Advanced GIS analysis using standard Web services

Various information can be extracted easily from the maps derived by using WMS. A combination of GIS data, which is often the source of the map image used in WMS, can provide more advanced information. For example, indices of landslide susceptibility can be obtained by analyzing the correlation among data on topographic and geological features, land coverage, and landslides. However, such a GIS application usually requires data preparation, which includes data collection from multiple data providers and loading them into a local computer. In addition, users are often required to perform additional data processing to make datasets manually. In the case of the landslide susceptibility mapping analysis, users need to control the map projection, spatial resolution, data formats, and extract elevation and surface inclination from the topographic data.

GEO Grid supports integrated use of GIS data by performing these processes on the server side. Users can use large amounts of data in their analyses, since the data collection and other simple but time-consuming operations are automated. At AIST, we have experimentally built an analytical service for landslide susceptibility mapping that automatically obtains the numerical topographic data, geological maps, and landslide distribution maps for the selected area and then calculates landslide susceptibility indices. The source data are obtained using OGC-standard Web services such as Web Feature Service (WFS) and Web Coverage Service (WCS). WFS provides geological data and landslide distribution data as a text file written in Geography Markup Language (GML), which is an XML grammar for expressing geographical features. WCS provides topographic data in a binary format such as GeoTIFF. Since both WFS and WCS have standard interfaces, data can be exchanged between the data providers and the users readily, even when they are managed in different formats by individual organizations. From the acquired data, the dataset for landslide susceptibility calculation is created using free open source software designed for processing geospatial data (e.g. GRASS and GDAL). The dataset is then passed to a program that calculates the landslide susceptibility indices.



Advanced analytical service using GIS data

Accelerating data analysis in earth science and related fields

Once after establishing the service on the GEO Grid system, users can get the calculation results by setting the target area and calculation conditions through the GEO Grid portal with a web browser. The results can be downloaded from the portal. Since the data collection and data processing are all carried out on the servers, a group of users can share applications without introducing new computers or analysis software. This model is especially useful when the same algorithms are to be used for different data in spatial and/or temporal, or vice versa, as for disaster prevention/management. In GEO Grid, we plan to apply this model

not only to the earth sciences but to the environmental and disaster prevention as well.

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Use of GIS in Geological Survey of Japan

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Geological Survey of Japan
Daisaku Kawabata

Services making available spatial information over the Internet have become increasingly common in recent years. For geological information, similarly, the Geological Survey of Japan (GSJ) of AIST has developed systems for providing the public with geological maps on the Internet. One is G-INDEX, a system providing indexed searches of geological information, while the other is GeoMapDB, an integrated geological map database. These systems are both based on Web-GIS, a system that makes use of some of the functions in GIS. The main purpose of G-INDEX is to help users find the location of geological information that has been made available up to now. It features comprehensive searches and links to various databases. GeoMapDB is a system that displays information concerning geological maps that are currently offered for public use.

As noted elsewhere, with the rapid progress of information technology, systems like these handling spatial information will also continue advancing at a fast pace. The GSJ and the Information Technology Research Institute of AIST are currently developing systems representing a further enhancement of the systems presently in use. The use of geological information based on the GEO Grid concept is likely to influence the ways in which earth science information is made public in the future.

Screen shot of Geological information indexed search system G-INDEX
http://riodb02.ibase.aist.go.jp/GINDEX/GSJ/index.html

Screen shot of Integrated geological map database GeoMapDB
http://iggis1.muse.aist.go.jp/ja/top.htm

Inquiries about the information in this article:
Geoinformation Center (See website at http://www.gsj.jp/HomePage.html)

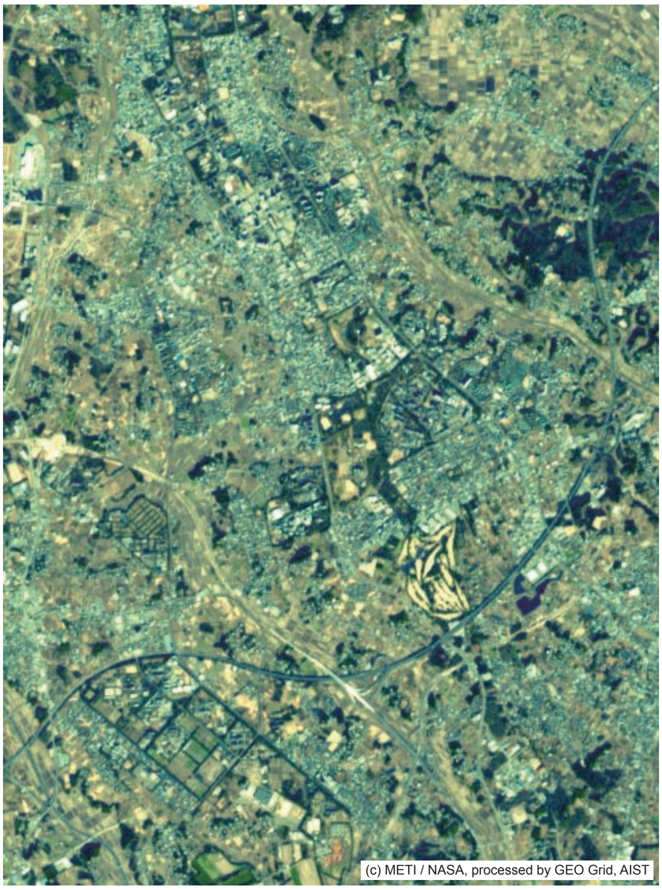
Extension to the Environmental Field

Social infrastructure data for the sake of the environment

Not only natural phenomena but also human activities have a major impact on the global environment. Assessing human activities on a global scale, however, is fraught with difficulties. One problem is the very limited availability of worldwide standardized socioeconomic data, in particular spatial information. For example, there is still a lack of world-scale social infrastructure data (maps) to tell us where people are living (urban distribution), the flow of people and things (roads, railways, etc.), and how human activities are changing the land (land coverage, land use changes). In the GEO Grid project, we are working to meet the needs of society for environmental impact assessments as well as adaptation and mitigation measures by providing social infrastructure maps that combine satellite images, field sensor data, socioeconomic statistics, and other such information.

Using GEO Grid to create social infrastructure maps

Creation of social infrastructure maps starts with the selection of images for each purpose from the vast number of satellite images available. Currently we are preparing social infrastructure maps, in particular city and road maps, based on more than 1.5 million ASTER images (figure). For cases where optimal ASTER images cannot be found, we are testing a satellite image database linking service able to perform multiple image searches at the same time, in order to supplement the missing images with those held by other organizations. The next step is preprocessing, which includes matching



An ASTER image (central Tsukuba) preprocessed by AIST
We performed similar processing on more than 1.5 million ASTER images and then extracted information about social infrastructure such as cities and roads.

the coordinates of the selected satellite images. For this purpose we are building an environment that uses grid technology for fast, simultaneous processing of a huge number of satellite images. Then the images are combined with multiple image processing algorithms, field sensor data, socioeconomic statistics and other such information to extract features such as roads and cities. We are now building a system that will implement multiple algorithms for road extraction and the like on the server side as a Web Processing Service (WPS), allowing researchers involved in map creation to execute these algorithms in the same environment. As the final step in this processing, the results are revised and verified.

International collaboration

The work of creating city and road maps is being carried out in the intergovernmental Group on Earth Observations (GEO), a forum for international collaboration on earth observation of which AIST serves as Japan representative (photo). Researchers in Japan and overseas are pooling their data and image processing algorithms in preparation for making available the highest-precision data in the world. There are strong expectations that GEO Grid will come to be used in this kind of international collaboration. We are also working closely with the Open Geospatial Consortium (OGC) on global standardization for achieving portability of earth observation data, one aim being to reflect in international standards the practical experience AIST has accumulated in satellite image distribution.

Information Technology
Research Institute

Koki Iwao

AIST took part in the December 2008 plenary meeting of GEO as a member of the Japanese government mission. We introduced the work of GEO Japan in collaboration with organizations involved in environmental observations in Japan.

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Extension to the Disaster Mitigation Field

Risk mechanism

Properly assessing the risk from earthquakes, tsunamis, and other disasters occurring somewhere in the world requires uniform worldwide spatial information regarding the objects of risk (people, social infrastructure, etc.) and their vulnerabilities (Fig. 1). If, for example, an earthquake or a windstorm occurred in the desert but there was no human activity in the vicinity, no damage would result. The vulnerability of a solidly built structure like a fallout shelter located on stable and hard bedrock is minimal, so the risk of damage from an earthquake or strong wind is small.

Evaluating risks based on satellite images

For the areas where recent maps and other information are lacking, satellite images from such sources as ASTER and PALSAR can be used to obtain spatial information. Using elevation data obtained from ASTER images (Fig. 2), we can make rough estimates of vulnerabilities based on slope angles and directions, shapes, and other factors. By combining the information with geological maps and other Geographic Information System (GIS) data, the precision of vulnerability estimation can be improved. Then from land cover maps we can extract the elements at risk such as buildings and major roads. If there are satellite image archives extending back far enough in time, we can trace changes in land cover. Knowing, for example, that a housing tract was built on land formerly used as rice paddies can make us aware of soft ground. Or, estimating buildings ages from urban growth data, we can approximate building vulnerability based on the seismic design standard for their construction. Both in Japan and abroad, valuable information like these examples can be obtained from the GEO Grid ASTER archive and from the geological maps published by participating organizations.

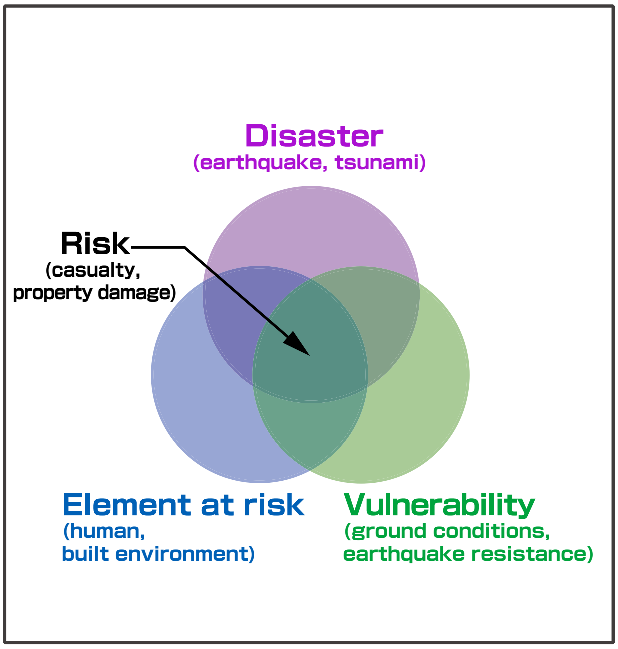

Fig.1 Chart of risk occurrence

Fig.2 Digital elevation model for area around Muroran, Hokkaido, Japan, generated from ASTER images

PALSAR images are invaluable for directly assessing the scope and nature of a disaster right after it occurs, since they show cloud-free views of the earth's surface. After a large earthquake struck the Sichuan area of China in 2008 we successfully provided damage information, using phase information from PALSAR images to understand the distribution of crustal deformation, and using intensity information to estimate the rate of severe damage of buildings (Fig. 3).

Toward global risk assessment by GEO Grid

GEO Grid makes it easy to integrate geospatial information from different sources, such as satellite images and GIS data, and to process images quickly. It thus lends itself readily to complex processing such as that for damage estimation, enabling proper risk assessment. Through alliances with related organizations based on such frameworks as Sentinel Asia, one of the international cooperation projects monitoring natural disasters from space, we plan to deploy services that will be useful for emergency responses to global disasters and for mitigating damage.

Information Technology
Research Institute

Masashi Matsuoka

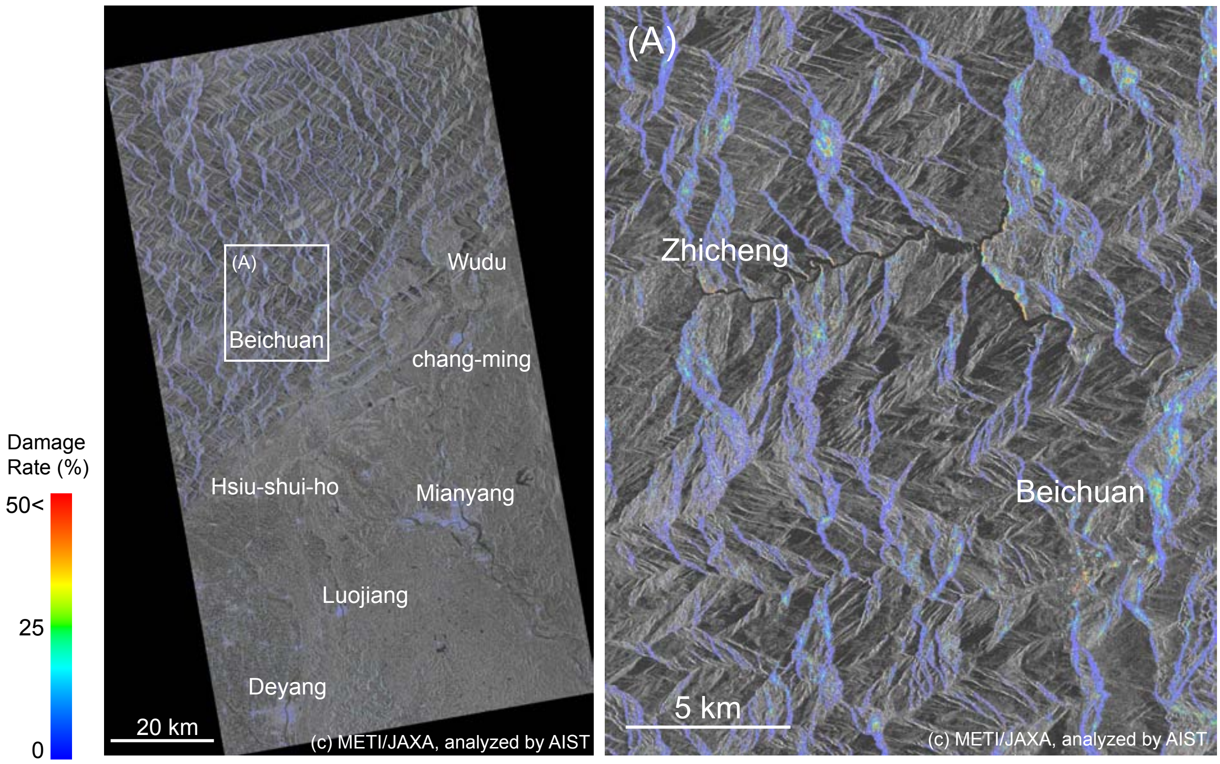

Fig.3 Building damage rate distribution due to the 2008 Sichuan earthquake estimated from PALSAR images

Inquiries about the information in this article:
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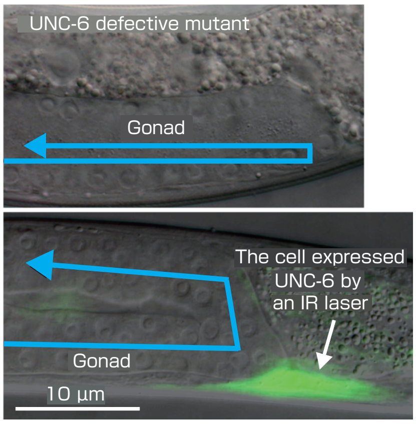
The abstracts of the recent research information appearing in Vol.9 No.4-6 of "AIST TODAY" are introduced here, classified by research area.
For inquiry about the full article, please contact the author via e-mail.

Life Science and Biotechnology

Turning on a gene switch in a single cell using an infrared laser

Development of a new microscopic technology for single-cell gene induction *in vivo*

We have developed infrared laser evoked gene operator (IR-LEGO), a microscope system optimized for heating cells without photochemical damage. Infrared irradiation causes reproducible temperature shifts of the *in vitro* micro-environment in a power-dependent manner. We applied the technology to a living organism, nematode (*C. elegans*), that is a widely used model animal in developmental biology and differentiation studies. We succeeded in single-cell gene expression and in manipulating cell behavior. The new microscopic technology has possibilities of application to many species (e.g. medaka, zebrafish and plant) and a target gene expression in a desired single cell will reveal gene functions *in vivo*.



A physiological demonstration of single-cell gene induction using IR-LEGO. The UNC-6 defective mutant (upper). The target cell was irradiated by an Infrared (IR) laser using IR-LEGO system. By the irradiation, the cell expressed UNC-6 and GFP (arrow), and a gonad was normally formed (bottom).

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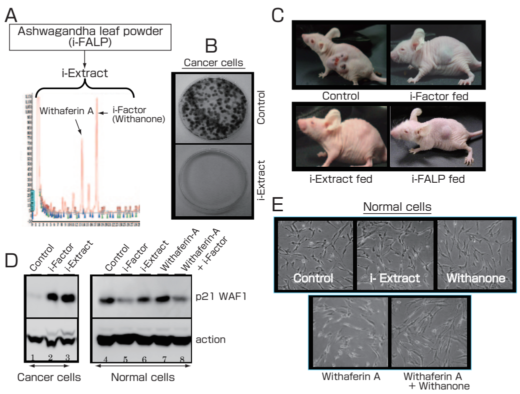
AIST TODAY Vol.9, No.4 p.18 (2009)

Life Sience and Biotechnology

Molecular mechanism of Ashwagandha (Queen of Indian herb) effects

From Indian traditional medicine to scientific facts

Ayurveda is one of the ancient systems of health care of Indian origin. Roughly translated into “Knowledge of life”, it is based on the use of natural herbs and herb products for therapeutic measures to boost physical, mental, and social harmony and improve quality of life. Although sheltered with long history and high trust, Ayurveda principles have not entered laboratories and only a handful of studies have identified pure components and molecular pathways for its effects. Ashwagandha is an Ayurvedic shrub that forms a common ingredient of health supplements, tonics and Indian home remedies. In our efforts to characterize Ashwagandha activities and their molecular mechanisms, we discovered selective *in vitro* cancer cell killing activity in the leaf extract (i-Extract) that operates through activation of tumor suppressor p53 pathway in cancer cells. We have also found that the i-Extract and its component i-Factor (Withanone) enhance health spectrum of normal human cells in culture. We provide the first example of phytochemicals that have both anti-cancer and anti-aging activities.



Chemical composition of the leaf extract of Ashwagandha made from i-factor rich Ashwagandha leaf powder(i-FALP)(A), its cancer cell killing activity *in vitro* and *in vivo* (B and C) and induction of p21 in cancer cells is shown in D. Protection against withaferin A-induced toxicity to normal cells is shown in D and E.

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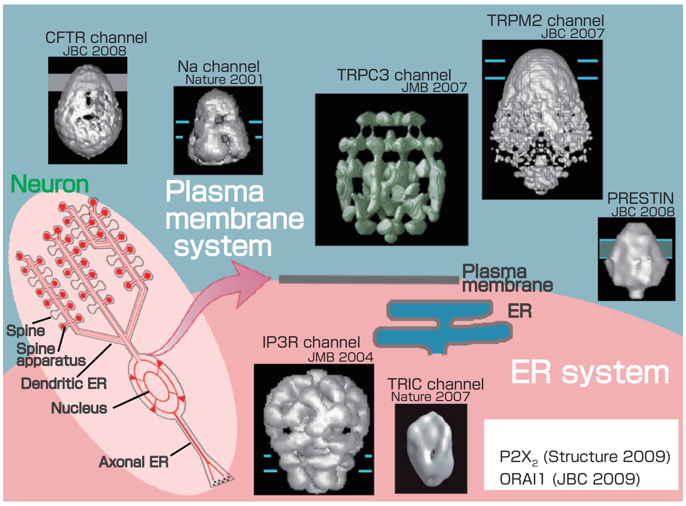
AIST TODAY Vol.9, No.5 p.10 (2009)

Structure analysis of ion channel proteins in membrane
3D structure of ion channels revealed by single particle electron microscopy

Ion channels, including six-transmembrane (6-TM) type channels, are membrane integral components of cellular signaling pathways conserved in almost all species including animals, plants, and some kinds of prokaryotes. We have recently determined the structure of four different 6-TM type cation channels: the voltage-sensitive sodium channel, the IP3 receptor, the TRPC3 and TRPM2 channels, using single particle analysis from cryo-electron microscope images. The basic structure of the molecules was found to be similar: a bell-like shape composed of a relatively small extracellular (or luminal) domain, a protein-dense transmembrane domain, and an expanded cytoplasmic domain. These structures were compared with the newly determined structure of CFTR, P2X2 and Orai1.



Ion channel structures determined by our group: Single particle analysis has a high potential to determine the structures of various kinds of proteins whose crystals are difficult to obtain.

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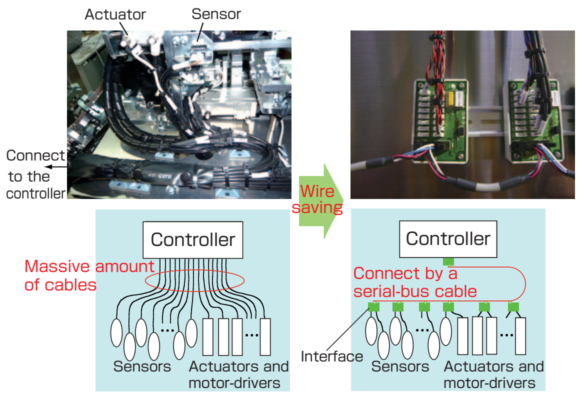
AIST TODAY Vol.9, No.6 p.16 (2009)

Development of low-cost, noise-proof, wire-saving technology
Serial bus communication system reduces wiring and improve productivity

We have developed a serial bus communication system that lays only a single cable in the industrial machine to interconnect the control unit with a number of sensors and actuators in it. The developed system employs a simple communication protocol with enhanced real-time capability and robustness. The prototype interface is built with electronic devices that are commercially available and inexpensive. The system is robust to external noise and achieves high speed in communications. The prototype system has recorded no longer than 0.2 ms in communication delay and as fast as 2 Mbps in transmission speed. These data from the test including the ones mentioned above have demonstrated the excellence of the system.

This system is expected to improve productivity in manufacturing industrial machines by reducing time and cost for wiring drastically and to make the machines lighter and smaller with far less maintenance cost. The technology developed can be applied in a broad range of industries such as: industrial robots, humanoid robots, and car electronics, in which massive amount of cabling is required.



(left) Conventional wiring
Hundreds of cable connecting components occupy a large space in the machine.
(right) The serial bus communication developed blows away massive amount of cables.

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Information Technology Research Institute

AIST TODAY Vol.9, No.6 p.17 (2009)

Diamond biosensor for specific sequence of DNA with ultra-high sensitivity

Showing the potential application in detecting a variety of diseases and biomolecules

The Diamond Research Center has developed a method to fabricate vertically aligned diamond nanowires with 10 nm lateral spacing on conductive diamond surfaces and succeeded in high sensitivity detection of DNA (2 pM) with the electrochemical sensor based on the nanostructured diamond electrodes. Sensitivity two or three orders of magnitude higher in comparison with conventional sensors using gold or glassy carbon has been achieved. Probe DNAs (23 mer) were grafted on the apex of diamond nanowires. When target DNAs are complementarily hybridized with the probe DNAs to make double strand chains, redox current measured on the electrode is decreased since the surface area opened for electrolyte decreases. This is the mechanism to detect specific sequence of DNAs on this electrochemical sensor. Several sequence of DNA can be detected by changing arrangements of probe DNA. Furthermore, this technology is beneficial for detection/measurement for variety of diseases and biomolecules.

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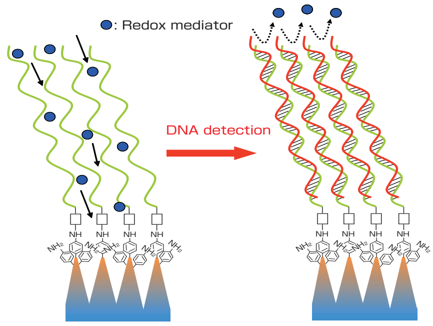
AIST TODAY Vol.9, No.4 p.19 (2009)



Conformation of linker molecules and DNAs fixed on diamond nanowire electrode and detection principal of DNA.

Lightweight hollow carbon fine particles produced from biomass

Elastic hollow fine particles resembling paper balloons

We have developed a new method for producing various lightweight hollow carbon fine particles (diameters ranging from several nanometers to several tens of micrometers) from lignin, which is a byproduct obtained in large quantities during the manufacture of paper or bio-ethanol, and inorganic salts. Global warming and depletion of oil reserves are issues of global concern; hence, it is desirable to use biological resources in place of fossil resources such as oil. In this method, lignin and inorganic salts are dissolved in water, and the solution is spray-dried to form fine composite particles; the particles are then pyrolyzed at 600 - 800 °C, washed, and finally dried to yield various lightweight hollow carbon fine particles. The forms of the hollow carbon particles depend largely on the kind of added inorganic compounds. The extremely lightweight hollow carbon particles of 200-ml in capacity weigh less than 3 g. Rubber or plastics can be reinforced by these lightweight materials instead of conventional carbon black.

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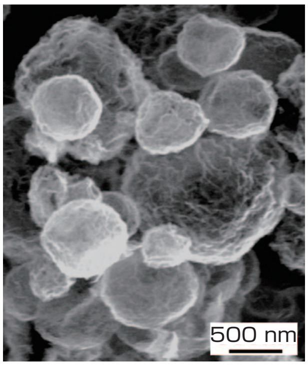
AIST TODAY Vol.9, No.5 p.11 (2009)



SEM image of ultra-lightweight hollow carbon fine particles

Development of novel organic ionic plastic crystals

Expectation for flexible, transparent and highly conductive solid electrolyte

We have developed a new attractive candidate for solid electrolyte, so called “organic ionic plastic crystals (OIPCs)”, through our ionic liquids (ILs) study. One of the salts composed of much familiar cations and anions used for ILs preparation is solid even in 90 ºC, however, this solid salt possesses plastic crystal phase in a wide range of temperatures from -50 ºC to 90 ºC. The OIPC is totally transparent and is a flexible self-standing film. Surprisingly, the conductivity of the OIPC with slight addition of Li salt (5 mol%) is 10^{-3} S cm^{-1} even in a solid at 25 ºC.

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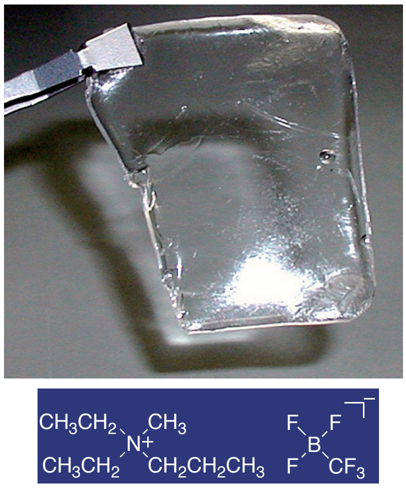
AIST TODAY Vol.9, No.5 p.12 (2009)



N_{1223} $[CF_3BF_3]$ m.p. 95 ℃ (ΔS_m = 7.4 J K^{-1} mol^{-1})

Photo image and chemical structure of developed organic ionic plastic crystal $N_{1223}[CF_3BF_3]$

Development of high-performance inorganic adsorbent for carbon dioxide

Efficient capture of carbon dioxide above atmospheric pressure

We have developed an efficient inorganic adsorbent for carbon dioxide. This adsorbent is porous material made of hydroxyl aluminum silicate. This material can be synthesized easily from cheap raw materials. As the material can be produced in a large scale, low cost production would be possible. The amount of adsorbed carbon dioxide on this material is more than 10 wt% when the pressure of carbon dioxide is raised from 100 kPa (atmospheric pressure) to 900 kPa. This value is about two times larger than the amount of carbon dioxide adsorbed on zeolite 13X, which is now used for a carbon dioxide capture system. If the pressure swing adsorption (PSA) system can be operated above atmospheric pressure by using this material, the PSA system can collect carbon dioxide with low cost compared with the present system.

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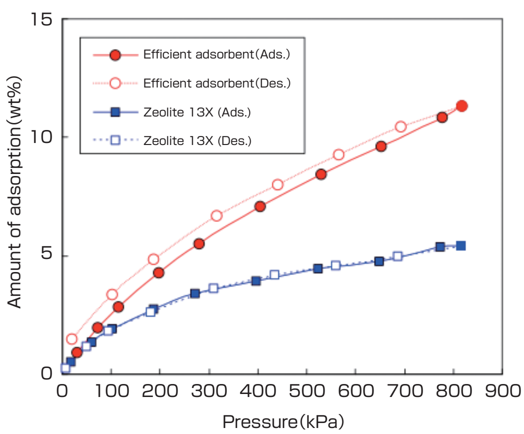
AIST TODAY Vol.9, No.4 p.20 (2009)



Carbon dioxide adsorption/desorption isotherm of the developed adsorbent and zeolite 13X (standard zero at atmospheric pressure)

Development of dose standard for X-ray used in mammography

Aiming for more precise dosimetry in breast cancer examination

Reference field for mammography has been established using a molybdenum-anode X-ray tube and a molybdenum filter (Mo/Mo). The calibration coefficients of an ionization chamber obtained in the mammography reference field are compared with those in the conventional soft X-ray reference field which were produced using a tungsten-anode X-ray tube with aluminum filters (W/Al). The difference in the calibration coefficients between these reference fields was about 1 %. This development is expected to improve the precision of dosimetry for mammography.

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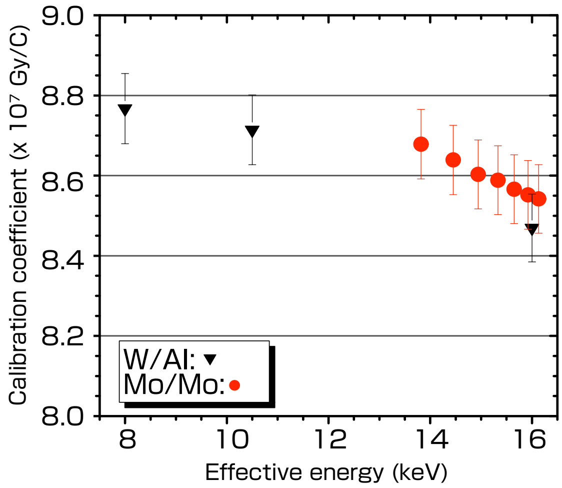
AIST TODAY Vol.9, No.5 p.13 (2009)



Comparison of calibration coefficients between radiation qualities of W/Al (conventional) and Mo/Mo (mammography)

Study of a new microwave power standard

Microwave power standard based on frequency measurement

We are developing a new method for measuring microwave power based on frequency measurement. An atomic Rabi frequency is proportional to the microwave field strength. The microwave field strength is thus uniquely determined by the Rabi frequency. The new microwave power measurement using the Rabi frequency has the advantages over the present calorimeter system in terms of stability, time constant and ability for remote calibration. Furthermore, it is possible to check the consistency of microwave power unit derived from different methods (i.e. the Rabi frequency and the calorimetric methods).

The microwave magnetic field strength was measured using the Rabi frequency between microwave and gaseous cesium atoms in a glass cell. Transformation from the field strength into the absolute value of the power and comparison between the new microwave power measurement and the present standard will be performed in a later work.

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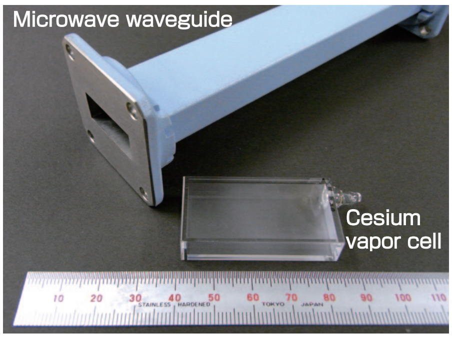
AIST TODAY Vol.9, No.6 p.18 (2009)



Microwave waveguide and cesium vapor cell
The cell was designed to fit in the waveguide.
The Rabi frequency was obtained in the waveguide.

Detection of chemicals hidden in opaque containers

The objects are colored temporally by multiphoton excitation using near-infrared femtosecond laser

We have developed a new spectroscopic system that can measure transient absorption spectra and 3D shapes of target objects that are hidden in an opaque container such as a colored glass bottle, an envelope, and a plastic bag. Multiphoton excitation by a femtosecond near-infrared laser pulse, which easily penetrates into the opaque containers, can induce transient coloring of the target material, and the transient absorption spectra can be measured by the light pulse following the exaction pulse with a controlled delay time. Even 3D imaging of the object is possible when the laser beam is spatially scanned since only the laser focus point gives the transient absorption signals. We are now trying to apply this system to illegal drug detection.

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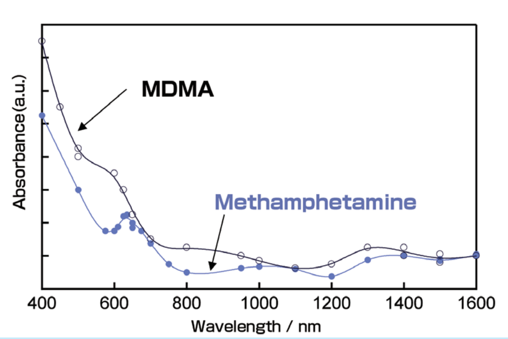
AIST TODAY Vol.9, No.6 p.19 (2009)



Transient absorption spectra of illegal drugs (collaboration with National Research Institute of Police Science)

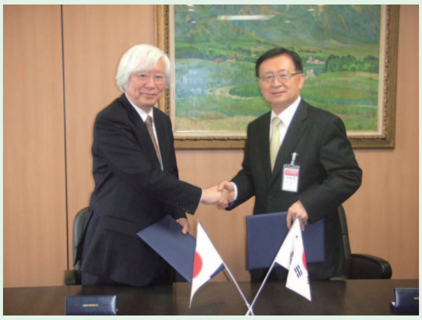
In Brief

MOU concluded with Korea Research Council for Industrial Science & Technology

On February 16, 2009, AIST concluded a MOU on comprehensive research cooperation with the Korea Research Council for Industrial Science & Technology (ISTK).

In 2008, many of the national research organizations were reorganized under two councils in Korea. ISTK is one of the two scientific concils in Korea and is under the Ministry of Knowledge Economy. Presently, under ISTK, there are 13 research institutes for mechanical engineering, electronics, chemistry, geology, energy, materials, manufacturing, and for other fields in common with AIST, and it has been transformed into a research organization of a size equivalent to AIST. At ISTK, the strengthening of new functions such as planning, management, and evaluation of these research institutes has become an issue.

AIST has concluded, over the years, 15 still active collaborative research MOUs and joint research contracts with ISTK institutes: the Korea Institute of Industrial Technology, the Korea Institute of Energy Research, the Korea Institute of Geoscience and Mineral Resources, and the Korea Research Institute of Chemical Technology. With this new MOU, not only further promotion of research cooperation is hoped for, but active cooperation is also expected in areas of research management such as of projects, research units, and researcher evaluation in which AIST has some experience.



ISTK Chairman Han (right) and then AIST President Yoshikawa (left) after signing the memorandum

Cover Photos
Above: SEM image of ultra-lightweight hollow carbon fine particles (p. 21)
Below: Photo image of a developed organic ionic plastic crystal (p. 22)

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