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Social Infrastructure Business in Emerging Economies and Global R&D for Regional Needs

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Message from the Planners

Hitachi operates its Social Innovation Business globally, supplying social infrastructure systems underpinned by highly efficient and reliable information technology (IT). In particular, these business operations focus on emerging economies, etc. Meanwhile, Hitachi is also working to strengthen its locally managed research and development (R&D) organizations so that it can satisfy the diverse needs of different nations and regions. This issue of *Hitachi Review* describes social infrastructure businesses in fast growing emerging economies and Hitachi's locally managed approach to infrastructure systems R&D, looking in detail at its operations in America, China, Europe, and India.

In this issue's "One Person's View," Kazuo Watanabe, Ambassador for Science and Technology Cooperation at the Ministry of Foreign Affairs of Japan, gives his thoughts on science and technology cooperation with emerging economies. In "Technotalk," a panel made up of key people involved in business operations and R&D in different parts of the world discusses the challenges and required responses for achieving global scale in Hitachi's Social Innovation Business.

A number of articles provide specific examples of R&D. One article from the USA describes model-based design and the development of cyber-physical systems, technologies used in automotive embedded systems. Another from Europe gives an overview of Hitachi's railways business operations in Europe and how they are underpinned by R&D.

As a nation experiencing remarkable economic growth, China is facing the dual challenge of satisfying an increase in energy demand while also protecting the environment. Articles in this issue describe how Hitachi is responding to these challenges through participation in energy-efficient eco-city construction projects, and through R&D strategies that are formulated to suit Chinese smart grids and smart systems.

India is another country where growth in social infrastructure investment is ongoing and an article inside describes Hitachi's business strategy for electric power systems and other fields, as well as the establishment of an R&D center in India to provide support for these infrastructure businesses from the research stage.

Elsewhere, other articles about emerging regions expected to experience strong economic growth cover Russia, which is seeking to move toward achieving this growth through innovation rather than through a dependence on resource extraction, and Brazil, where Hitachi has had business operations for more than 70 years.

Hitachi aims to satisfy the diverse needs for social infrastructure systems in different parts of the world through partnerships that span the entire globe. We hope that readers of this issue of *Hitachi Review* will find it to be useful and informative.

Planners for this special issue "Social Infrastructure Business in Emerging Economies and Global R&D for Regional Needs"

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Technotalk

Social Infrastructure Business in Emerging Economies and Global R&D for Regional Needs

Hitachi is working to accelerate the global development of its Social Innovation Business, which supplies social infrastructure systems supported by highly efficient and reliable information technology (IT). To grow more and operate as a global business, Hitachi needs to expand its business activities and research and development (R&D) resources in both emerging markets and developed economies and regions so that it can meet the changing needs of its various global operations. Here, we have brought together key people responsible for R&D and business operations in different parts of the world to discuss the specific measures needed to realize this strategy, and the challenges they will face.

Social Infrastructure Markets in each Region, and Current Status of Business and R&D

Takeda: Hitachi's overseas sales ratio is expected to be 43% in the current year, and we are seeking to increase this above 50% to further expand our operations in global markets. What do you think of the current state of global business development at Hitachi?

Toyoshima: The question is how to shift resources to specific areas of the world. And we need to focus on our Social Innovation Business, meaning the infrastructure business. Initially, we selected 11 nations and regions, including the fast-growing Asian Belt Zone*, South America, and Central and Eastern Europe. But we shouldn't ignore other parts of the world since we have lots of new business in Africa, as well as in developed economies, including Europe and the USA. This infrastructure business must deal with many unique local characteristics. How to adapt to different local conditions is a key challenge.

Takeda: China and the Asian countries are among the most active parts of the world for building new infrastructure.

Chen: China is in the second year of its 12th Five-Year Plan, in which promoting urbanization is one of the major goals. Targets for city construction have been established across the country. This is reflected in terms such as "smart city," "wireless city," "digital city," "eco city," and "knowledge city." Smart cities in China can be broadly divided into two categories. The first, indicated by terms such as "smart city," "digital city," or "wireless city," seeks to provide cities with IT infrastructure. The second category is the eco-city, meaning low-carbon, energy-efficient cities with a closed-loop approach to resource use. These eco-cities can be further divided into those built by upgrading existing cities and those being built on new sites, with China having as many as 400 of these newly constructed cities. Hitachi currently has an active involvement in smart city construction at Tianjin Eco-city and other sites throughout China.

Hohmann: Compared to China, the social infrastructure business in Europe is growing slowly but steadily. Hitachi is engaged in some smart city projects in Europe. Smart cities in Europe are defined as knowledge cities including e-health care, smart energy, sustainable housing, comprehensive information and transportation infrastructure as well as e-education and e-government. The challenge in Europe is to modernize and maintain existing infrastructure.

Hitachi is able to provide technology and expertise for smart grid solutions for small and middle size local

* Asian Belt Zone consists of countries and areas, totaled 24, such as but not limited to China, ASEAN countries, India, Middle Eastern countries and other countries located within the territory.

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governments in Europe. In the rail sector, Hitachi is the first Japanese company supplying high-speed trains to the UK. Hitachi Rail Europe has gained a very good reputation over the last decade and continue to do so with the success of the Class 395 model, which has been in service since 2009. Further Hitachi is participating in infrastructure projects involving electric vehicles and water purifying technologies in the south of Europe.

Saikalis: My focus in the USA is on new approaches to applying new technology in the automotive sector. Right now, we are establishing some collaborative work with customers on model-based design, which involves predicting the behavior of the overall system to optimize design, and on electromagnetic compatibility at the vehicle level. Another important research field for us is cyber-physical systems, in which real-world ("physical") measurements are incorporated into systems built in cyberspace. Model-based design and the cyber-physical concept help the design process go very fast from the conceptual idea all the way to implementation or to a feasibility study. We're virtualizing electronic control systems that include central processing unit (CPU) operation all the way to engine/plant behavior, and connecting the different parts together to see the whole system in action.

Simulation technology like this uses large amounts of data, so we need to take greater advantage of cloud computing in the automotive world.

Takeda: You are also working to explore new business fields in South America?

Saikalis: Yes. I believe that our research laboratory at Hitachi America can contribute to some achievements in fields like bioethanol, for example. The level of Brazilian universities and R&D centers is high, and I hope we will have numerous opportunities to work with these institutions in the future.

Takeshita: The Brazilian government has an infrastructure plan, called Programa de Aceleração do Crescimento 2 (PAC 2) (growth acceleration program 2). Infrastructure is an urgent issue for Brazil because it will be hosting both the World Cup of football and the Olympics. So, we are trying to promote our technologies in our Brazil business, especially transportation (monorails and high-speed trains), and also in the field of smart grids.

Contributing to Operation of Social Infrastructure Business through Global Partnerships

Takeda: One thing we should not forget is that social infrastructure is for the people who live in that society. This means that building strong partnerships with local institutions is essential. What can you tell me about activities in each region?

Saikalis: At the Automotive Products Research Laboratory (APL) of Hitachi America Ltd., our mission has always been to contribute to the automotive business in the USA by customizing products for that market, such as engine management systems, components for hybrid vehicles, suspension and brake systems. I have been working for Hitachi in R&D since 1990, including in fields like model-based design. Over the years, we have created a network, not only within Hitachi Automotive Systems, Ltd. but also among our customers.

We are also localizing more design and manufacturing in the USA, and the key to this is long-term human relationships. It is important that researchers like myself are based in the USA, and that we build close relationships with the engineering community there.

Takeda: Hitachi Design Centre Europe (HDCE) has a long history, and I understand the type of design work being undertaken has also been changing.

Hohmann: Yes. I have been working at HDCE since 1992, and over that time the design team focus has moved away from the consumer products we've targeted in our early years. One example is our activities in the information

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Joined Hitachi America, Ltd. in 1990. Appointed Chief Researcher, Research & Development Division in 2001, Senior Director and Laboratory Manager in 2006, and his current position in 2012.

system design. This includes king size displays in the semi public area, where people are able to interact with local information through simple gestures, iconography and mobile phone interaction. The Hitachi railway business is another challenge for comprehensive experience design solutions. From invisible railway maintenance, human workflows and man-machine interactions to the train interior/exterior design to the train signaling and control room interface design support.

Hitachi is able to provide advanced technology solutions in various applications and the design team provides meaningful user interfaces and experiences to make technology work smoothly within a given cultural context.

Takeda: How about partnership?

Hohmann: As Hitachi changes towards social infrastructure business, we're exploring the cultural context, human factors and provide value interfaces for the new public services in the future. For example, we're applying a range of user-centered methodologies like ethnography, user observations, qualitative questionnaires, workflow scenario creation etc. to explore local user, or workforce problems with an existing infrastructure in order to provide new solutions to cope with the challenges of future cities. In Europe we are actively working with universities such as King's College London, University of Siegen, Germany or Royal College of Art in London to conduct studies and analysis based on our new service design approach.

Takeda: Dating back only to 2000, Hitachi's R&D in China has a shorter history than in the USA or Europe, but it's notable for the speed of its growth.

Chen: I have been involved in R&D in China since 2000 and this work is growing in collaboration with local partners. Given Hitachi's current focus on its Social Innovation Business, partnerships in China are taking on a growing significance and Hitachi is expanding the scope, objectives, and format of these collaborations in conjunction with the expansion of its China business.

In 2001, for example, back in the early years of our R&D in China, we set up a joint laboratory with Tsinghua University, one of the top universities in China, to undertake advanced research in the area of telecommunications technology. When the focus of Hitachi's business in China subsequently shifted to its Social Innovation Business, joint research with universities also expanded into a wider range of fields, such as energy management systems, with the aim of contributing to local projects and building local partnerships. This has included collaborations with other major universities such as Fudan University and Shanghai Jiao Tong University.

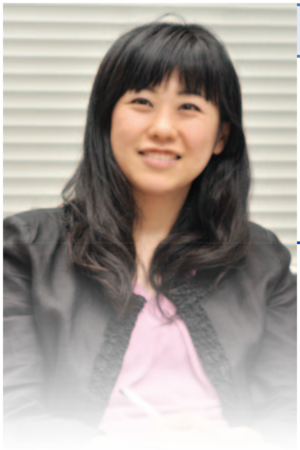
In the smart city field, we're also working with local governments on city development in Tianjin, Guangzhou, Dalian, and Chongqing. Together with the operational businesses, we are working on partnerships and on the development of technology aimed at satisfying local needs.

Toyoshima: Talking about partnerships in Asia, another example is how we've been active in Singapore for 40 years or more. Like Japan, they have few natural resources and a very limited number of human resources, so they need sustainable growth by being deeply involved in developing overseas infrastructures. They have considerable information on this, so maintaining good partnerships with the Singaporean government is very important.

Takeshita: Brazil sometimes requires products and solutions to be designed specifically for that nation. Other factors include distinctive business practices and complex taxation rules, and these too make partnerships with local companies, universities, and R&D institutions an important part of doing business in Brazil.

Future Outlook for Business and R&D in each Region

Takeda: Are there any particular regions or R&D topics you are focusing on in terms of our next steps toward



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globalization?

Toyoshima: We see the Mekong Delta, Mexico, and Australia as being unique markets. The Mekong Delta region has booming potential economies, including Myanmar. Mexico, too, is unique. It has free trade agreements with more than 40 countries, so we should take advantage of that mechanism, which will allow us to export automotive related products to many countries including Brazil without any tariffs. Australia, meanwhile, presents major opportunities in the mining sector, including construction machinery.

Chen: Smart city construction in China is encouraging the application of IT to the field of social infrastructure. This means considerable business opportunities exist in the fusion between IT and social infrastructure being promoted by Hitachi. However, factors such as the scale of data and application features are different to those in Japan. That is why we are undertaking R&D into cloud systems for use as smart city platforms, telecommunications gateways, and other key applied technologies such as energy management and monitoring systems and transportation systems. We are working closely with the operational businesses to deploy these technologies in areas such as the Tianjin Eco-city project or Dalian Biodiverse Emerging Science & Technology (BEST) City project.

Hohmann: In Europe we see the aging of society as an important factor driving future trends and business opportunities for Hitachi in the field of Social Innovation Business. We see the challenges in medical information management, e-health care, personal data security and privacy will play an important role in this context. I believe this will provide significant opportunities for Hitachi. Japan is facing similar problems locally and a closer collaboration would be inspirational for Hitachi's global business. I do see further challenges in the energy and water business in Europe, where Hitachi is able to contribute with advanced technology, after a customization process to meet specific local requirements, explored by a local team including the designer.

Saikalis: In the USA, we try to be very solution-oriented with our R&D. One technology we're trying to use is system level virtualization. One example is virtual hardware in the loop system. This solution models the whole system, not just components. We can see the interaction between all the components, virtually. It's an approach that can also be applied in other areas outside the automotive field, such as construction equipment.

Global Perspectives on the Hitachi Group

Takeda: How do you feel about Hitachi from an overseas perspective? Also, what do we need to do with our global R&D strategy to make a greater contribution to the world?

Takeshita: In Brazil, they use the term "tropicalization" to represent the Brazilian approach. What this means is the design of technology and culture in the Brazilian style. I believe this word has been taking on increasing importance recently as Hitachi has been developing its business in Brazil. Customers in Brazil demand system solutions designed in the Brazilian style as well as imported equipment. It is quite possible that Hitachi will need to establish an R&D center in Brazil in the future.

Toyoshima: Another point relates to how to localize operations. The Social Innovation Business can be said to be order-made type business. This requires people who understand the local markets. In India, for example, we had a manufacturing joint venture for air-conditioning that was successful because it designed and manufactured products to suit local requirements.

Hohmann: It is essential to engage in constructive discussion with the people of each local business in each country or region regarding what constitutes the best technology or the best integration for the infrastructure in their region. I think it's also important to exchange people frequently and have a global pool of ideas and inspirations. Here the extensive use of social media as an in-house technology may provide the knowledge management base where Hitachi employees would be able to collaborate on small incubation projects worldwide and collaborate as a multi-disciplinary team.

Saikalis: I think the language barrier also needs to be lowered and more use made of English as a common language to ease communication and have strong global participation.

Chen: When talking about the globalization of R&D, we need both to encourage the shift to local management and also to strengthen the global unity of our approach. While the current focus is on promoting local management, making the most of Hitachi's strengths in the Social Innovation Business will require that we demonstrate the comprehensive global capabilities of Hitachi throughout the world. This means that, rather than having local operations focus only on customizing applied technologies to suit the requirements of their region, I believe it is also desirable that our research institutions inside and outside Japan should work together on the joint development of common platform technologies in all of our business fields. To satisfy market needs in different parts of the world, it is also important to be able to offer solutions promptly that combine applied technologies developed locally with platform technologies that can be shared globally.

Takeda: We will meet each region's social infrastructure needs by strengthening partnerships, not only between Hitachi's own global R&D departments, but also with other institutions and customers. Thank you very much for your participation today.

Hitachi's Global Business and R&D Strategies

Yukio Toyoshima
Yasuo Osone, Dr. Eng.

GROWING IMPORTANCE OF REGIONAL FOCUS IN GLOBAL BUSINESS

WITH emerging economies increasingly surpassing advanced industrial economies as the world's key markets, Hitachi is pursuing specific business strategies in each market. With products and services that span a wide range, it is important that the activities of Hitachi's internal and group companies in each region of the world be coordinated by both group and regional headquarters. It has also become more important for the group and regional headquarters to coordinate their activities and plot further strategies.

Aiming to expand its Social Innovation Business globally, Hitachi has identified key regions*1 as being of critical importance in the future, and is proceeding with measures that include collaboration with local partners and adopting a locally focused approach to operating its businesses. This issue contains articles that describe Hitachi's business activities in China, India, Brazil, and Russia, and its research and development activities in North America, Europe, China, and India.

*1 Arab Republic of Egypt, Central and Eastern Europe, Federative Republic of Brazil, India, Kingdom of Saudi Arabia, People's Republic of China, Republic of Indonesia, Republic of South Africa, Republic of Turkey, Russian Federation, and Socialist Republic of Viet Nam (alphabetic order)

HITACHI'S GLOBAL BUSINESSES

Hitachi has designated six hubs, located in Japan, USA, Europe, Asia, China, and India, to undertake product development, production, sales, and servicing relevant to their respective regions. Hitachi has 599 subsidiaries spread across 54 countries, with activities spanning the continents of America, Africa, Europe, Asia, and Australia (see Fig. 1 and Table 1). This issue includes articles on how Hitachi is operating its Social Innovation Business in global markets, and on its global research and development activities. In pursuing its international business activities, it is becoming ever more important that Hitachi's involvement starts from the research and development phase.

The following sections use examples from China, India, Russia, and Brazil to describe the activities of Hitachi's Social Innovation Business.

Social Innovation Business in China

China is experiencing rapid economic growth with ongoing social infrastructure construction anticipated, including in the northeast and interior regions. There is also a need to create an environmentally conscious society, namely a "low-carbon society." Hitachi has formulated its business strategy with the aim of

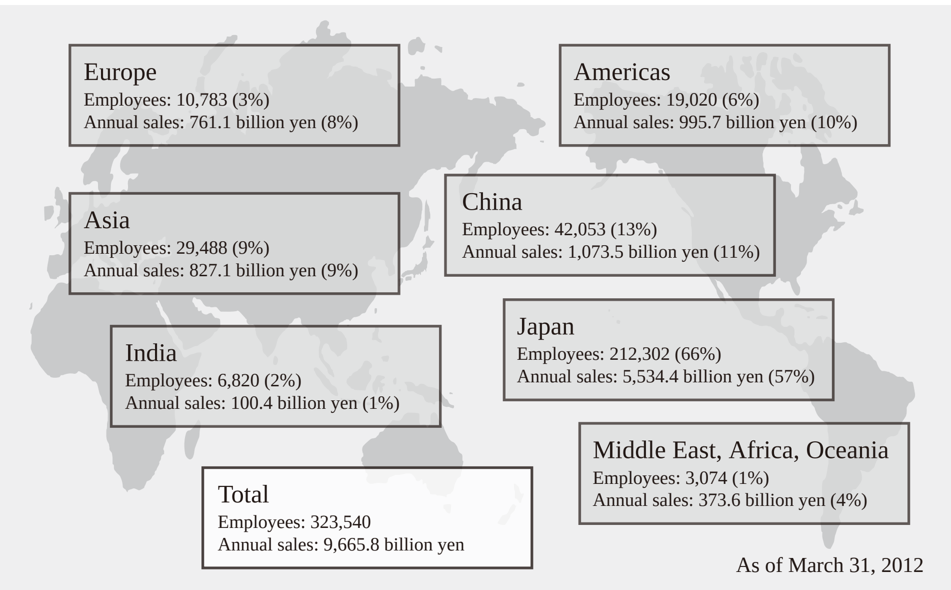


Fig. 1—Overview of Hitachi's Global Business.
Hitachi's global business is based around six hubs, including Japan.

TABLE 1. Number of Hitachi Companies in Each Country

The number of Hitachi companies in each country. Hitachi currently has 599 companies spread across 54 countries.

Country or region		No.	Country or region	No.	Country or region	No.
People's Republic of China		173	Spain	10	State of Israel	2
	Hong Kong	20	Federative Republic of Brazil	8	Kingdom of Norway	2
	Taiwan	19	Kingdom of Belgium	6	New Zealand	2
	Macau	1	Republic of South Africa	6	Ukraine	2
United States of America		63	Republic of Austria	5	Republic of Bulgaria	1
United Kingdom of Great Britain and Northern Ireland		35	Russian Federation	5	Republic of Chile	1
	Bermuda	1	Czech Republic	4	Arab Republic of Egypt	1
Kingdom of Thailand		33	Hungary	4	Republic of Ghana	1
Malaysia		26	Republic of Italy	4	Hellenic Republic	1
Republic of Singapore		25	Socialist Republic of Viet Nam	4	Republic of Kenya	1
India		21	Swiss Confederation	3	Republic of Mozambique	1
Federal Republic of Germany		19	Kingdom of Denmark	3	Federal Republic of Nigeria	1
Republic of Korea		14	Ireland	3	Republic of Panama	1
Republic of Indonesia		13	Republic of Poland	3	Portuguese Republic	1
Republic of the Philippines		13	Slovak Republic	3	Romania	1
Australia		12	Kingdom of Sweden	3	United Republic of Tanzania	1
Canada		12	Bolivarian Republic of Venezuela	3	Republic of Uganda	1
United Mexican States		12	United Arab Emirates	2	Republic of Zambia	1
Kingdom of the Netherlands		12	Argentine Republic	2		
French Republic		11	Republic of Finland	2		
					Total	599

* As of March 2012

helping China progress in accordance with the nation's Five-Year Plan.

Specifically, Hitachi established a China Energy Conservation and Environment Commercialization Promotion Project Team at Hitachi (China) Ltd. in April 2006. It has also helped China Central Television with filming, factory visits, and similar activities in Japan, based on the idea that China can draw on Japan's experience as it seeks to combine protection of the environment with economic growth.

In addition to signing the Model Project for Energy Saving and Utilization of Waste Heat/Pressure through Electrical System in the Steel and Chemical Industries in Yunnan Province, one of the Japan-China Energy Conservation and Environmental Business Promotion Model Projects[a] agreed upon between the Japanese and Chinese governments in 2007, Hitachi is also participating in a number of other projects, including an energy efficiency assessment model project in Ningbo City, a joint project with the National Development and Reform Commission, and a joint project with Dalian City. Elsewhere, Hitachi is helping to establish the infrastructure for resource recycling in China through home appliance recycling as well as in the fields of smart grids and water treatment. In October 2011, Hitachi signed a memorandum of understanding on collaboration in fields such as resource recycling and the low-carbon economy with the Liangjiang New Area of Chongqing City. In the future, Hitachi intends to continue meeting the need for social infrastructure that takes account of the environment and energy efficiency by supplying its know-how, technology, products, and services, and by making extensive use of its local operations.

Social Innovation Business in India

Hitachi is involved in a range of social infrastructure businesses in India, a nation where robust economic growth is driving vigorous investment in infrastructure. In the field of information, telecommunications, and networks, where the government published a draft National Telecom Policy in 2011, Hitachi is strengthening businesses that handle Big Data. In electric power generation and transmission, Hitachi

(a) Japan-China Energy Conservation and Environmental Business Promotion Model Projects
Projects that seek to encourage the development of energy conservation and environmental businesses involving Japanese and Chinese companies with the aim of expanding mutually beneficial cooperation between Japan and China in these fields. In addition to ensuring that business activities such as energy efficiency assessments, feasibility studies, and the supply of equipment proceed smoothly, and that wider use is made of Japan's excellent technology and management experience in the fields of energy conservation and the environment, the projects also aim to act as model examples.

has established a joint venture company with BGR Energy Systems Limited, a large Indian company in the field of thermal power plant construction, and is seeking to win ongoing orders for boilers and turbine-generators for thermal power plants to help meet the shortfall in India's electric power supply. Hitachi has also established a base for the design, manufacture, and maintenance of monitoring and control systems for thermal power plants to put in place the capabilities for helping these plants achieve higher efficiency.

In the field of infrastructure systems for industry, Hitachi is working to expand its photovoltaic power generation systems business, including participating in "The Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies" being run by Japan's New Energy and Industrial Technology Development Organization (NEDO) along with the Indian government and others. Hitachi is also speeding up its provision of complete system support in the field of control systems for steel mills, from sales through to design, manufacturing, and maintenance services.

With predictions of water shortages becoming more severe in the future, Hitachi also intends to contribute to the use of water resources in India through its seawater desalination and recycling businesses.

In the railway systems field, Hitachi's activities include working to promote the adoption of aluminum carbodies in high-speed and quasi-high-speed trains, and supplying solutions for the modernization of railway signaling systems, including digital automatic train control (ATC)[b]. It is also actively promoting monorails.

Hitachi now has 22 local subsidiaries and 6 branches or offices operating in India, and these are working as a group on Hitachi's social infrastructure business.

Social Innovation Business in Russia

Hitachi has had business activities in Russia since 1982, and currently 10 group companies have a presence in the form of a subsidiary, branch, or permanently staffed office.

To achieve economic stability over the long term, the Russian government is adopting an "Economic Modernization Program" aimed at shifting from a resource-dependent economy to an innovative economy. As the five sectors prioritized for modernization are energy efficiency, healthcare, space and communications, information technology (IT), and nuclear energy, there is a good fit between Russian government policy and Hitachi's technologies. This has set the stage for business expansion.

Rapid market growth is anticipated, with per capita personal income having more than doubled in real terms over the eight years from 2002, and a willingness to spend evident among the middle classes. The Russian market is one with great potential, including the construction of new social infrastructure to cater to the series of major events being hosted over coming years, namely the Asia-Pacific Economic Cooperation (APEC) Russia 2012 summit in Vladivostok, the Sochi 2014 Winter Olympics, and the 2018 FIFA[*2] World Cup Russia.

While the size of its business in Russia remains very small compared to the size of the potential market, Hitachi intends to take a strategic approach to business development.

Social Innovation Business in Brazil

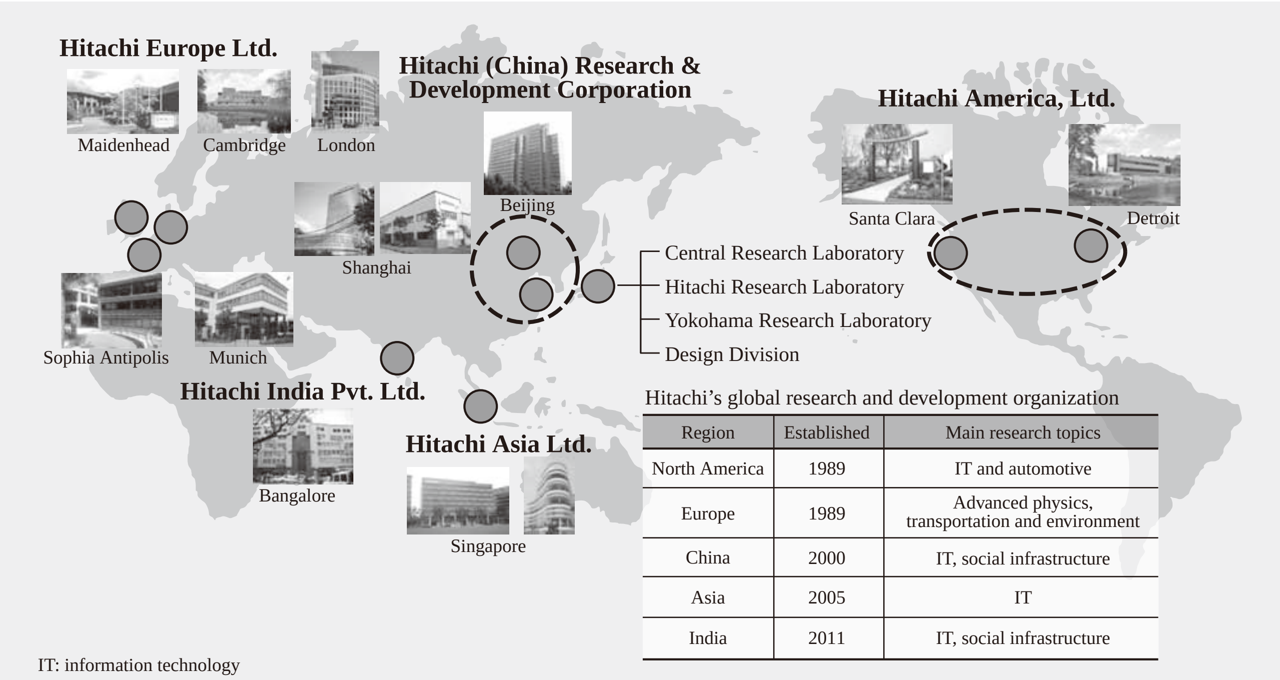
Hitachi has been doing business in Brazil for more than 70 years, starting with the supply of hydroelectric generation equipment for the Macabu Hydro Power Plant in 1939 and the establishment of a Brazilian Office in 1940. Already boasting the largest economy in South America, it is predicted that the nation will enjoy strong economic growth in the future. Scheduled to host the FIFA World Cup Brazil in 2014 and the Rio de Janeiro Olympics in 2016, expansion is anticipated in the Social Innovation Businesses on which Hitachi is focused, including ongoing investment in infrastructure. Hitachi is undertaking a range of measures aimed at expanding its businesses in the future, including plans to enhance further its sales organization as well as building and strengthening its local production capabilities and working with local partners.

GLOBAL RESEARCH AND DEVELOPMENT ACTIVITIES

Hitachi has been progressively globalizing its research and development since establishing research and development centers in the USA and Europe in 1989. Centers have also been established in China, Asia (Singapore), and India since 2000, and Hitachi now operates research and development sites in six hubs of the world based around the core made of its Japanese

(b) Digital automatic train control (ATC)
A railway signaling system for preventing collisions and other incidents on busy railway lines such as those used by Japan's Shinkansen. A feature of digital ATC is its use of digital signals for communications between the wayside equipment and on-train systems.

*2 FIFA is a trademark of Fédération Internationale de Football Association (FIFA).



Hitachi's global research and development organization

Region	Established	Main research topics
North America	1989	IT and automotive
Europe	1989	Advanced physics, transportation and environment
China	2000	IT, social infrastructure
Asia	2005	IT
India	2011	IT, social infrastructure

Fig. 2—Hitachi's Global Research and Development Organization.
Hitachi is expanding its locally managed research and development in North America, Europe, China, Asia, and India.

laboratories (see Fig. 2). To keep pace with its global business expansion, Hitachi is seeking to build local research and development systems that are managed by local headquarters and can devise solutions to the specific needs of different regional markets, while also utilizing core technologies developed in Japan. The following sections describe the research and development missions of each site, along with their main research topics and recent activities.

Development in North America is focused mainly on supporting local business operations targeted at sophisticated markets and customers. To accelerate its development of next-generation data storage systems, Hitachi is developing virtualization technology for data storage systems at its Santa Clara laboratory by utilizing its contacts with leading customers in Silicon Valley. Hitachi also established an "Innovation Laboratory" in conjunction with Hitachi Data Systems Corporation in 2011. Meanwhile, Hitachi's Detroit laboratory is working closely with customers on the development of technology for environmentally conscious vehicles.

In Europe, Hitachi has been researching commercial applications of leading-edge technologies and participating in European Union (EU) projects based around joint work with world-leading research institutions. It also established the new Transportation, Energy and Environment Research Laboratory (TEEL) in 2011 to strengthen its social infrastructure business in that region. Key research topics include spintronics[c] for use in revolutionary new computer systems, the development of technology for complying with European regulations on vehicle exhaust emissions, and the development of railway technologies that can contribute to Hitachi's comprehensive capabilities that extend from the manufacture of rolling stock to operation and maintenance (O&M).

Hitachi's laboratory in China has more than 100 staff members and acts as a center for local research and development, developing technology suitable for China and engaging in collaborations with leading Chinese universities. Hitachi also established a Social Infrastructure System Laboratory in 2010 with the aim of participating in Social Innovation Businesses at a national level. Its work includes eco-city development and the development of a smart grid simulator.

In Asia, Hitachi is working on the development of cloud storage for social infrastructure targeted at social experiments in Singapore. It also built a research and development center in India in 2011 to develop technology that will facilitate market access based on Indian market conditions. Its main mission is to conduct locally based technology development

(c) Spintronics
Spin is the magnetic property of an electron, analogous to its electrical property of charge. The technology of spintronics seeks to utilize the transport of both spin and charge. Research in the field is accelerating in anticipation of its use in the development of revolutionary new devices in semiconductors and other applications.

to help open up IT business opportunities and expand Hitachi's social infrastructure business in India.

This issue contains articles describing some of the research and development work for social infrastructure business being conducted by these centers, including model-based design technology for automotive systems in North America, railway research in Europe, smart grids in China, and social infrastructure research in India.

Cyber-physical Model-based Design

Model-based design is used in the development of power trains, transmissions, vehicle control, vehicle information systems, and other vehicle-mounted embedded systems. The Automotive Products Research Laboratory of Hitachi America, Ltd. uses virtual ("cyber") spaces to link sensor outputs and other control information from these embedded systems to perform design work efficiently in a virtual environment, and to provide links that allow design work to be shared across sites in different parts of the world. This issue includes an article that describes this concept and the results of a demonstration, using the development of a fuel pump control system for gasoline engines as an example.

Railway Research in Europe

Hitachi has achieved considerable success with its Class 395 high-speed trains in the UK, the birthplace of railway. In addition to the supply of rolling stock and maintenance services in conjunction with the Intercity Express Programme, a major upcoming project of the UK's Department for Transport for the replacement of high-speed trains, Hitachi is also seeking to undertake extensive work as a total systems integrator, including electrical components and railway signaling systems. An article in this issue describes Hitachi's railway business operations in Europe and what its research and development center is doing to support these activities.

Chinese Smart Grid

The growth in energy demand and the increasing urbanization of the population that come with economic progress mean that strengthening its energy supply capabilities while simultaneously protecting the environment represents an important challenge for China, and it is anticipated that the nation will proceed with the construction of smart grids and smart cities. While Hitachi also supplies solutions that incorporate equipment, control systems, and information systems to contribute to the development of each region, an article in this issue focuses on current progress in the field of smart grids and smart systems, as well as on Hitachi's research and development strategy.

Research into Social Infrastructure in India

While investment in social infrastructure in India continues to grow, its infrastructure systems need to be redesigned to cope with the wide diversity within the nation in the level of infrastructure provision. This includes some cases where an advanced level of infrastructure is already in place, and others where infrastructure has yet to be installed. An article in this issue covers Hitachi's activities in India, as well as the issues faced in the research and development of social infrastructure intended to serve such a diverse market.

EXPANDING GLOBAL BUSINESS AND RESEARCH AND DEVELOPMENT ACTIVITIES

Having set itself a target of achieving more than 50% of its sales from outside Japan in the near future, Hitachi is strengthening its global business and research and development capabilities. This issue focuses on business activities in emerging markets (a particular target for Hitachi in the future), and on how Hitachi works closely with local businesses on research into social infrastructure, including in developed economies. This includes articles that describe activities in North America, Europe, China, India, Brazil, and Russia from a global point of view.

As its business becomes more global in the future, Hitachi intends to continue expanding its business activities and research and development work, with a focus on key regions.

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Cyber-physical MBD for Multi-physics Automotive Systems

Sujit S. Phatak
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Yasuo Sugure

OVERVIEW: The need for CPSs derives from the complexity of modern automotive embedded systems, which can contain more than 100 ECUs, a large ROM capacity, and a large amount of software code. Another issue is that traditional design methodologies find it difficult to cope when fundamental hardware problems are identified late in the development process, during the validation phase. The MBD approach is one possible solution to these issues and it lays the foundation for CPSs.

INTRODUCTION

THE defining feature of cyber-physical systems (CPSs) is their close integration between physical processes and systems on one hand and computational systems on the other(1). CPSs integrate the dynamics of physical processes with those of the software and network, providing abstractions for modeling and design as well as analysis techniques suitable for integrated systems. In contrast to traditional embedded systems, where the emphasis is more on operation as a standalone device, CPSs emphasize the network of interacting systems. Similarly, while traditional embedded systems focus on the computational components, CPSs primarily focus on the interfaces between the computational elements of the system. Their scope of application covers all sensor-based control systems, embedded systems, and autonomous systems. These cover a very wide range, from device-based systems such as automotive systems, entertainment and home appliances to integration systems such as social infrastructure, energy, freight and transportation, aeronautical and space applications, and healthcare, and also technical platforms such as manufacturing systems.

The mechatronic control systems that are typically implemented in automotive applications, such as engine control, transmission control, throttle control, and braking, typically involve multiple complex physical systems with dedicated embedded controllers that communicate with each other via a vehicle network, such as Controller Area Network (CAN) or FlexRay. Model-based design (MBD) is adopted as a way of making the design process for these complex system more efficient(2). The system design stage integrates models of physical system behavior (also called "plant models") with controller models to produce an abstracted system implementation. The controller models can be implemented either at the algorithm level, using popular tools such as MATLAB*1/Simulink*1, or they can be implemented at a lower abstraction level using virtual central processing unit (CPU) modeling techniques.

Virtual CPU modeling(2) involves development of a software model of the microcontroller hardware itself. This microcontroller model can then be integrated with the behavioral models of the plant (physical system) so that realistic system performance measurement and validation can be performed. This approach allows concurrent development of the plant models and control software applications, and also their validation, including the realtime operating system (RTOS) and device drivers.

Sometimes the system may consist of multiple plant models (physical systems) representing different components of the mechatronic system that need to be implemented in different domains, and that need to be connected to a controller (computational system) via some interface. Together, these elements form a mechatronic CPS.

This article reviews the basic approach to implementing a CPS adopted at the Automotive Products Research Laboratory of Hitachi America, Ltd., and describes a CPS case study in the form of a gasoline fuel pump that was implemented as a multi-domain co-simulation platform(3).

NEED FOR CPS IN AUTOMOTIVE APPLICATIONS

Challenges for Automotive Embedded Systems

The automotive embedded systems used in different parts of modern vehicles (including the powertrain, transmission, vehicle dynamics, and infotainment) can be very complex, consisting of more than 100 electronic control units (ECUs). These ECUs are microcontroller-based embedded systems.

*1 MATLAB and Simulink are registered trademarks of The MathWorks, Inc.

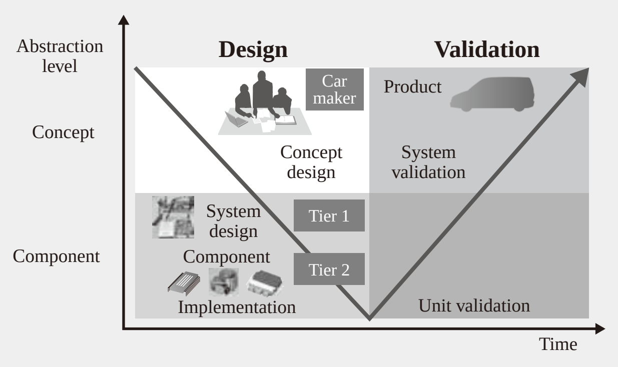

Fig. 1—Traditional V-cycle Development Process.
The typical development cycle for automotive electronic control units (ECUs), including the role of the respective contributors.

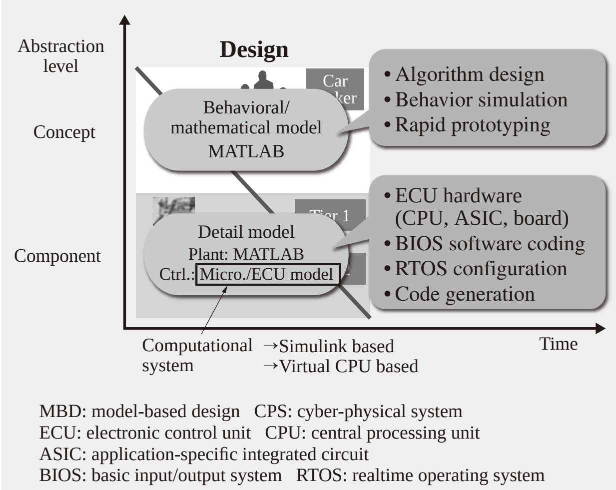

Fig. 2—V-cycle Incorporating MBD and CPS Approach.
The role of MBD and the CPS approach in V-cycle development, including the different activities involved.

Typically, each sub-component of the physical system has a dedicated ECU. Automotive network protocols such as CAN and FlexRay are used to link these ECUs in a network.

Modern automotive applications often require more than 4 Mbyte of read-only memory (ROM) (program memory), which stores a dedicated application program. The size of software code is also increasing exponentially. It is estimated to grow more than 1,000 times in the next 20 years. In contrast, the capacity of the microcontroller hardware (computational system) typically grows by only 20 times over 10 years. To cope with this gap between increasing code size and hardware capacity, and to improve cycle performance and reliability, it is anticipated that multi-CPU or multi-core architectures will be required in the near future.

Inefficiency in Traditional Design Methodology

Traditionally, automotive embedded controller development has often followed the V-cycle shown in Fig. 1.

The V-cycle is broadly divided into two phases, the design phase and the validation phase. The vertical axis shows the level of abstraction while the horizontal axis represents time. The design phase begins with the concept design at a high level of abstraction. This takes place at the car maker or original equipment manufacturer (OEM). Typically, the process then proceeds through progressively lower levels of abstraction, to system design at a tier-one supplier and then to the actual components and hardware supplied by a tier-two supplier. This is the implementation phase, and is followed by the validation phase. This begins with unit validation, which happens at the same level of abstraction as the design implementation. Next is system validation, which represents a higher level of abstraction, with the final product as the end result.

A problem with this traditional V-cycle is that, if a fundamental hardware problem is not detected until the validation phase, going back to the design phase to identify its cause is not always time- and cost-effective. It is important to identify any inherent hardware problems early in the design phase, before investing in hardware development. Also important for business expansion and innovation is the research, development, and testing of future advanced system architectures (hardware and software).

MBD is one possible solution to these problems. The MBD approach is also called “model in the loop simulation” (MILS). It lays the foundation for CPS development. Fig. 2 shows the V-cycle when MBD and CPS are incorporated.

The figure shows how use of MBD concentrates activity in the design phase. This includes algorithm design, behavior simulation, and rapid prototyping, which are carried out during concept design. Initially, signal flow or conserved system simulators like MATLAB/Simulink or Synopsys[*2] Saber[*2] are used to develop behavioral or mathematical models.

This is followed by component simulation at a lower abstraction level. The main development activities here are ECU hardware specification, basic input/output system (BIOS) software coding, RTOS configuration, and autocode generation. In terms of MBD, this phase involves developing detailed models

*2 Synopsys is a registered trademark of Synopsys, Inc. and Saber is a registered trademark of SabreMark Limited Partnership and is used under license.

of both the physical system (plant) and the ECUs and control system (computational system).

The computational system can be built in Simulink or using a virtual CPU. This gives two different configurations for the CPS. Typically, when using MBD, the next step after developing a Simulink-based computational system is to perform autocode-generation and implement the generated software on a real hardware ECU. This is called “processor in the loop simulation” (PILS). The work described here, however, adopts a new approach whereby a simulation of the processor (CPU) is also included in the model. This approach could be called “virtual PILS,” although the term “virtual CPU modeling” is used here for consistency. The following section gives a detailed description of CPS using both the Simulink and virtual CPU methods.

CPS FOR AUTOMOTIVE APPLICATIONS

Simulink-based CPS

Fig. 3 shows a simplified block diagram of a Simulink-based CPS.

The system consists of two main parts: the plant model (physical system) and the control / soft ECU model (computational system). The plant models model the physical systems of the vehicle, such as the engine for a gasoline car or the electric motor of a hybrid electric vehicle (HEV) or electric vehicle (EV). The control models implement the logic used to control the plant models in such a way that they achieve the desired functionality. These models also provide visualization of the control parameters.

Simulink is used for simulation, and communication between the plant and the control models is in terms of physical quantities or parameters represented in engineering units (Pascals for pressure or Amperes for current). The system uses feedback control whereby the user/driver inputs are applied to the plant model together with the actuator inputs determined by the control algorithm running on the control model. An important point to note here is that the link between the plant and control models is handled within the simulation system via a direct connection between the models.

In the case when different models running on different simulators are used, a co-simulation needs to be implemented to provide the connection between the simulators. Co-simulation can be achieved by a direct connection between the models if their respective simulators support such a function, or it can be achieved using a co-simulation bus[4]. The physical location of models may or may not be on the same personal computer (PC) in the case of a co-simulation bus implementation. Co-simulation also requires that the simulators support its use, or that it can be implemented using a high level programming language such as C/C++.

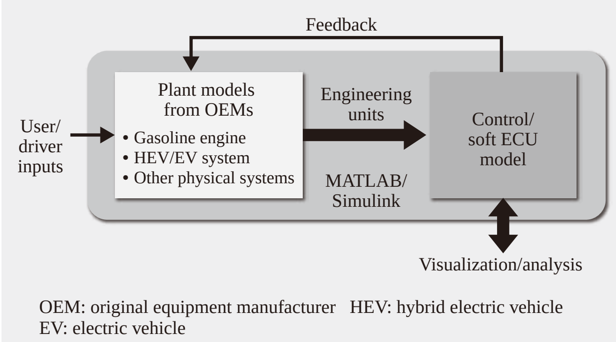

Fig. 3—Simulink-based CPS.
This simplified block diagram shows the CPS simulation model.

Use of a co-simulation bus offers several other benefits. (1) It enables a multi-domain/multi-physics system simulation where models stay in their native domain but work together. (2) The multi-domain interaction yields a robust design methodology. (3) The co-simulation bus also provides a framework for implementing the interface between the computational and physical systems of the CPS.

Virtual-CPU-based CPS

Fig. 4 shows a simplified block diagram of a virtual-CPU-based CPS.

The system architecture for a CPS based on a virtual CPU is an extension of the Simulink-based CPS architecture. In this case, the control model is implemented using a virtual CPU simulator, which can emulate a microcontroller model or virtual CPU model for the specific microcontroller specified by the user. Microcontroller models are available for the main automotive semiconductor suppliers, including Freescale Semiconductor, Inc., Renesas Electronics Corporation, and Infineon Technologies AG.

These models emulate the microcontroller hardware and can execute the same object code as the actual hardware. This simulator also gives access to internal information about the microcontroller hardware, such as the program counter, instruction cycles, interrupts, and software states.

As in a real microcontroller, these models process analog or digital voltage signals and cannot work with engineering units directly. Hence an additional sensor model (sensor models in Fig. 4) needs to be

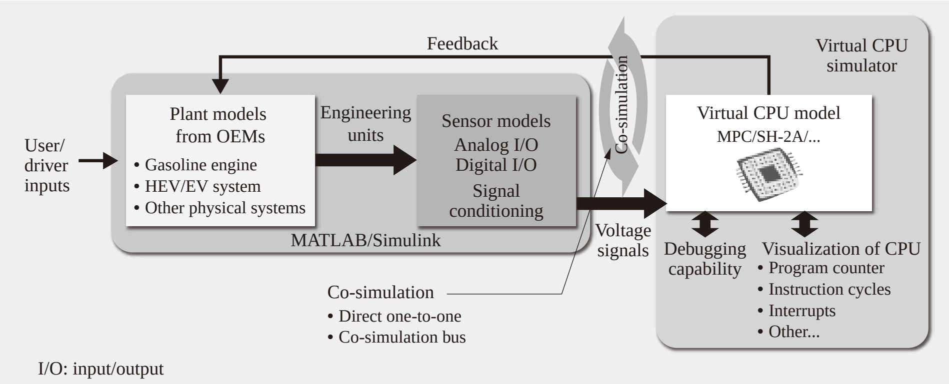

Fig. 4—Virtual-CPU-based CPS.
The simplified block diagram of the CPS shows how it now includes a virtual CPU model instead of the traditional Simulink-based control model.

implemented to act as an interface and perform the required signal conditioning between the plant model and the virtual CPU model. In other words, this block handles analog and digital input and output (I/O) and converts engineering units into voltage signals, which can be processed by the virtual CPU model. The rest of the system architecture remains the same, including the feedback loop and the user/driver inputs.

Another important point to note is the use of co-simulation. The plant models and sensor models are typically implemented using MATLAB/Simulink while the virtual CPU is implemented using a dedicated virtual CPU simulator as described above. Therefore, a co-simulation is required between these simulators and can be achieved either via a direct one-to-one connection or by using the co-simulation bus. While a direct one-to-one connection is available for systems that run entirely within Simulink, this is not supported for some other simulators, in which case the co-simulation bus approach must be used. This is described in detail in the case study in the next section.

AUTOMOTIVE CPS CASE STUDY: GASOLINE FUEL PUMP SIMULATION

A gasoline fuel pump simulation model developed by Hitachi was used to investigate CPS implementation by comparing the results obtained using the Simulink-based and virtual-CPU-based approaches respectively.

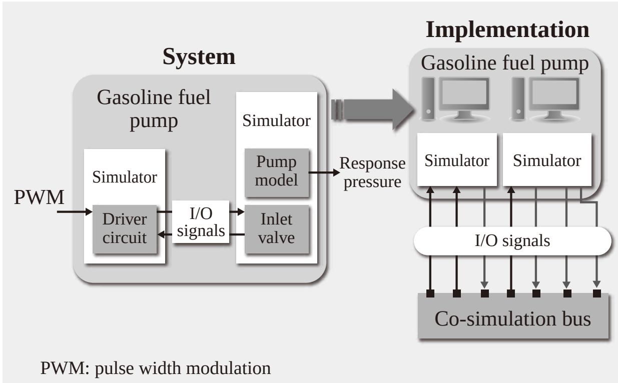

Fig. 5—Gasoline Fuel Pump Physical System.
This block diagram of the gasoline fuel pump system and its simulation model represents a multi-PC implementation with a co-simulation bus.

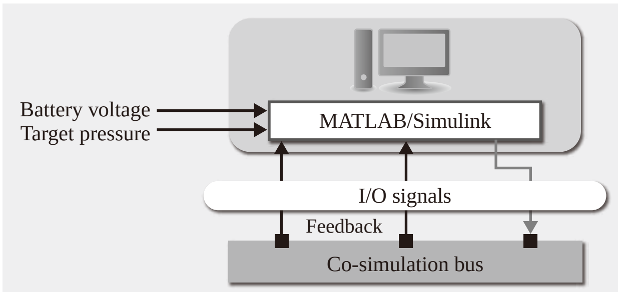

Fig. 6—Gasoline Fuel Pump Computational System.
The simulation model of the gasoline fuel pump control system interfaces to a co-simulation bus.

Simulink-based CPS for Gasoline Fuel Pump

A physical system model (plant model) was implemented using a co-simulation bus (see Fig. 5).

The physical system of the gasoline fuel pump consists of three parts: a driver circuit simulated using an electromechanical simulator, and separate pump and inlet valve models, which are simulated using the hydraulics simulator. Using a co-simulation bus, the driver circuit was implemented in the electromechanical simulator running on one PC and the pump and inlet valve models of the actual pump were implemented in a hydraulic simulator running on a second PC.

The computational system (control model) was implemented using Simulink (see Fig. 6). Fig. 7 shows the complete integrated Simulink-based CPS for the gasoline fuel pump.

Proportional-integral (PI) control was used to generate the controller output based on the difference between the target pressure and the pressure feedback

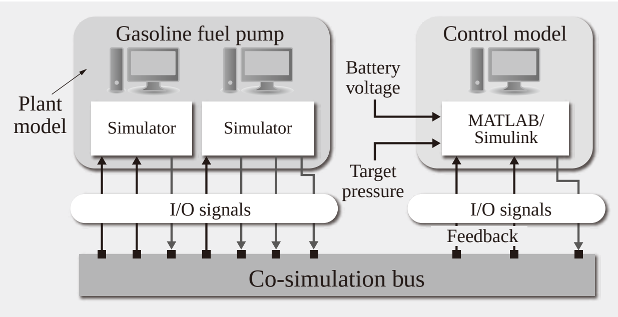

Fig. 7—Simulink-based CPS for Gasoline Fuel Pump.
This Simulink-based CPS uses a co-simulation bus.

at a constant battery voltage input level. Since the final goal was to implement this control algorithm on hardware (virtual in this case), and as triggering the solenoid in response to the controller output costs energy, pulse width modulation (PWM) duty-cycle control was added to the original control. While the solenoid had to be fully triggered to open the inlet valve, less force was required for holding it open and therefore the current through the solenoid could be reduced. The percentage reduction in this solenoid current was determined by the PWM duty factor. Based on several tests and on experience, data were gathered on the relationship between the duty factor for various start angles and the revolutions per minute (RPM) and battery voltage. From these were produced a look-up table that could be used to obtain the duty-cycle value(1). The PWM based control also enabled the use of the virtual CPU based approach for implementing this CPS.

Virtual-CPU-based CPS for Gasoline Fuel Pump

The first requirement for the virtual-CPU-based CPS was to obtain the object code for the software control algorithm used in the Simulink CPS. This was achieved using auto-code generation to generate the application layer of the software from the Simulink control model. The virtual CPU used was a Renesas Electronics Corporation's SH-2A*3 microcontroller. Other development included hand coding the device driver software for the SH-2A and configuring the RTOS to be used for this application (see Fig. 8).

The virtual CPU simulation itself combined two simulators: the virtual CPU simulator and MATLAB/ Simulink. Accordingly, the virtual CPU simulation used a direct one-to-one co-simulation between these two simulators. In terms of the overall system, this co-simulation bus approach involved using the MATLAB/

*3 SH-2A is a trademark or registered trademark of Renesas Electronics Corporation.

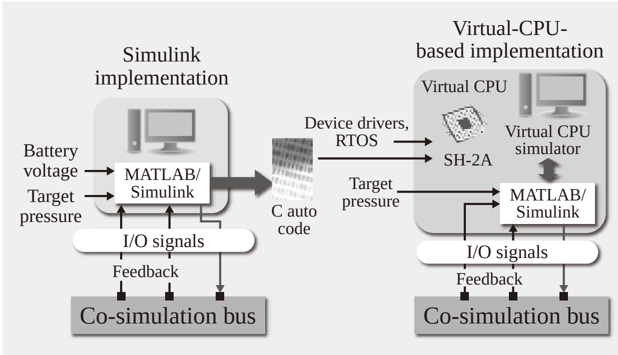

Fig. 8—Auto-code Generation for SH-2A CPU.
The Simulink-based control model was converted into C code, compiled with the device drivers and RTOS, and executed on the Renesas Electronics Corporation's SH-2A CPU.

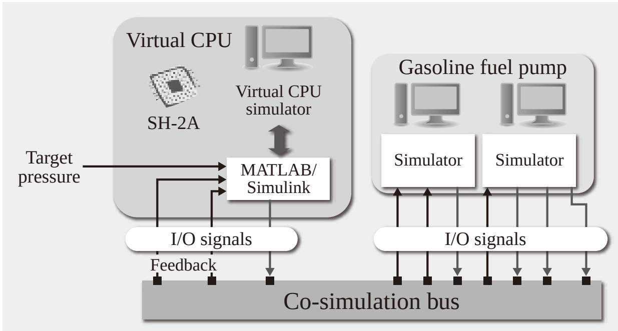

Fig. 9—Virtual CPU-based CPS for Gasoline Fuel Pump.
The virtual SH-2A control model integrates with the plant model of the gasoline fuel pump via a co-simulation bus.

Simulink portion of the virtual CPU as an interface to the co-simulation bus since the virtual CPU simulator did not directly support the co-simulation bus. Fig. 9 shows the complete system using the virtual-CPU-based CPS for the gasoline fuel pump.

This system enabled the virtual tuning of the PI control algorithm, which will help accelerate overall pump controller development in the future.

Correlation between Simulink-based CPS and Virtual-CPU-based CPS

After adopting both the Simulink-based and virtual-CPU-based approaches for CPS implementation, the next step was to observe the relationship between the behaviors of the pump simulation using these two approaches under identical simulation conditions and configuration (see Fig. 10).

The comparison shows a very good correlation between the Simulink-based and virtual-CPU-based approaches for the gasoline fuel pump control system under identical simulation configurations (same target pressure at different engine RPMs).

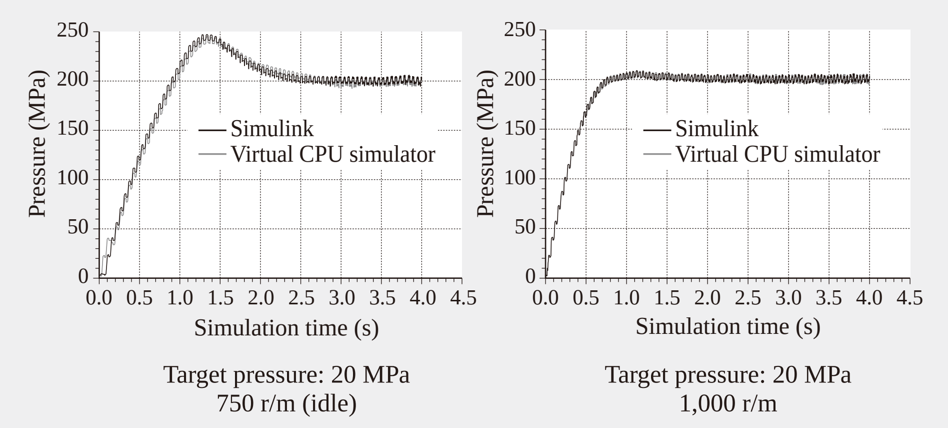

Fig. 10—Correlation between Simulink-based and Virtual-CPU-based CPS for Gasoline Fuel Pump.
This comparison shows the proportional integral (PI) control profiles for the gasoline fuel pump for two target pressure settings.

FURTHER ACHIEVEMENTS USING CPS

After the successful implementation of the CPS for a gasoline fuel pump control system at the Automotive Products Research Laboratory of Hitachi America, Ltd., a decision was made to experiment with the flexibility offered by the co-simulation bus approach for a multi-location co-simulation. The trade-off when a multi-location CPS implementation was tested was that the analysis took longer due to the slower data transfer time. The problem in this case was slower speed due to latency on the Ethernet-based Transmission Control Protocol/Internet Protocol (TCP/IP) network. At a sampling rate of 100 μs, for example, the co-simulation across offices in Japan and the USA was three times slower than the equivalent co-simulation run in the USA (see Fig. 11).

As shown in the figure, the gasoline fuel pump physical model was implemented on two PCs, one at the Japan office and one at the USA office, while the computational system model was implemented on a PC at the USA office. Apart from the problem with the data transfer time, this demonstration showed that a co-simulation could span two offices, one in Japan and the other in the USA, and proved that it was possible to achieve a flexible CPS implementation across offices in different countries.

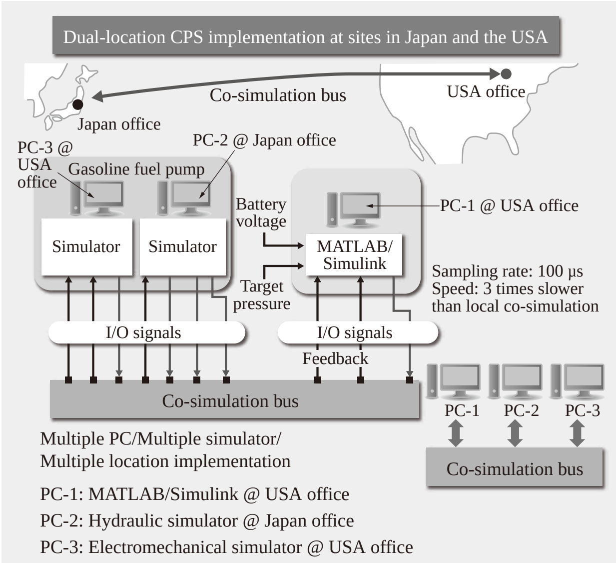

Fig. 11—International Multi-location CPS.
This distributed implementation of the gasoline fuel pump control operated a co-simulation bus between two Hitachi offices in USA and Japan.

CONCLUSIONS

This article has reviewed the basic approach to implementing a CPS adopted at the Automotive Products Research Laboratory of Hitachi America, Ltd., and described a CPS case study in the form of a gasoline fuel pump that was implemented as a multi-domain co-simulation platform.

An automotive CPS involving a gasoline fuel pump was implemented to enable virtual tuning of the PI control algorithm and accelerate the overall development process. The system behavior was first simulated using Simulink and later using a virtual-CPU-based approach. Both approaches achieved a good correlation. An international multi-location CPS implementation was also tested and validated to prove the flexible multi-location implementation of these systems as a multi-physics robust design methodology.

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Railway Business Strategy and R&D in Europe

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OVERVIEW: Hitachi's European railway business has achieved considerable success with its Class 395 high-speed trains in the UK, the birthplace of the railway. Hitachi has contracted to supply rolling stock and maintenance services for the Intercity Express Programme in the UK, including extensive work as the total systems integrator including electrical traction equipment, signaling etc. Aiming at further expansion of the railway business, Hitachi Europe Ltd. European R&D Centre is strengthening the railway research activity to resolve issues specific to European requirements in fields such as rolling stock, maintenance, signaling, and traffic management.

INTRODUCTION

THE Class 395, the first high-speed train supplied by a Japanese manufacturer to Europe, is built by Hitachi and running on the High Speed 1 line (a dedicated line for high-speed trains) that links London to the Channel Tunnel (see Fig. 1). Since the formal commencement of commercial operation in December 2009, the Class 395 has contributed to the highly reliable passenger service on the line. Representing the first step of Hitachi's European railway business plans, the record of success of the Class 395 is set to boost further business expansion, promoting the strong technical capabilities of Hitachi in the field of railway systems.

This article features how Hitachi is moving on from the Class 395 to further success in European railway business, and how the Hitachi Europe Ltd. European R&D Centre is tackling it.

Fig. 1—Class 395 High-speed Train in UK.
A Class 395 high-speed train is shown at St Pancras International Station in London.

RAILWAY BUSINESS ACTIVITIES IN EUROPE

Having built up a solid base for its railway business in Japan, Hitachi is stepping up its moves into overseas markets as a way of further expanding its business. A key facet of this strategy involves its UK subsidiary, Hitachi Rail Europe Ltd., taking a leadership role in promoting an expansion of sales in Europe.

Europe has well-developed railway networks built using railway transportation systems supplied by European manufacturers. The following sections describe what Hitachi has achieved to date in this mature market by utilizing the technical strengths built up in Japan, and also the prospects for the future.

Past Strategy and Business Success

Hitachi's strategy for entering the European railway market was the verification train (V-Train) project in the UK (see Table 1). This initiative successfully demonstrated the viability of Hitachi's railway technology in the European environment and led to orders in the UK.

TABLE 1. V-Train Project
Hitachi's involvement in a series of rolling stock verification trials in the UK contributed to its winning of orders such as for the Class 395.

Project	Schedule	Description
V-Train 1	2002 to 2005	Performance verification of electrical traction equipment Helped win Class 395 order.
V-Train 2	2007 to 2008	Verification of technical capabilities through use of a hybrid traction system in a high-speed train
V-Train 3	2008–	ETCS system development and performance verification

V-Train: verification train ETCS: European Train Control System

The Class 395 has made a remarkable contribution to the business success. The project was in the form of a package deal, including maintenance services as well as the supply of 29 trains with a total of 174 cars[1]. Maintained at Hitachi's Ashford Depot, which is located at a junction between the High Speed 1 line and other existing lines, the Class 395 is delivering highly reliable transportation every day. In addition to the Class 395 high-speed trains, Hitachi also has a successful track record on other work, such as the replacement of electrical systems on the Class 465 commuter trains, steadily promoting its presence in the European market.

Future Business Prospects

The largest project is the Intercity Express Programme (IEP) in the UK. Following the contractual close in July 2012 which Hitachi, Ltd. announced, Hitachi will provide service and maintain a total of 596 rail carriages to run on the UK East Coast Main Line and the Great Western Main Line to replace the aging fleet of Intercity (HST) trains (see Fig. 2). This contract announcement paves the way for the investment by Hitachi to build a rolling stock manufacturing and assembly plant in the UK[2].

In addition to the rolling stock and maintenance services, Hitachi is also seeking to draw on its strengths as a total systems integrator to expand its operations into a wider range of railway business, including electrical traction systems and signaling. Hitachi, including Hitachi Rail Europe Ltd., is now working hard to build comprehensive capabilities in these areas especially focusing on the IEP project.

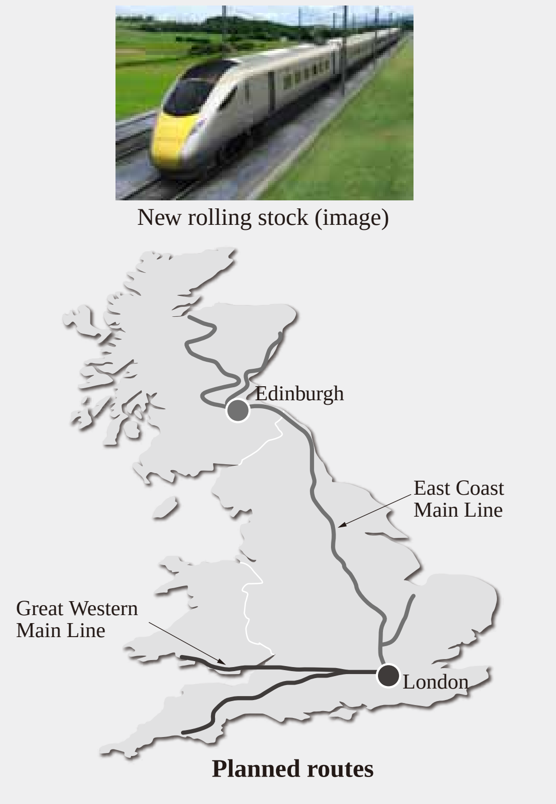

Fig. 2—Image of New Rolling Stock for IEP and Planned Routes.
The Intercity Express Programme (IEP) project will replace aging high speed trains (HSTs) on the Great Western Main Line from London to the west, and the East Coast Main Line to the north.

RESEARCH AND DEVELOPMENT SUPPORT FOR EUROPEAN RAILWAY BUSINESS

In expectation of further expansion in its European railway business, Hitachi set up a railway research team at the Transportation, Energy and Environment Research Laboratory (TEEL), which was established in April 2011 at the European R&D Centre. The aim is to support this expansion and strengthen Hitachi's research capabilities in a range of fields such as rolling stock, maintenance, signaling, and traffic management. Based in the London office of Hitachi Rail Europe Ltd., the railway research team works closely with the on-site operations department, customers, and also in collaboration with local universities so as to identify and resolve issues specific to European circumstances. This section describes the research on rolling stock, maintenance, and signaling.

Rolling Stock

An important consideration for rolling stock is compliance with the specific requirements imposed by the technical standards and other infrastructural circumstances that apply in Europe. For example, trains must provide good ride comfort when running on the track used in Europe. Other examples include the need to satisfy standards for crashworthiness requirement (to ensure safety in the event of a crash) and aerodynamic characteristics (to improve passenger comfort and reduce noise in tunnels).

To work on these problems, the European R&D Centre utilizes analysis leads design in cooperation with the research and development department in Japan. This design method uses computer simulations based on advanced analysis techniques to perform tasks, such as optimizing designs or verifying compliance to obtain standards certification, more quickly and at lower cost than using prototype testing.

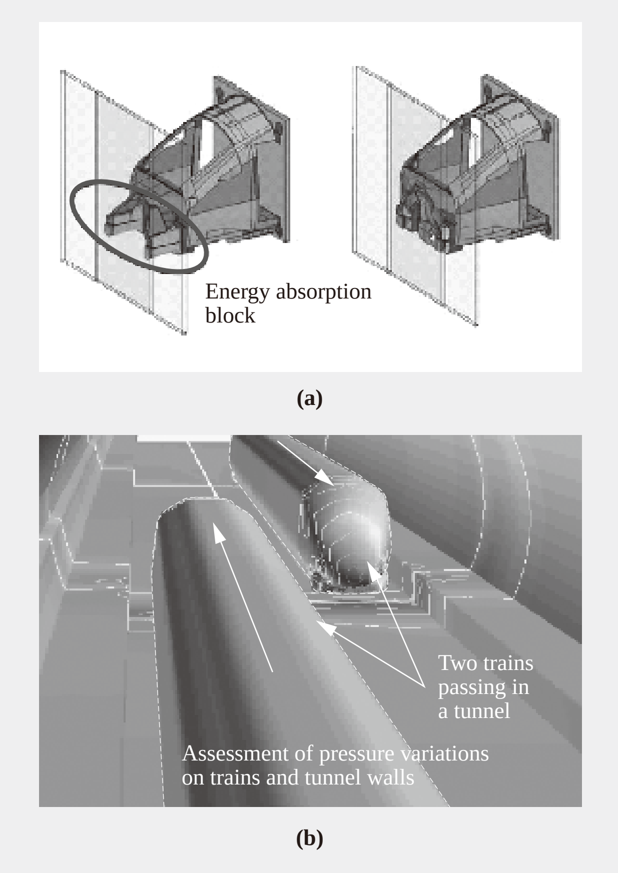

Fig. 3—Example Applications of Analysis Leads Design.
Crash analysis for leading car fitted with an aluminum energy absorption block (a), and analysis of surface pressure variations on two trains passing in a tunnel (b) are shown.

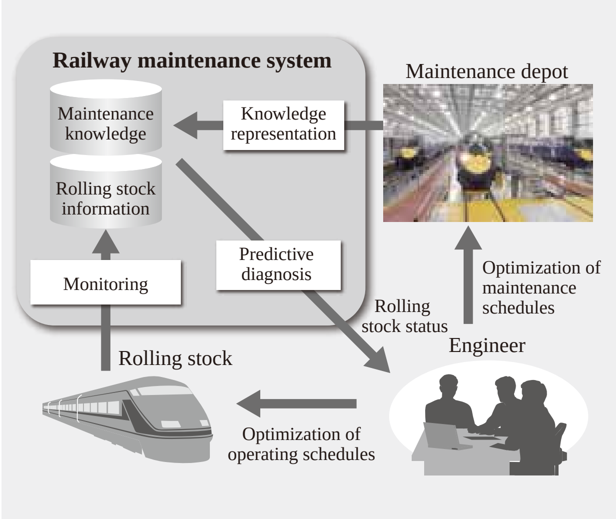

Fig. 4—Overview of Railway Maintenance System.
Practices include status monitoring and maintenance that combines technologies for monitoring and predictive diagnosis, and techniques for representing knowledge about fault detection and analysis at the maintenance depot.

This method proved its ability to shorten lead times and reduce costs when it was used in the design and development of the Class 395 to identify and verify designs that would satisfy requirements such as for the maximum body acceleration during a crash, or the variations in the internal and external pressure when a train passes through a tunnel[(3)] (see Fig. 3).

For the future, European R&D Centre intends to press forward with the use of analysis leads design on the UK IEP and other projects by taking the needs identified by working closely with local players, environmental circumstances, and knowledge gained through discussion with local experts, and feeding this information back into the analysis techniques.

Maintenance

In addition to being the first example of a Japanese manufacturer delivering high-speed trains to Europe, the Class 395 project is also the first case where Hitachi has taken on a long-term maintenance contract for rolling stock.

Rolling stock maintenance is essential to safe and reliable operation. As rolling stock maintenance is always handled by the railway operator in Japan, this constituted a new challenge for Hitachi, but the business was able to be put on the right track thanks to cooperation from local staff and consultants as well as knowledge acquired from railway operators in Japan. For the future, the challenge is to establish maintenance schemes that suit the European market, and also, to maintain and improve reliability of railway service.

For this challenge, Hitachi is developing condition based maintenance technology, based on wireless remote monitoring and predictive diagnosis of faults based on sensor data. Also under development is technology for the structuring of knowledge acquired through the systematic collection of information on fault analysis and countermeasures so that measures can be put in place quickly and appropriately when a problem does occur. Through these technologies, Hitachi is seeking to achieve even higher levels of reliability and safety by allowing maintenance to be undertaken based on the actual condition of the rolling stock[(4)] (see Fig. 4).

The European R&D Centre is working in conjunction with the maintenance team in the UK on research and development aimed at implementing these technologies in the field. The technologies are also intended to contribute to the IEP, which, like the Class 395 project, is a package deal that includes both rolling stock and maintenance services.

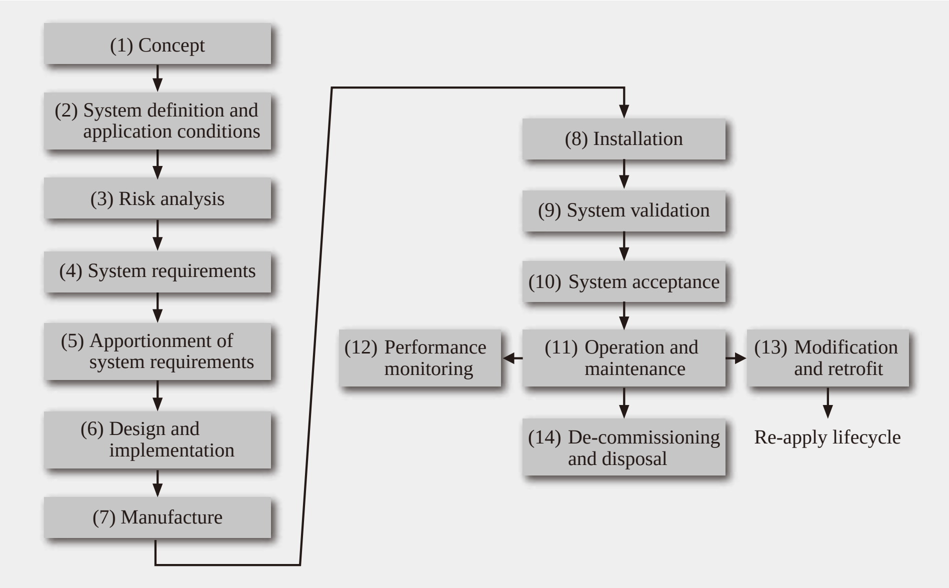

Fig. 5—System Lifecycle for Railway Applications.
The EN 50126 shows the tasks to be performed at each phase of the system lifecycle.

Signaling

The signaling system is responsible for train detection and control to prevent crash, hence requires the highest level of safety design in a railway system. The challenge in this field is to demonstrate the required safety in line with the European safety standards.

Having built up a track record in the signaling products utilizing digital or wireless communications technology, Hitachi is now developing new product compliant with the European Train Control System (ETCS) standards.

In this development it is required to satisfy and demonstrate the safety levels stipulated in the ETCS standards. For example there are some European standards to stipulate the development process for preventing an erroneous output causing a hazardous event(5) (see Fig. 5). While based on Hitachi's proven safety design, it is also necessary to satisfy these standards.

For this challenge, the European R&D Centre is contributing to more efficiency in development with analysis and systematization of the differences between European approach to safety design and the Hitachi proven one through consultation with local experts.

CONCLUSIONS

This article has described Hitachi's railway business strategy for Europe and some of the works being carried out by the European R&D Centre to support this, focusing on the fields of rolling stock, maintenance, and signaling in particular.

Hitachi has broken into the European market through its success with the Class 395 in the UK, and is seeking to expand its business further by strengthening its European railway business capabilities based around the IEP. The European R&D Centre is going to commit further to enhancing and developing railway activity to support the business.

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Hitachi's Energy Conservation and Environmental Activities in China

—Progress of Energy Conservation and Environmental Projects

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OVERVIEW: Since establishing the China Energy Conservation and Environment Commercialization Promotion Project Team in April 2006, Hitachi (China) Ltd. has been involved in a wide range of activities aimed at building its energy conservation and environmental businesses in China. Working with other Hitachi companies, Hitachi (China) Ltd. has facilitated and undertaken a variety of projects involving cooperation on energy conservation and environmental protection, including a model project for energy saving and utilization of waste heat/pressure in Yunnan Province, an energy efficiency assessment model project in Ningbo City, and joint projects with the National Development and Reform Commission.

INTRODUCTION

AVERAGE annual growth in China's gross domestic product (GDP) exceeded 10% over the five year period from 2006 to 2010. With GDP growth of 9.2% in 2011 and a forecast of close to 10% for 2012, this rapid economic growth is continuing. Further expansion in domestic demand is also anticipated, with the provision of social infrastructure such as power, transportation, water, and information technology (IT) being expected to pick up pace over a wide area, including the northeast and interior regions as well as the coastal provinces. In addition to economic growth, there is also a need to create a society that is conscious of the environment, such as a low-carbon society and green economy.

Taking note of this rapidly growing market and with reference to China's 12th Five-Year Plan (2011 to 2015), Hitachi has formulated and is implementing its own China Business Strategy 2015 based on taking advantage of group synergies and expanding local operations with the aim of contributing to the advancement of Chinese society.

This article shows what Hitachi is doing that can contribute to energy conservation and environmental protection in China by describing this work along with the progress of its projects.

PAST ACTIVITIES

Since setting up the China Energy Conservation and Environment Commercialization Promotion Project Team in April 2006, Hitachi (China) Ltd. has been involved in a wide range of activities aimed at building its energy conservation and environmental business in China. At that time, building a sustainable society characterized by energy conservation and protection of the environment had been identified as an important strategy in China's 11th Five-Year Plan (2006 to 2010), and it was anticipated that China could learn from the experience of other countries, particularly from the way that Japan overcame environmental contamination and pollution in the 1960s and was able to successfully combine economic growth with protection of the environment.

At the end of 2005, the State Environmental Protection Administration (now the Ministry of Environmental Protection of the People's Republic of China) and China Central Television (CCTV) developed a television series called "A Window on Environmental Protection in Japan—Japan's Closed-loop Economy" about how Japan incorporated recycling into its economy and how this has progressed over time. Along with other well-known Japanese companies, Hitachi was featured in the programs and cooperated in their production. A production crew visited Japan in April 2006 where, among other things, they filmed major Hitachi plants and laboratories as well as Shinjuku District Heating and Cooling Center to which Hitachi had supplied a large cooler. This footage was subsequently broadcast nationwide in China by CCTV and helped raise awareness of Hitachi's advanced technology (see Fig. 1). Since then, Hitachi has actively accommodated filming and interviews by numerous major Chinese media agencies. It has also presented itself at trade fairs around China as a company that creates environmental value (including at the Shenzhen High-tech Fair and the Kunming International Environmental Protection & Renewable Energy Exposition).

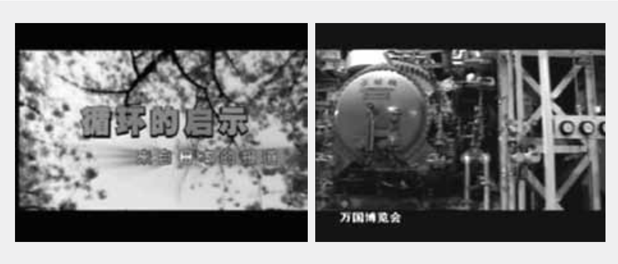

Fig. 1—Scenes from CCTV Television Broadcasts.
Coverage of Hitachi's work on the closed-loop economy was included in the Green Space (epiphany on recycling) program on the science and education channel (channel 10) of China Central Television (CCTV) on September 14, 2006.

A web site devoted to the environment and energy conservation was launched in China in 2007. The site actively promoted Hitachi's brand image of being a company dedicated to the environment and energy conservation. In addition to reaching an agreement with the National Development and Reform Commission to pursue cooperation in the environmental and energy conservation fields in January 2007, three separate conferences (Energy Conservation and Environmental Protection Technology Exchange Conferences) were also jointly hosted.

The first of these (held in January 2007) had as its main theme, "energy saving technology for electrical machinery systems." The technology conference provided an opportunity to discuss specific topics with the participants, and presented Hitachi technology, past projects, and other material on such subjects as "trends in energy conservation in Japan, and Hitachi's involvement," "energy saving in electrical machinery systems," and "technology for energy-saving engineering" aimed at other companies whose businesses are steel, coal, electric power, petrochemistry, and cement, etc. The second technology conference (held in May 2007) focused on water treatment with presentations on "development of the next generation of water treatment technology," "work on membrane separation technology," and "new technology for more advanced sewage treatment." An agreement on joint research on environment by Sichuan University, Hitachi (China) Ltd., and Hitachi Plant Technologies, Ltd. was also signed. The topic of the third technology conference (held in January 2008) was "eco-cities," and discussions were held on subjects such as "cogeneration," "power generation from heat produced during waste processing," and "financing service for energy conservation and environmental protection projects."

MODEL PROJECT FOR ENERGY SAVING AND UTILIZATION OF WASTE HEAT/ PRESSURE IN YUNNAN PROVINCE

Discussion with the government on the subject of energy saving in electrical machinery systems continued after the first technology conference and the Model Project for Energy Saving and Utilization of Waste Heat/Pressure through Electrical System in the Steel and Chemical Industries in Yunnan Province was signed at the Second Japan-China Energy Conservation and Environment Forum held in Beijing in September 2007. The project was one of the Japan-China Energy Conservation and Environmental Business Promotion Model Projects agreed between the Japanese and Chinese governments. This model project subsequently led to the joint undertaking of an energy conservation project involving the use of inverters with Kunming Iron & Steel Group Co. Ltd. and Yuntianhua Group, a steel maker and chemical company respectively in Yunnan Province.

Hitachi undertook engineering work to improve the energy saving characteristics of high-voltage motors and pumps used in association with boilers, and supplied high-voltage inverter systems to Kunming Iron & Steel Group and Yuntianhua Group, which entered operation in fiscal year 2008. These systems delivered energy saving gains well in excess of Chinese government targets (see Fig. 2).

ENERGY EFFICIENCY ASSESSMENT MODEL PROJECT IN NINGBO CITY

Hitachi embarked on energy conservation work based in Ningbo City in May 2008, reaching an agreement with the National Development and Reform Commission to hold a joint conference on new energy conservation projects in the form of model projects for energy conservation and reducing waste at small and medium-sized enterprises (SMEs) in China, and

Fig. 2—Work on Various Projects.
Adjustment work during a project to install high-voltage inverter systems in Yunnan Province (left) and survey work during an energy efficiency assessment model project in Ningbo City (right).

a joint agreement with the China Center for Business Cooperation and Coordination and the government of Ningbo City on the Cooperation Project for Energy-saving and Emission Reduction among SMEs in Ningbo. These projects went beyond merely supplying products and systems, also including the supply of know-how in the field of energy efficiency assessment, which Hitachi had developed for use by itself and group companies, to SMEs in Ningbo City in the form of a consulting service. Energy efficiency assessments have been conducted for 12 companies to date.

With the average benefit of implementing the recommendations of an energy efficiency assessment being a 10% saving in energy use across an entire plant, Hitachi's assessment capabilities are highly regarded by both Ningbo City and the companies that received the assessments.

JOINT PROJECTS WITH NATIONAL DEVELOPMENT AND REFORM COMMISSION

The activities of Hitachi are highly regarded by the Chinese government and this led to the signing, in November 2009, of a memorandum of understanding on undertaking joint projects with the National Development and Reform Commission in a comprehensive way (see Fig. 3). These joint projects have covered a wide range, including setting up joint companies to undertake model projects, joint research, and the training of personnel. The main focus has been on highly efficient energy systems and smart grids, water treatment systems that ensure safe water supplies, recycling and reuse of home appliances (which are becoming increasingly common in China), and the building of urban transportation systems with a small impact on the environment. The first step was the holding of the Hitachi Green Economic Technology Exchange Meeting in Beijing in March 2010, which provided an opportunity for lively debate among the more than 400 people who attended from Chinese government agencies, corporations, industry bodies, and research institutions.

JOINT PROJECTS WITH DALIAN CITY

Subsequently, after undertaking investigations under the direction of the National Development and Reform Commission, an agreement was reached with the Dalian Municipal Development and Reform Commission in Liaoning Province at the Fifth Japan-China Energy Conservation and Environment Forum in October 2010 to commence cooperation in the fields of resource recycling and the low-carbon economy (see Fig. 4). The cooperation is to focus primarily on smart grids, water treatment, and home appliance recycling, and in addition to seeking to implement model businesses using Hitachi's latest technologies, know-how, products, and solutions with support from the Dalian Municipal Development and Reform Commission and in collaboration with Dalian City partner corporations and relevant agencies, the agreement also includes embarking on investigations into such activities as new research, development, and demonstrations, with the results of this collaboration

Fig. 3—Signing Ceremony at Fourth Japan-China Energy Conservation and Environment Forum.
An agreement was signed with the National Development and Reform Commission on Good Will Joint Project for Building a Low-carbon Society and Resource and Environment Sector.

Fig. 4—Signing Ceremony at Fifth Japan-China Energy Conservation and Environment Forum.
Agreement was reached with the Dalian Municipal Development and Reform Commission to embark on collaboration in the fields of resource recycling and the building of a low-carbon society, resulting in the first model city.

to be deployed to other parts of China in the form of model case studies.

Following further investigation and fine tuning under the direction of the Dalian Municipal Development and Reform Commission, projects are now getting underway in all of the targeted fields (smart grids, water treatment, and home appliance recycling). These are summarized below.

Smart Grids

Hitachi is undertaking a model smart grid project at the Dalian Biodiverse Emerging Science & Technology (BEST) City in conjunction with the Dalian BEST City Management Committee and the Dalian BEST City Development Co., Ltd. with the aim of creating an advanced smart city. Specifically, Hitachi is supplying a proposed trial community energy management system (CEMS) along with the associated technology required for the model project as part of a trial aimed at installing a CEMS for office blocks, condominiums, schools, shopping centers, and other buildings in the pedestrian mall (1.35 km^2) being developed by the Dalian BEST City Management Committee and the Dalian BEST City Development Co., Ltd.

Also, a demonstration of visual representation of energy covering part of the region was undertaken in August 2012, and investigations into establishing this as a business in Dalian in the future will be conducted jointly.

Water Treatment

Two projects are underway in the field of water treatment. The first includes participation in investment, design, construction, and operation in conjunction with the Dalian Changxing Island Economic and Technological Development Zone Management Committee in a project involving seawater desalination and wastewater treatment facilities at a global-level petrochemical industry complex in the Xizhong Island Petrochemical Industrial Park located in the zone administered by the committee. In addition to undertaking a feasibility study to determine factors such as the scope and business scheme for the project, work planned for the future on Dalian Changxing Island includes research and development into water treatment and investigating the construction of a manufacturing plant.

The second project involves a range of water treatment related activities, including water purification, water distribution, industrial waste water treatment, recycled water treatment, sewage treatment, and seawater desalination, being undertaken in Liaoning Province in collaboration with Dalian Dongda Group Ltd. Specifically, this involves working together to identify and commercialize new projects by utilizing the intelligent water system, which seeks to optimize the water cycle through the use of information and control systems for high-level integrated management of the individual water treatment systems, together with the technologies associated with each type of infrastructure. In addition to design and commercial support along with supply of specialist technology, Hitachi is also engaged in business investigations that include financing in accordance with the progress of the project. Dongda Group, meanwhile, conducts investigations into things like business schemes and the development of new projects through market research, surveys of information on specific projects, and analysis of project feasibility. The first step in the collaboration is the undertaking of a water cycle model project for the Dalian National Bio-industry Model Zone being developed by Dongda Group.

Home Appliance Recycling

Hitachi is supplying recycling technology and plant operating know-how it has built up through the home appliance recycling business it operates in Japan to Dalian Huan Jia Group Co., Ltd., a recycler in Dalian City, in the form of plant design engineering and operational consulting. Through collaboration on the construction of home appliance recycling plants with features such as advanced technology and cost performance, Hitachi is seeking to help build a resource recycling society in China.

JOINT PROJECTS WITH CHONGQING CITY

Following on from the joint projects with Dalian City, and representing a second wave of projects, Hitachi signed a memorandum of understanding on collaboration in fields such as resource recycling and the low-carbon economy with the Liangjiang New Area of Chongqing City in October 2011. Liangjiang New Area in Chongqing City is the third sub-provincial new area ratified by the State Council of the People's Republic of China, following Pudong in Shanghai and Binhai in Tianjin. It is also the only national-level new area in inland China. In addition to opening up new model businesses in this area, Hitachi, Ltd. and Liangjiang New Area are currently considering the scope and nature of their collaboration in fields such as the Internet of things, smart grids and smart communities, electric vehicles, solar power generation, wind power generation and inverters, railway systems, cloud computing, and the closed-loop economy. The plan for the future is to undertake specific projects like the joint projects with Dalian.

CONCLUSIONS

This article has described what Hitachi is doing in the fields of energy conservation and environmental protection in China by describing that work along with the progress of its projects.

Hitachi is deploying energy systems, water treatment systems, energy-saving machinery, technologies for preventing atmospheric pollution, and other technologies in the Chinese markets for energy conservation and environmental protection, and has been involved in numerous projects under the cooperation of the Chinese government. In the future, in addition to continuing to supply its know-how, technology, products, and services, Hitachi will also engage in activities that expand the options for customers by turning services into businesses. Hitachi will also strengthen its involvement with new forms of energy as well as renewable energy like wind and solar power. In undertaking these activities and introducing technology, Hitachi also has high expectations for state-directed support policies, including subsidies and the establishment of regulatory regimes.

China is undergoing rapid economic growth, and also has major requirements in terms of the environment and energy conservation. In the future, Hitachi aims to contribute by doing its utmost to become "The Most Trusted Partner in China."

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R&D Strategy for Smart Grids and Smart Cities in China

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Nariyasu Hamada

OVERVIEW: Drawing on its ability to deliver a fusion of social infrastructure and IT, and its extensive technology, experience, and know-how in the fields of energy efficiency and environmental protection, Hitachi is participating in a variety of environmentally conscious city projects in China, including smart grid and smart city projects. To ensure that its research and development remains closely tied to the region, Hitachi is also taking an increasingly globalized and localized approach. This involves the development in China of technologies that are designed for use with Chinese smart grids and in Chinese smart cities, specifically network simulator technology for the analysis of electric power distribution networks and technology for energy management systems.

INTRODUCTION

AGAINST a background that includes increasing energy demand driven by economic growth, and a population that is increasingly concentrated in cities (urbanization), China needs to strengthen its energy supply capacity while also protecting the environment. The realization of smart grids and smart cities are seen as offering ways of overcoming this challenge, where a "smart grid" is one that uses next-generation power infrastructure supported by information technology (IT), while a "smart city" is a next-generation city that uses IT to strike a balance between the environment, comfort, and economy.

Through its Social Innovation Business in China, Hitachi is seeking to contribute to regional development by supplying solutions that draw on its strengths in machinery, control systems, and information systems.

This article describes the current situation in China in the fields of smart grids and smart cities, together with the research and development strategy that Hitachi has formulated to keep pace with the nation's progress.

SMART GRIDS AND SMART CITIES IN CHINA, AND HOW HITACHI IS INVOLVED

Demand for electric power in China is forecast to continue growing (see Fig. 1). To satisfy this demand, China's 12th Five-Year Plan (2011 to 2015) has budgeted 6.1 trillion Yuan of investment in the electricity sector. The coal and hydro resources that fuel China's power generation are concentrated in the nation's southwest, while most renewable energy such as wind and photovoltaic power is generated in the northwest. The bulk of demand, in contrast, is located in eastern cities such as Beijing and Shanghai. Achieving a balance of supply and demand across the entire nation requires long-distance, very-high-voltage transmission networks with high capacity, and this is behind a proposed West-East Electricity Transmission

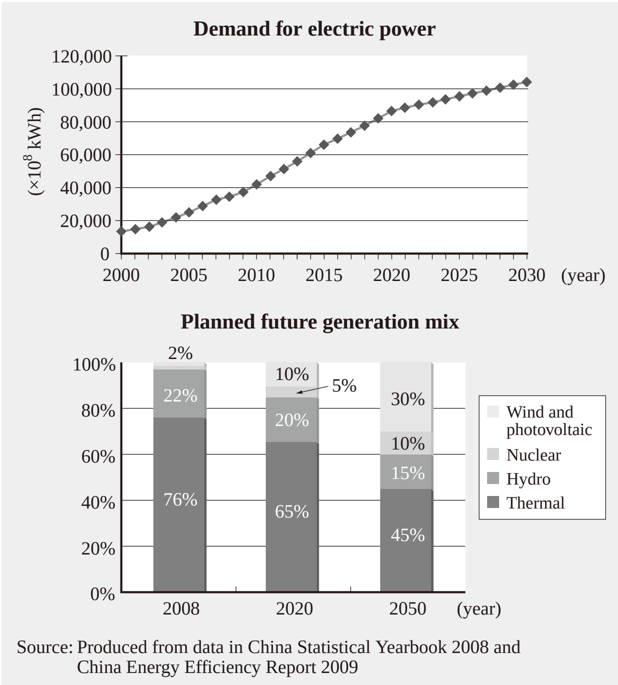

Fig. 1—Change in Chinese Electric Power Demand and Planned Generation Mix Over Time.
Along with growth in the economy, demand for electric power in China is on a long-term rising trend. Meanwhile, greater installation of wind and photovoltaic power generation is planned to help protect the environment.

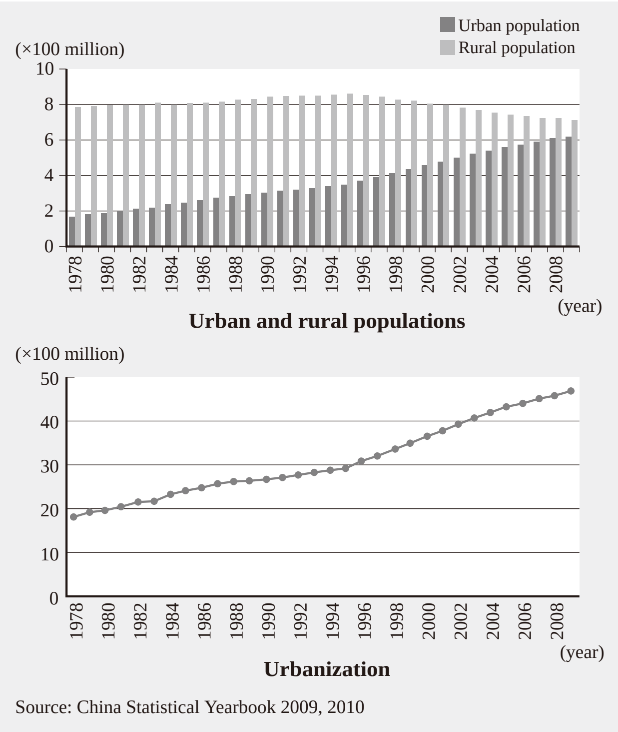

Fig. 2—Trend in China's Urban Population.
Each year, more than 10 million people migrate to the cities from rural areas.

Project. Based on the concept of a "strong smart grid," China is currently strengthening its transmission and distribution network, and also expanding use of renewable energy.

China's urban population continues to grow year on year, with more than 10 million people annually migrating to the cities from rural areas. This represents an annual movement of people comparable in size to the population of metropolitan Tokyo (see Fig. 2). A consequence has been a rise in concern about degradation of the natural environment caused by economic activity and the concentration of population.

Hitachi supplies electricity distribution management systems, grid stabilization systems, battery systems, community energy management systems, and other solutions for smart grids and smart cities, and is currently promoting proposals and participating in demonstration projects in cities around China, including Tianjin and Dalian[(1), (2)].

RESEARCH AND DEVELOPMENT STRATEGY IN CHINA

Hitachi (China) Research & Development Corporation has for some time being conducting locally based research and development in the field of power distribution and smart grids, as well as in information and telecommunications, digital equipment, and other similar fields. The following sections describe the scope of this research, looking in particular at its work on network simulator technology for the analysis of electric power distribution networks and technology for energy management systems.

Scope of Research

The systems covered by research at Hitachi (China) Research & Development Corporation can be broadly divided into distribution management systems used by power suppliers and community energy management systems used by consumers (see Fig. 3). In the future, it is anticipated that these two classes of systems will be coordinated using IT to optimize operation of the power distribution system. Data on infrastructural and consumer equipment is measured using IT, and this data is then used for analysis and control on various management systems. It is also anticipated that the future will see more widespread use of distributed generators such as wind or photovoltaic power, and energy storage devices such as batteries or electric vehicles (EVs).

Network Simulator Technology for Analysis of Electric Power Distribution Network

(1) Challenge

A challenge for management of the grid in China today is that losses of electric power in the distribution network make up approximately 70% of losses across the entire power system[(3)]. Work is also underway on strengthening the distribution network in response to issues with security of supply.

Meanwhile, greater use of wind, photovoltaic, and other forms of renewable energy is being encouraged to reduce carbon dioxide (CO_2) emissions and otherwise help protect the environment, and progress is being made on use of distributed generators (including small gas turbines as well as renewables) to foster "local production for local consumption" in the field of energy. However, greater use of distributed generators leads to reverse power flows in the distribution network. If the change in the power flow is large, it can influence the generation plans of power companies and complicate the task of maintaining power quality. Currently, the rules for power transmission and distribution in China do not permit reverse power flow. This has created a need to establish "local production for local consumption" of energy among power consumers by accurately forecasting and controlling the generation output of

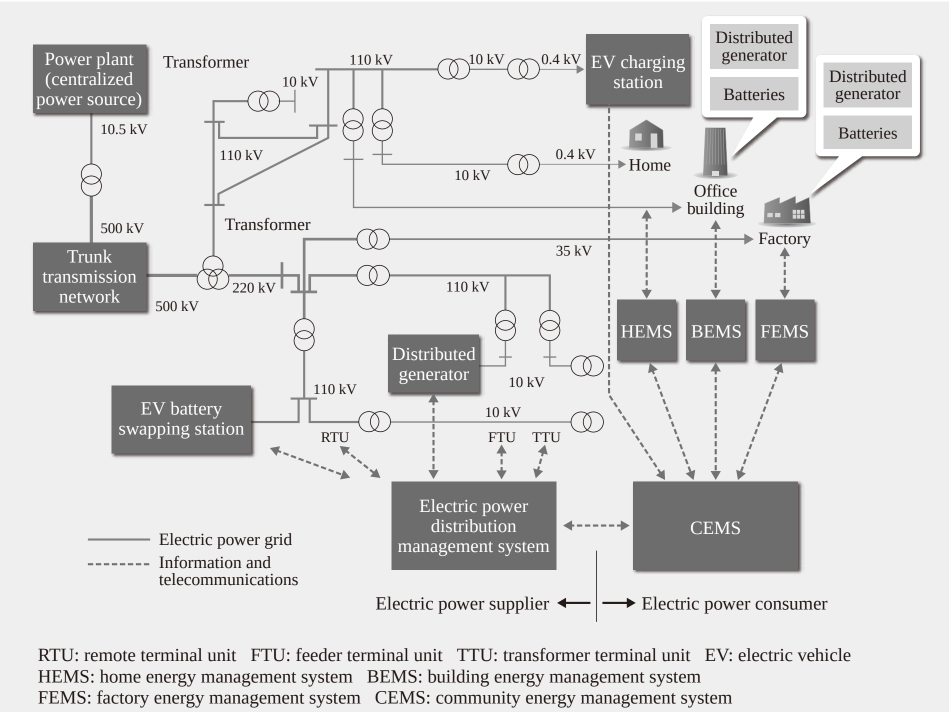

Fig. 3—Overview of Smart City Energy Infrastructure in China.
Future smart cities will make greater use of renewable energy and other distributed generators, and will coordinate the control of electric power distribution management systems and community energy management systems.

distributed generators (including renewable energy) to minimize the impact of reverse power flow on the distribution network.

(2) Research approach

Power grid companies like State Grid Corporation of China and China Southern Power Grid Co., Ltd. stipulate rules for the operation and design of electric power infrastructure on China's power distribution networks(4), and solutions are required for these technical issues that take account of actual conditions in China. For example, Hitachi believes it is necessary to assess the security of supply, safety, economics, and other aspects of the national grid stipulated by State Grid Corporation of China. This includes the reduction in power quality that results from the connection of distributed generators to the distribution network, how to minimize the duration of power outages through rapid fault detection and recovery, and the cost of equipment installed to strengthen the grid.

Hitachi (China) Research & Development Corporation is developing a simulator for analyzing electric power distribution networks that can analyze a variety of phenomena associated with the connection of distributed generators to a distribution network. The network simulator has data links to a distribution management system. It consists of a platform, with core functions such as performing (three-phase unbalanced) power flow calculations, and a set of applications for recreating a variety of distribution network phenomena (see Fig. 4).

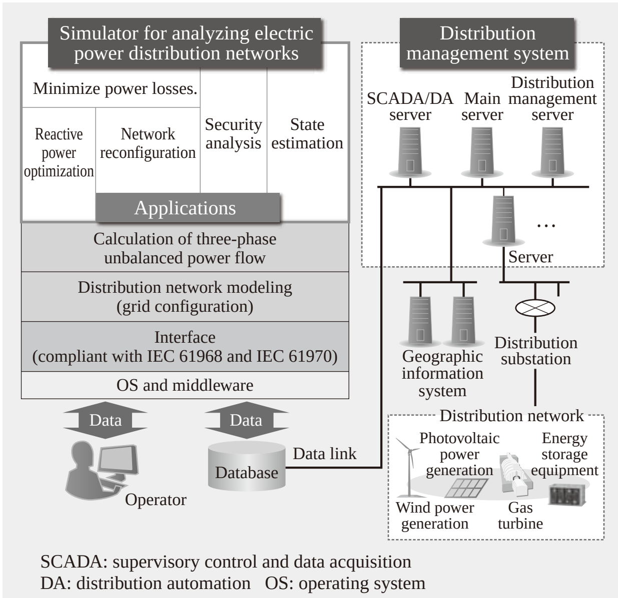

Fig. 4—Overview of Simulator for Analyzing Electric Power Distribution Networks in China.
The network simulator has a data link to a distribution management system and is used to recreate and analyze a variety of phenomena that occur in distribution networks (such as the impact of connecting distributed generators).

The first step involves modeling factors such as the configuration of China's distribution network, the features of its equipment, and its distributed generators (see Fig. 5). Modeling of distributed generators includes photovoltaic cells, synchronous generators, asynchronous generators, and doubly-fed induction

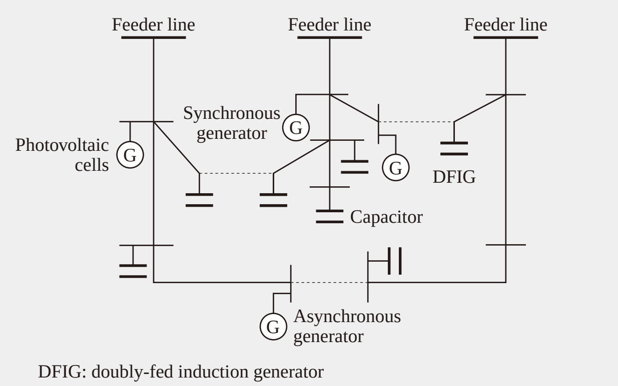

Fig. 5—Example Power Distribution Network in China.
The network simulator models the configuration of the power distribution network and equipment characteristics, and performs calculations such as minimization of power losses.

generators (DFIG). Next, the system calculates the impact of connecting a distributed generator to the grid, and countermeasures for dealing with this. Examples include the voltage fluctuations in the distribution network and the amount of reactive power that needs to be injected to minimize power losses. Other analyses include the impact of and recovery from grid faults, and the benefits of consumers using batteries for peak shifting (smoothing of power demand). In addition to existing analysis techniques developed and used in Japan, work is also in progress on developing the simulator using actual data from China. Hitachi is also working on joint research with Tsinghua University to keep up with the technical issues, technology developments, and other trends in China's electric power infrastructure.

Technology for Energy Management Systems

(1) Challenges

Protection of the environment is becoming a higher priority as China becomes increasingly urbanized, bringing a growing need for energy management and control by consumers. One example can be found at the Sino-Singapore Tianjin Eco-city, where development work is targeting 22 key performance indicators (KPIs) (see Table 1). Controlling for a particular objective requires the collection of relevant data so that it can be used for analysis and prediction to elucidate the causal relationships with the control objective. If the control objective changes, ongoing data collection and the modification of the control method to suit the objective are required.

(2) Research approach

Hitachi develops and supplies IT platforms (smart city platforms) that support social infrastructure(5). Hitachi (China) Research & Development Corporation is developing energy management applications that are built on IT platforms developed in Japan, but which also take account of the requirements and other circumstances specific to China. Energy management is a cycle that involves measuring and visualizing data from equipment and other sources; conducting analysis, prediction, and evaluation of energy supply and demand; formulating plans for the operation, equipment, and other aspects of energy supply and demand; and performing actual control, maintenance, and repair work (see Fig. 6). The main aims of control are to save energy; reduce energy costs; cut or shift peaks in energy demand; make efficient use of photovoltaic power generation and batteries; and reduce CO_2 emissions. Specifically, this includes using meteorological information to predict the generation output of photovoltaic and other distributed generators, and also adjusting supply and demand in accordance with electricity tariffs that vary depending on the time of the day, and in accordance with other considerations such as which areas are used (including homes, offices, and commercial buildings) and how consumers behave (including information on people's movements, and when they arrive at, leave, or use a facility). Other considerations are the need for standardization and factors that are difficult to measure or evaluate, such as ensuring consumer comfort (including temperature, humidity, illumination, and restrictions on when a facility can be used) and whether the KPIs referred to above have been achieved.

Table 1. Examples of Key Indicators for Eco-cities (from Sino-Singapore Tianjin Eco-city Key Performance Indicators)
With the aim of building an environmentally conscious city, the development of the Sino-Singapore Tianjin Eco-city is targeting a set of key performance indicators (KPIs).

Eco-city KPI	Target	Target date
Usage of renewable energy	≥ 20%	2020
Usage of water from non-traditional sources*1	≥ 50%	2020
Proportion of green trips*2	≥ 30%	2013
	≥ 90%	2020
Proportion of green buildings*3	100%	from 2011

Source: Sino-Singapore Tianjin Eco-city Key Performance Indicators
*1 Non-traditional sources such as recycled water, rainwater, and seawater desalination.
*2 Use of forms of transportation that conserve energy, produce little pollution, and are good for health, such as cycling or walking, and bus, subway, or other modes of public transportation.
*3 Buildings that are environmentally conscious throughout their life cycle, from construction to use and demolition, including by making maximum use of renewable energy, conserving resources, reducing pollution, and providing comfortable spaces.

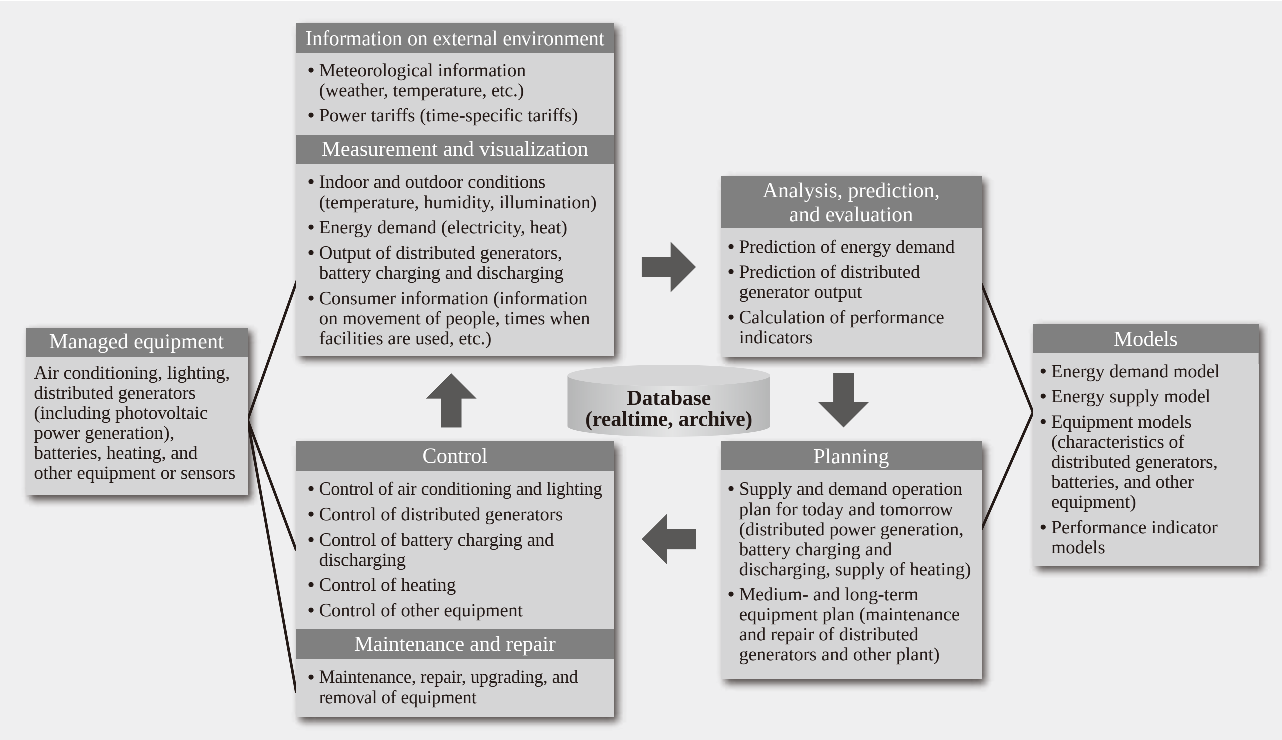

Fig. 6—Building Energy Management Flowchart.
Energy management involves a cycle that includes measuring and visualizing data from equipment and other sources; conducting analysis, prediction, and evaluation of energy supply and demand; formulating plans for the operation, equipment, and other aspects of energy supply and demand; and performing actual control, maintenance, and repair work.

Hitachi is currently involved in the international standardization of smart city infrastructure measurement indicators[6]. This work aims to collate the different requirements for urban infrastructure, which include improving the quality of life for residents, delivering sustainable growth and efficient operation for city managers, and taking account of the environment to satisfy world opinion, and to standardize the evaluation and measurement methods for determining the extent to which these are achieved. Through its research and development in China, Hitachi's plan is to develop performance indicators and technology for energy management systems by using activities such as the smart city and eco-city projects in Tianjin and Dalian to evaluate and verify actual operational data.

CONCLUSIONS

This article has described the current situation in China in the fields of smart grids and smart cities, together with the research and development strategy that Hitachi has formulated to keep pace with the nation's progress.

Being characterized by differences in the pace of progress and the development policies pursued in different parts of the nation (urban versus rural, costal versus interior), customer needs in China are very diverse. Hitachi is taking an increasingly globalized and localized approach to research and development, the most upstream of all corporate activities, seeking to build a value chain that is closer to its customers and extends from research and development through to sales and marketing and the supply of products, solutions, and services. Hitachi aims to contribute to the progress of social infrastructure in China by taking the system technologies it has built up through its experience with social infrastructure in Japan and enhancing them based on an understanding of Chinese culture.

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Strategy of Social Infrastructure Systems Business in India

Ichiro Iino
Masakazu Uetani
Yasuo Sasabe
Kotaro Koizumi
Kentatsu Ito

OVERVIEW: Hitachi sees social infrastructure systems as lying at the heart of its Social Innovation Business and is actively expanding its operations aimed at building sturdy foundations in the rapidly growing nation of India. India was designated as an independent territory within Hitachi's global business in October 2011, with Hitachi India Pvt. Ltd. taking up a position alongside Japan as one of Hitachi's six international hubs. Hitachi intends to draw on its many years of experience in social infrastructure systems to contribute to the development of India by widely supplying highly efficient, safe, and reliable systems that are conscious of the global environment.

INTRODUCTION

HITACHI'S business activities in India date back to the 1930s. Over that time, its involvement has included equipment supply and construction work on projects associated with the provision of social infrastructure, such as rolling stock, hydroelectric power plants, and thermal power plants. More recently, the scope of Hitachi's business has expanded in step with the development of the Indian economy to the point where 22 group companies now have operations in India, with sites in nine different cities.

Hitachi's social infrastructure business needs to establish a foundation for itself in India with roots in that country, with the sharing of values and other aspects of culture being most important. India faces challenges such as population increase, shortages of energy, and the provision of employment, and Hitachi supplies social infrastructure systems over a wide range of areas to assist with India's ongoing development.

This article gives an overview of the systems for information and telecommunications, electric power generation and transmission, industry, and railways that form part of Hitachi's social infrastructure systems business in India, together with its business strategy for these products.

OVERVIEW OF INDIAN MARKET

Having achieved strong growth in gross domestic product (GDP) of 6.5% in the 2011 fiscal year, and having the advantage of a young population (with an average age of about 25 years), India is forecast to maintain strong GDP growth into the future. It is anticipated that the size of its economy in 2040 will match that of the USA.

Against the background of this ongoing rapid growth, the budget indicating government policy for the 2012 fiscal year was released in March. This budget is particularly significant because it indicates the direction to be taken in the initial year of the Indian government's Twelfth Five Year Plan (2012 to 2017), which will be officially released in September. The Indian government is struggling under difficult financial circumstances, but while the budget's measures included some that detract from industrial development, such as an increase in service taxes, it also provides active support for the provision of social infrastructure, with measures including the ongoing allocation of 10.2 trillion rupees to the information and telecommunications sector and 20 GW/year of additional power generation capacity.

SOCIAL INFRASTRUCTURE SYSTEMS BUSINESS IN INDIA

Information and Telecommunications Network Business

The progress of information and telecommunications in India is evident in the explosive growth in mobile phone subscribers and is anticipated to accelerate further in the future (see Fig. 1). This is seen as being due to ongoing encouragement of the sector, with users predominantly being young people with a high level of education, as indicated by the population structure referred to above.

India is located centrally in a region that extends from Southeast Asia and the Pacific to its east and to the Middle East and Africa to its west, giving it a geopolitically convenient and advantageous location. Also, the fact that English is the nation's common language means that India has numerous

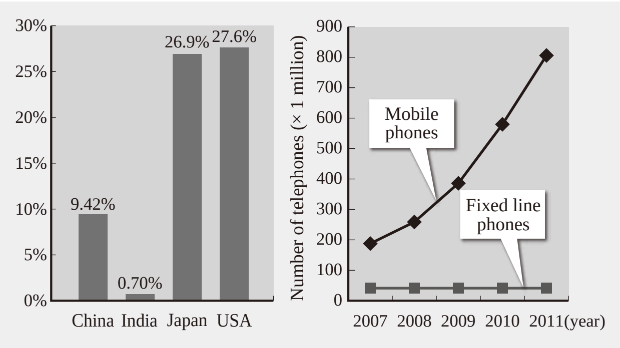

Fig. 1—Broadband Penetration Rates in Different Countries (left) and Number of Telephones (right).
The graphs show the broadband penetration rates in different countries (left) and number of telephones (right).

system integration (SI) vendors that operate globally. However, many of these SI vendors are focused on fields such as software development and outsourcing, and India has made less progress in the development and manufacture of advanced hardware for the information and telecommunications sector. Telecommunication networks are part of the social infrastructure. Compared to other countries, there remains an urgent need for further enhancement of telecommunications networks in their role as part of the social infrastructure, and this has the potential to become an obstacle to the future development of India's information and telecommunications industry.

To overcome this challenge, the Indian government, as part of its national growth strategy, has formulated policies to encourage local development and manufacture of information and telecommunication products, and to promote the provision of communication network infrastructure. In keeping with this strategy, the government published a draft National Telecom Policy in October 2011, 12 years after the previous such policy issued in 1999. This draft policy sought to develop information and telecommunications infrastructure on a national scale and included a target of rolling out a nationwide fiber optic network with a total length of 1,100,000 km. A cabinet decision promptly authorized an initial budget of 200 billion rupees for this project for the 2012 fiscal year. The aim is to connect 175 million broadband subscribers by 2017 and 600 million by 2020 (where broadband is defined as communication speeds of 2 Mbyte/s or more).

In anticipation of rapid demand growth for Big Data processing in India driven by the development of the telecommunications infrastructure, Hitachi established Hitachi Consulting Software Services India Limited (HCSSI) in January 2011 to act as a base for the provision of information technology (IT) consulting services. It is intended that HCSSI will work closely with Hitachi Data Systems India Private Ltd. (HDS), which has been in operation since 2002.

The nature of the construction and deployment of communication network infrastructure is that, rather than acting as its own independent infrastructure, it has a central role to play across the broad range of social infrastructure. This makes it a field that calls on the overall technologies of Hitachi.

Power Generation and Transmission Business

India has suffered from chronic power shortages for many years, a situation that has only become more severe since the turn of the century as the economy has grown rapidly. In response, the Indian government targeted a 78,700-MW increase in power generation capacity in its Eleventh Five Year Plan (2007 to 2012)[3]. Although India had achieved a hundred-fold increase in its power generation capacity in the 60 years from 1947 (installed capacity of 1,360 MW) until 2007 (132,000 MW), this plan had the ambitious target of adding generation equipment with approximately 50% of this capacity over this five year period. Approximately 75% of this increase was to be provided by coal-fired thermal power generation, and the plan encouraged the construction of large supercritical coal-fired power plants with high performance.

As of March 2012, although new power generation capacity equivalent to nearly 80% of this target is anticipated, total generation capacity remains below 200,000 MW, as shown in Fig. 2. Like India, China is experiencing rapid economic growth and has a population of 1.3 billion. As China already has close

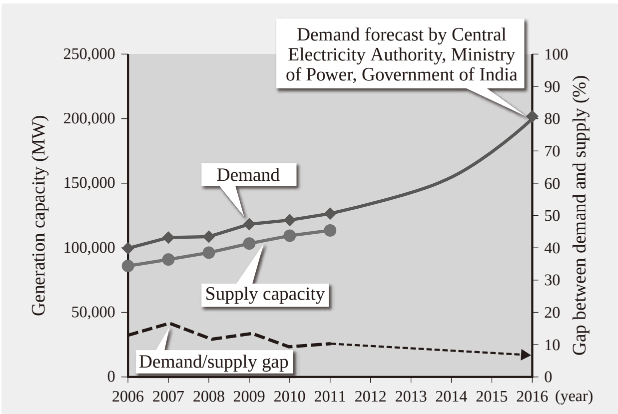

Fig. 2—Yearly Figures and Growth in Power Generation in India.
The graph shows the growth in annual power generation in India.

to 1,000,000 MW of power generation capacity, the Indian government aims to achieve even greater increases in capacity during the term of the next Five Year Plan and beyond, with a long-term objective of reaching 800,000 MW in the early 2030s.

These policies for encouraging the construction of thermal power plants have resulted in the establishment of numerous joint venture companies between Indian and overseas corporations since 2008.

In August 2010, Hitachi established a joint venture company for boilers and turbine-generators with BGR Energy Systems Limited, a large Indian company in the field of thermal power plant construction. The company won its first contract in the 2012 fiscal year for a 660-MW boiler. It also expects to win a contract for an 800-MW turbine for a supercritical coal-fired thermal power plant, with further projects to follow in the future.

Meanwhile, new obstacles have emerged recently, with delays and other slippage in the plans being caused by a number of significant problems, including difficulties in acquiring land and environmental consents, shortages of domestically produced coal, rises in the price of imported coal for power plants, and inadequate transmission line capacity. Increasing the capacity of power generation from nuclear, hydro, and renewable energy is planned for the medium to long term as a way of dealing with global warming, and Hitachi, which has considerable experience in these fields, also intends to cooperate actively on these power plants.

In the field of power transmission, although rapid progress is being made on the construction of new ultra-high-voltage lines (400-kV to 765-kV class) and direct current transmission lines (400-kV to 800-kV class) by the national transmission company, Power Grid Corporation of India Limited (PGCIL), regional electricity authorities, and some private power transmission and distribution companies, this is not enough to keep up with the pace at which additional power generation capacity is being added (as described above). The elimination of transmission and distribution losses of more than 20% is major bottleneck, and there is an urgent need for measures such as investment in the development and deployment of high-performance power distribution equipment and the upgrading of supervisory control systems for electricity supply and distribution.

Recognizing these circumstances for power generation and transmission, Hitachi established Hitachi NeST Control Systems Pvt. Ltd. (headquarters: Bangalore) in October 2011 as a joint venture with SFO Technologies Pvt. Ltd. of India in the field of monitoring and control systems (see Fig. 3). Hitachi NeST Control Systems Pvt. Ltd. is a hub for the design, manufacture, and maintenance of monitoring and control systems for thermal power plants that supplies global-standard systems and delivers value in a form that is tailored to suit the challenges that customers confront as well as their other needs.

Fig. 3—Ceremony Marking Establishment of Hitachi NeST Control Systems Pvt. Ltd.
Hitachi has established a joint venture with SFO Technologies Pvt. Ltd. for the design, manufacture, and maintenance of monitoring and control systems.

Fig. 4 shows an example from a project to upgrade monitoring and control systems for Units 3 and 4 at the Mettur thermal power plant and Unit 5 of the Tuticorin thermal power plant of the Tamil Nadu Electricity Board (TNEB), which completed commissioning in 2011. This project involved upgrading existing Hitachi HIACS-3000 systems to the latest HIACS-5000M systems. The system upgrade approach taken on this project involved keeping control panel enclosures, cabling, and other existing equipment and only replacing units such as controllers or process input/output (PI/O) modules. Using this approach kept the length of the plant shutdown down to only 15 days. By offering energy-efficient inverters, combustion optimization systems, and other enhancements as solutions to the problem of rising prices caused by the coal shortage, Hitachi will also deliver value by using efficiency improvements to reduce fuel costs.

Monitoring and control systems also have a major role to play in reducing losses during power distribution. Optimum grid operating practices built up through Hitachi's past experience, and decision support systems (DSSs) that support grid configuration, are seen as being extremely effective solutions to the problem of distribution losses.

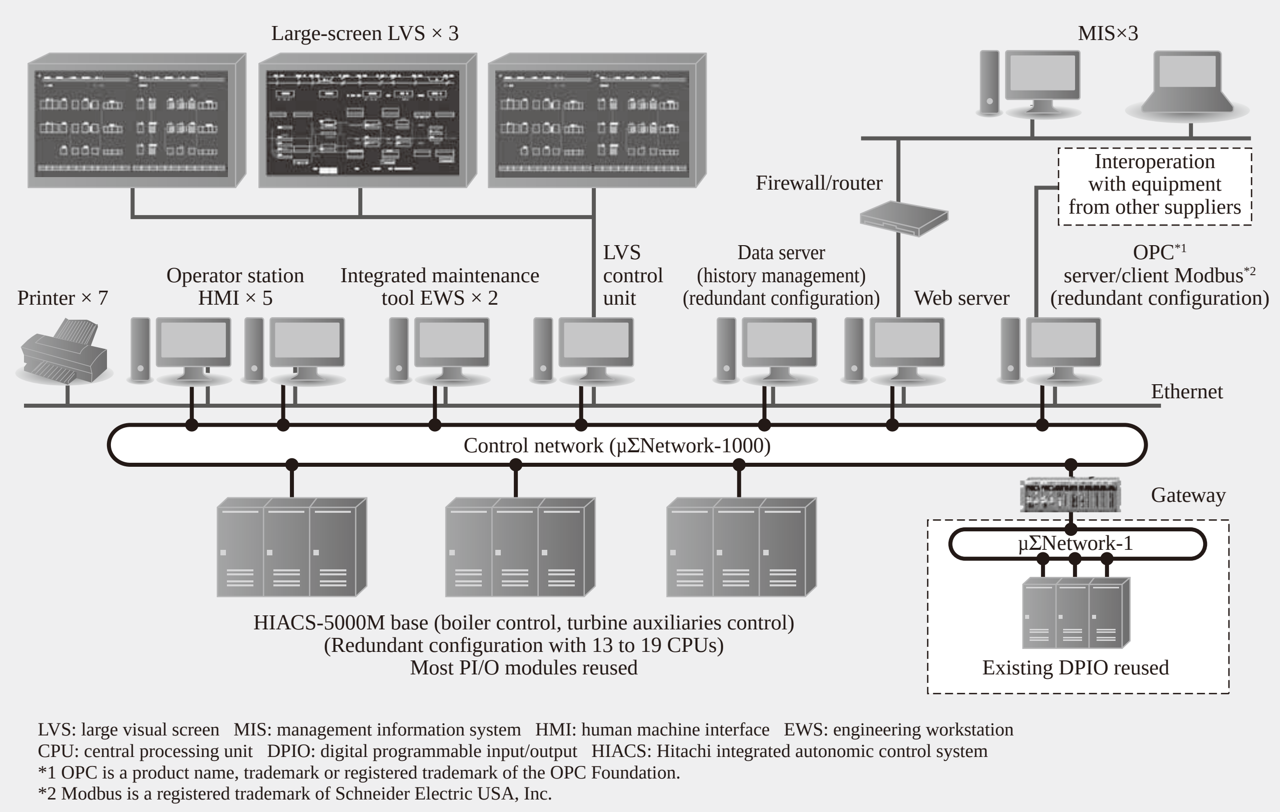

Fig. 4—Thermal Power Plant Monitoring and Control System Upgrade Supplied to Tamil Nadu Electricity Board.
The system upgrade approach taken on this project involved replacing units such as controllers or process input/output (PI/O) modules.

Industrial Infrastructure Systems Business

To increase national income and reduce the gap between rich and poor by boosting the earnings of people on low incomes, the key pillars of Indian government policy have been: (1) Increase employment through secondary industrial expansion based around manufacturing, (2) Develop India as a development and production hub for manufacturing industry within the South Asian region, and (3) Encourage public and private investment in order to achieve this development.

Hitachi's business strategy is to draw on its extensive experience, not only in Japan but also in various other countries, and to work together to resolve the challenges facing its social infrastructure business in concert with the economic development policies of the Indian government. In October 2011, Hitachi brought Hi-Rel Electronics Ptv. Ltd., a company with strengths in uninterruptible power supplies and industrial drive systems, into the group to establish Hitachi Hi-Rel Power Electronics Pvt. Ltd. (headquarters: Ahmedabad in the state of Gujarat) (see Fig. 5). Hitachi also established an engineering center at Hitachi India Pvt. Ltd. with a total of about 600 employees, including those of Hitachi NeST Control Systems Pvt. Ltd. (referred to above), and created the foundations of its infrastructure systems business by establishing an organizational structure comprising two development and manufacturing centers, sales offices in eight cities, and 30 service centers.

The main focuses of the infrastructure systems business are on solutions for improving the quality of electric power generated from solar energy and control systems for steel plants.

Fig. 5—Ceremony Marking Establishment of Hitachi Hi-Rel Power Electronics Pvt. Ltd.
Hitachi Hi-Rel Power Electronics Pvt. Ltd. was established as a base for design, production, maintenance, and sales of power electronics products.

Solar power generation systems

The Indian government published its policies for encouraging wider adoption of solar power generation in the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010. This document set targets for achieving solar power generation capacity of 20 GW (connected to the commercial power grid) and 2 GW (separate from commercial power grid) by 2022. Other policies included a scheme for the purchase of power from generation operators, industrial development measures including some domestic production of solar panels, supply to areas that currently lack a power supply, the encouragement of education through the supply of computers, and support for the refrigeration of food.

Meanwhile, Hitachi is actively engaged in expanding its solar power related businesses in India, drawing on its experience such as the construction of the Ohgishima Solar Power Plant of The Tokyo Electric Power Co., Inc., which will be one of Japan's largest megasolar power plants (with a maximum output of 13 MW), and the trial of an energy management system that covers a number of sites as well as photovoltaic power generation at Hitachi City in Ibaraki Prefecture. Hitachi is also participating in "The Model Project for a Microgrid System Using Large-scale PV Power Generation and Related Technologies" project of the New Energy and Industrial Technology Development Organization (NEDO) in the state of Rajasthan, with aims that include connection to the commercial power grid and installation of a microgrid control system incorporating solar power generation at an industrial complex. States are also undertaking their own initiatives, including the establishment of a long-term power purchasing scheme in the state of Gujarat and construction of a 590-MW solar park in Charanka, and it is anticipated that investment will expand further as the results of collection and analysis of data on generation efficiency become clear.

Hitachi is taking a lead over its competitors by commencing domestic production of power conditioners for solar power plants (typical specifications include a rating of 500 kW and maximum efficiency of 98.7%) in July 2012 at Hitachi Hi-Rel Power Electronics Pvt. Ltd. (referred to above) (see Fig. 6). In addition to adapting to the Indian market, which is expected to grow rapidly, Hitachi is also supplying solutions to minimize the influence on the grid, which is likely to become a problem in the future.

Fig. 6—Solar Power Inverter.
Production in India commenced from July 2012.

Steel plant control systems

In addition to construction demand, particularly for housing, demand for automobiles is also increasing as economic growth in India accelerates, and therefore it is expected that production of finished steel products will also increase (see Fig. 7). In terms of the number of cars produced annually, India's automotive industry surpassed that of Japan in 2011, and numerous foreign automotive manufacturers are planning the construction of plants in India. As a result, it is anticipated that a large amount of high-grade steel products will be produced, such as thin sheet steel for automotive use and silicon steel for use in electrical equipment. Hitachi supplied India's first continuous pickle line and tandem cold strip mill to Tata Steel Ltd. in 2000, and the plant continues to operate successfully. Hitachi is expanding its business, having won a contract to supply the electrical system for a hot strip mill belonging to the Kalinganagar steel plant in the state of Orissa in 2011.

For the future, Hitachi intends to accelerate its system-wide measures for responding promptly to the needs of customers in India, including everything

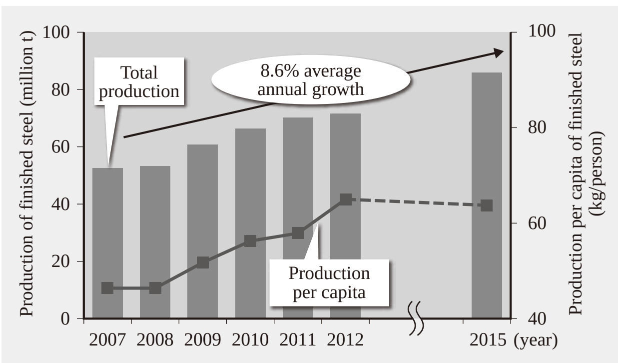

Fig. 7—Total and per Capita Production of Finished Steel.
The graph shows total and per capita production of finished steel in India.

from sales through to design, manufacturing, and maintenance services.

Water business

It is expected that population growth and industrialization will lead to even more severe water shortages in India in the future and growing demand is anticipated for things like seawater desalination in coastal locations and water recycling. Hitachi has already formed a consortium to look at the commercialization of smart communities as part of the 2009 Fiscal Year Ministry of Economy, Trade and Industry Commissioned Project For Studying Promotion of Export of Infrastructure-Related Industries and System, which seeks to construct energy-efficient, low-carbon, smart communities. This project is part of the Delhi-Mumbai Industrial Corridor Project being undertaken jointly by the Japanese and Indian governments to utilize private investment to establish industrial complexes and other facilities along a 1,500-km corridor from Delhi to Mumbai.

Following these investigations, the consortium of Hitachi, Ltd., ITOCHU Corporation, and Hyflux Ltd. signed a joint seawater desalination development contract with Dahej SEZ Ltd. of India on March 22, 2012 (see Fig. 8). This project is intended to overcome a shortage of industrial water by using seawater desalination to supply industrial water to companies with operations in the coastal industrial zone at Dahej in the state of Gujarat. When complete, the project is expected to be the largest seawater desalination project in Asia and it will contribute to the effective use of water resources in India.

Fig. 8—Signing Ceremony for Joint Development Contract.
A joint development contract was signed for a seawater desalination project to supply industrial water to a coastal industrial zone at Dahej in the state of Gujarat.

Railway Systems

Safety improvement has become a pressing issue at Indian Railways, the world's fourth largest network with a total of 64,000 km of track, which has been concerned by a growing number of accidents in recent years. It is also seeking to increase the efficiency of goods and passenger transportation to help support economic progress.

In the field of urban transportation services, the Ministry of Urban Development issued a policy in November 2011 stating that all cities with populations of 2 million or more should have commuter transportation systems (metros). Progress is also being made on the introduction of monorails to act as feeder lines to metro systems or as medium capacity transportation systems, and moves to seek out the active use of private investment to complement public investment are accelerating.

Hitachi has maintained a degree of presence in the Indian railway market since first supplying steam locomotives to Indian Railways in 1953. In 1981, Hitachi supplied the main motors for the WAG5-class of electric locomotives in conjunction with a Technical Transfer. Partner companies continue to manufacture products to the present day. Hitachi supplies the latest urban transportation rolling stock, high-speed rolling stock, and electrical equipment for rolling stock in Japan and other parts of the world, and is characterized in particular by its technologies, which include carbody production using aluminum alloy, and variable-voltage, variable-frequency (VVVF) inverters using insulated gate bipolar transistors (IGBTs) that Hitachi was the first company in the world to commercialize. While carbodies made of aluminum alloy are currently only used in the Indian market in a small number of isolated instances where ready-made rolling stock have been imported, Hitachi is promoting their advantages, which include lower maintenance costs due to the use of lighter weight rolling stock, and is taking note of the medium- to long-term progress of plans for high-speed and quasi-high-speed trains that require aluminum carbodies

In the field of railway signaling systems, meanwhile, Hitachi has established a secure place for itself as a leading digital automatic train control (ATC) supplier in the Japanese market. In India, work is underway on modernizing a wide range of different signaling systems.

Hitachi will utilize the experience and know-how it has built up over the past to supply solutions that meet the needs for signaling modernization in India. A number of major projects are planned, including dedicated freight corridor (DFC) and high-speed railway projects, and Hitachi will draw on its overall

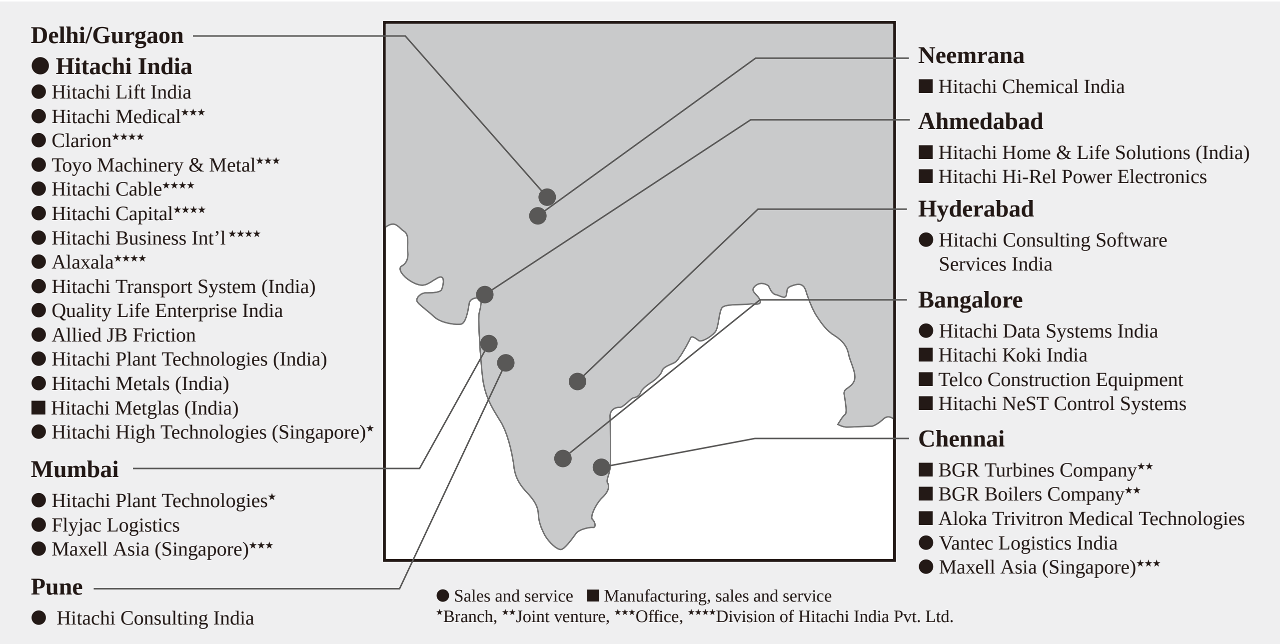

Fig. 9—Hitachi Companies in India.
Hitachi has 22 subsidiaries active in India.

strengths to propose solutions. Hitachi also intends to establish its own arrangements in India to identify customer needs quickly and provide prompt service.

In monorail systems, Hitachi has extensive experience from Japan both in their use for urban transportation and in theme parks. Hitachi has also built up operational experience outside Japan, having completed orders for monorails in Chongqing (China), Sentosa Island (Singapore), and Palm Jumeirah (Dubai). A monorail in Daegu (South Korea) is expected to enter service in the near future.

There is also a high degree of interest in monorail systems in India, and Hitachi is working actively to promote these with work underway on specific projects in large cities such as Chennai, Delhi, and Pune.

HITACHI ACTIVITIES IN INDIA

Hitachi currently has 22 local subsidiaries operating in India (see Fig. 9). To respond more rapidly to customer requirements, Hitachi India Pvt. Ltd. shares its accumulated know-how with other Hitachi subsidiaries to support the smooth operation of these companies' businesses.

For the future, Hitachi intends to expand its business by strengthening this operational structure based around Hitachi India Pvt. Ltd. as described in this article. Consolidated group sales in India reached approximately 90 billion yen in the 2010 fiscal year, and are planned to increase to approximately 200 billion yen within the next few fiscal years.

CONCLUSIONS

This article has given an overview of the systems for information and telecommunications, electric power generation and transmission, industry, and railways that form part of Hitachi's social infrastructure systems business in India, together with its business strategy for these products.

Hitachi intends to continue working actively toward building a sturdy business foundation in India, which represents a typical example of an emerging nation and in which the social infrastructure business is experiencing strong demand. Hitachi also intends to utilize its strengths in advanced IT and social infrastructure to contribute to progress in India through its smart city business.

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Challenges for Social Infrastructure R&D in India

N. Vinoth Kumar

OVERVIEW: India is a large nation with a growing level of infrastructure investment. Key challenges for global businesses include India's expansiveness and the economic, cultural, geographical, environmental, and political diversity this brings. One question that must be asked when market opportunities arise is whether a product, solution, or service can be adapted to the Indian market with only minor changes, or whether significant redesign is needed. Given that India's diverse market includes a broad spectrum of local and global competitors, each with their own competitive advantages, redesign of the product, solution, or service may be needed just to cope with the market's diversity. This redesign must address three key issues: (1) whether mass customization can be used to scale the features and affordability, (2) whether the product can stand up to harsh operating environments, and (3) whether the interface is suitable for the diversity of end-users. Given their local knowledge and implicit understanding of India's diversity, this redesign for India is, in many cases, best undertaken by local researchers.

INTRODUCTION

SOCIAL infrastructure investment in India is doubling every five years, with a budget of $US1 trillion for the Twelfth Five Year Plan (2012–2017)[(1)]. This investment can be divided into a variety of categories, including by sector (including power, transportation, and water), state (Gujarat, Tamil Nadu, and so on) and type of community (including rural, semi-urban, and urban). While some projects are entirely government funded, others are public-private partnerships (PPPs). The government-funded projects tend to focus on the bottom of the pyramid, particularly people living in rural areas. PPPs, meanwhile, are focused more on the middle class and affluent, especially in the area of urban infrastructure.

The key challenge therefore is to adapt technologies to suit the diversity of India, which extends from affordability at one extreme to cutting-edge at the other. Global infrastructure companies are localizing both manufacturing and research and development in order to remain competitive. However, cost savings achieved through local manufacturing and adaptations are insufficient for business groups that aim to supply the entire Indian infrastructure market. Redesign is also essential to create platforms that address the needs of a diverse, changing, and large society.

This article considers five stages of evolution in infrastructure technology (see Fig. 1). These are: nonexistent infrastructure, unstable infrastructure, unreliable infrastructure, high-quality infrastructure, and fail-proof infrastructure. Using power infrastructure as an example, the dotted line in Fig. 1 represents the target root mean square voltage in a distribution line. The first stage of evolution corresponds to the case when a region lacks any power infrastructure, the second stage to the power supply being unstable both in quality and availability, the third stage to greater availability but with quality still poor, the fourth stage to high-quality power that remains vulnerable to natural disasters and other special circumstances, and the fifth stage to a system that guarantees both quality and availability. Note that, while the fifth stage appears ideal, the system may require a level of redundancy that makes it inefficient and less valuable in some cases.

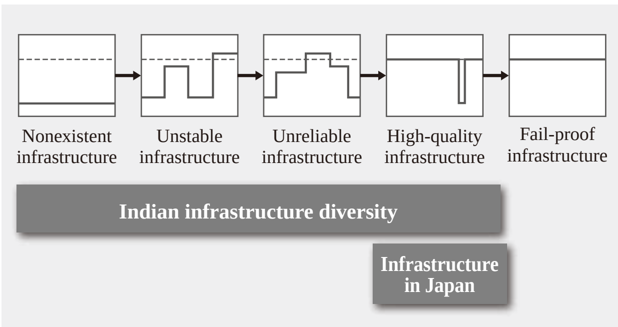

Fig. 1—Five Stages of Infrastructure Evolution.
Various stages of infrastructure evolution co-exist in India, unlike Japan where the infrastructure is of uniform high quality.

Given this picture, the question that arises is whether a control and information system that has evolved to operate social infrastructure at the fourth stage of evolution is ideal for a country in which stages one to four continue to co-exist. Or, whether it is necessary to redesign the system to handle a situation of diversity, so that it can cope with stages one to five collectively.

This article describes the issues facing research and development of this social infrastructure in India, and how Hitachi is active in this field.

REDESIGN FOR DIVERSITY

Redesigning for diversity, or diversity innovation, can be considered an alternative to merely adapting an information and control system for social infrastructure to fit the regulatory or affordability needs of the Indian market. The following sections describe three key points to consider when redesigning.

Design for Mass Customization

Diversity in the market may result in a range of expectations for the cost and features of an infrastructure system and its components. Whereas one segment of the market may place a priority on efficiency and reliability, another may be satisfied merely with functional compliance at an affordable price. Having a design that can be customized using variant and configuration management tools to address this variety of requirements in India provides a competitive advantage. One possible solution is to use a single information and control system design that can be scaled up or down to meet the needs of the nonexistent, unstable, unreliable and high-quality stages of infrastructure evolution. This can be achieved by reviewing and re-organizing the software and hardware architectures for re-configurability and mathematical modeling. Since a significant portion of the technology in information and control systems resides in the software and algorithms, one of the opportunities for mass customization is in software.

Krueger[(2)] describes several models for adopting software mass customization. The extractive model seeks to collect features from multiple products into a single product that may be configured to produce different variants, while the proactive model aims to produce new architectures or designs for a single product that can be customized through configuration. Although both the extractive and proactive models may be considered for redesign, the choice depends on the time and human resources available for the redesign work (see Fig. 2). Whereas the extractive model may be suitable when time and human resources are short, the proactive model is attractive for new products that may be candidates for reverse innovation with a long-term realization perspective.

When creating an architecture and platform that allow customization for Indian conditions, information systems require local intelligence and customization options because they must be able to function at the different stages of infrastructure evolution. If the control system hardware is to be manufactured locally, the following options for hardware redesign should be considered to enhance affordability and reduce the risk of obsolete components.

(1) Redesign the hardware platform to support critical components from different suppliers. In his

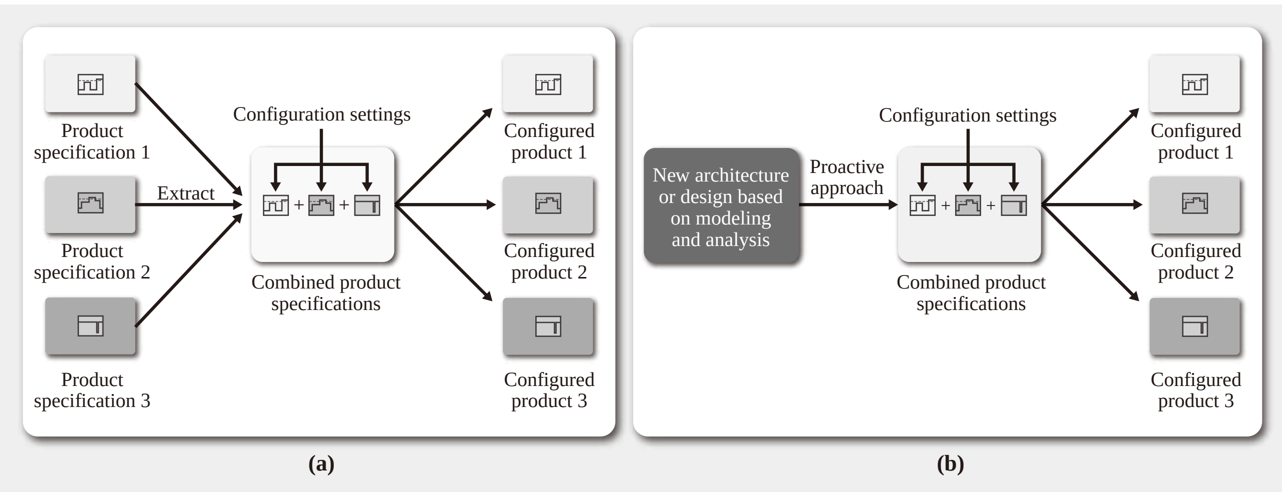

Fig. 2—Krueger's Extractive (a) and Proactive (b) Models of Software Mass Customization for Indian Infrastructure.
To create variant configurations, the extractive model involves studying existing products and features whereas the proactive model involves upfront innovation and analysis to create new architectures.

framework for industry analysis, Porter[(3)] lists the bargaining power of suppliers as one of the five factors affecting competitive intensity within an industry. One possibility for dealing with Indian market conditions, where Hitachi systems must be affordable to be competitive, is to redesign the hardware platform to allow the use of components from different suppliers. (2) When functional compliance is a key consideration and provision for scalability is required, it may be possible in some cases to make more affordable product variants by using mathematical modeling to substitute for non-critical sensors.

In one example, Infrastructure Systems Group, Hitachi India Pvt. Ltd. is promoting smart grids, railway traffic management, and intelligent water systems, and is considering a redesign of control boards to suit local conditions and allow mass-customization of the hardware and software for the Indian market.

Design for Immunity

Every control system design starts by defining the input-output characteristics. Control system equipment designed for high-quality infrastructure assumes that inputs (such as voltage, current, and frequency) will have a certain level of quality. In an environment in which infrastructure at all four evolutionary stages co-exists, however, systems must be designed to tolerate a lower quality of inputs. In the case when the hardware platform has been redesigned to use components from a wider range of suppliers, as proposed above, it may also be necessary to design the system to tolerate component malfunctions. Faults can have a range of severities and can be categorized into three groups based on fault location: (1) at the source or input side, (2) at the load or output side, or (3) inside the system at the component or sub-system level (see Fig. 3).

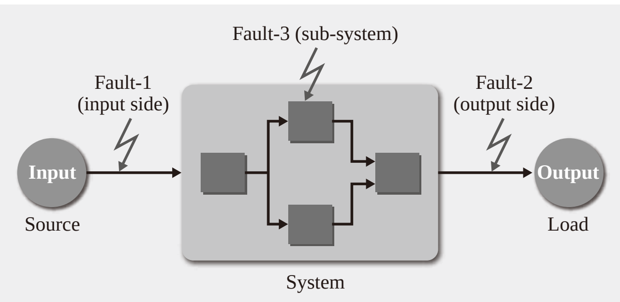

Fig. 3—Types of System Fault from which Immunity is Required. Faults can occur on the input side, output side, or in internal sub-systems. Systems must be designed for immunity to these different types of fault.

Under Indian conditions, the characteristics of inputs and outputs are unpredictable and the failure modes of locally procured components and sub-systems are uncertain. Accordingly, technology that is able to, (1) proactively sense fault severity for each of the above three fault locations, and (2) continue to function even if a fault occurs, or raise a timely alarm, has added value because it extends equipment life. Dominant designs often use technology of this nature. Normally, a new system must deal with the sensing infrastructure that is already in place. However, opportunities may also exist for dynamic configuration of control systems so that this proactive sensing and fault immunity can be achieved remotely.

An example is Hitachi Hi-Rel Power Electronics Pvt. Ltd., which supplies inverters and drives throughout India. While one installation may have few power outages per year and acceptable limits of transients and total harmonic distortion (THD) on both the source and load, another installation may have frequent daily power outages, as well as excessive transients and THD on the source or load that affect the life of the power electronics devices in the system. One way to deal with this is to incorporate a dynamic control system into the controller module that can learn the disturbance characteristics and provide case-based immunity (through active filter variants) or general immunity for worst-case scenarios.

Interface for End Users

"Poka-yoke" is a Japanese term in global use that means fail-safing systems to prevent them from being operated incorrectly. However, there is also a need to identify concepts that promote effective use of a system independently of the diversity of operating conditions. Once commissioned, a social infrastructure project must function within society, and the effectiveness of its use is dependent on factors such as regional culture and literacy. Another consideration when redesigning is to provide a user interface that can cope with the diversity of the Indian population.

An example of this is the Hitachi NeST Control Systems Pvt. Ltd. Operators who work with this distributed control system (DCS) used by Indian power utilities prefer pictorial and animated representations of processes. Another unique requirement cited by an Indian utility was to modify the user interface so that users could not open any other applications installed on the personal computer, because of their potential to distract an operator on duty.

In India, social infrastructure users may have different user interface needs, and catering to these may enhance their experience. Some of these differing needs can be satisfied using the mass customization variant configurations described earlier in this article. Other special requirements can be incorporated by involving the user in the design process. A simple tool chain could be developed to help users self-design the user interface of the Hitachi information and control system, with provision for necessary authentication.

RESEARCHERS FOR DIVERSITY INNOVATION

Having discussed the challenges and possible methodologies for managing Indian diversity by redesigning, the next important question is to identify appropriate human resources for this redesign work.

Local researchers who have both explicit and tacit understandings of this diversity are ideal candidates for diversity innovation. The redesign process involves extensive regional data gathering along with multi-modal and multi-lingual local communication, and also requires mathematical skills for modeling and simulating the unstructured regional data. Key points are listed below:

(1) India as a country has rich mathematical skills and a multi-lingual society. Local researchers may be able to offer several answers to the diversity challenge.

(2) One of the objectives of Hitachi India R&D Center is to enhance its research network through academic collaborations with institutes of international repute, such as the Indian Institute of Technology (IIT) and Indian Institute of Management (IIM). Recruitment of talent from institutions such as these may enhance this collaboration.

(3) Hofstede(4) uses five dimensions to categorize national cultures (see Fig. 4). A key difference between India and Japan is in the dimension of uncertainty avoidance. This implies that Indian culture is better at handling ambiguity and uncertainty than is Japanese culture, which encourages strict codes of conduct and behavior. For diversity innovation in a country like India, a low score on uncertainty avoidance may be an essential cultural trait.

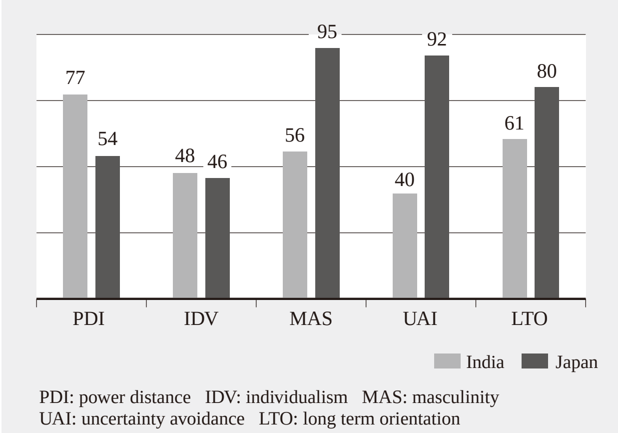

Fig. 4—Comparison of India and Japan Using Hofstede's Criteria.
Uncertainty avoidance appears to be the key difference when comparing the national cultures of India and Japan.

CONCLUSIONS

This article has described the issues facing research and development of social infrastructure in India, and how Hitachi is active in this field.

Businesses considering entry to the social infrastructure market in India need to consider diversity innovation, which means redesigning systems to support multiple stages of infrastructure evolution rather than merely adapting them to the conditions. This redesign must focus on meeting the diverse requirements of the Indian market through a common platform that supports mass customization, immunity to operating environment, and an interface suitable for use by diverse user groups.

To ensure that its research and development can continue to innovate in ways that match the market's diversity, R&D Center of Hitachi India Pvt. Ltd. is seeking to recruit talented local researchers with a thorough understanding of the variety of regions and markets that make up India.

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Market Trends in Brazil and Hitachi's Business Strategy

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Masako Inokuchi
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OVERVIEW: Although the Federative Republic of Brazil suffered from hyperinflation and external debt problems during the 1980s and 1990s, inflation was finally overcome through the adoption of the "Plano Real" in 1994, whereby the nation's currency, the Real, was linked to the US dollar (a floating exchange rate was subsequently adopted in 1999). Since then, Brazil has enjoyed sustained economic growth, backed up by its extensive natural resources, population, and land area. Hitachi has been doing business in Brazil for more than 70 years, starting with the export of a turbine and generator for the Macabu Hydro Power Plant in 1939, and the establishment of a Brazilian Office in 1940. Entry into the Brazilian market by group companies has further picked up pace since 2010. Also, Brazil was identified as one of 11 nations targeted in the group-wide New Globalization Plan launched in FY 2010, and Hitachi has stepped up its business operations in the country through measures such as holding Brazil Hitachi Exhibition encompassing all group companies.

INTRODUCTION

MORE than 10 years have passed since Goldman Sachs, a large US financial company, coined the term "BRICs" in the 2000s to refer to the fast growing economies of Brazil, Russia, India, and China. Although growth in the economy was slowed by the financial crisis of 2008, it has since recovered thanks to robust consumer demand.

With Federative Republic of Brazil due to host a series of large national-scale events, including the "Rio+20" United Nations Conference on Sustainable Development in June 2012, the FIFA* World Cup in 2014, and the Rio de Janeiro Olympics in 2016, the next 10 years have been called "Brazil's Golden Decade." It is anticipated that these events will lead to further economic growth through public investment in transportation networks, electric power, and water and sewage infrastructure, as well as through strong consumer demand.

This article reviews Hitachi's history in Brazil as well as its latest activities.

SITUATION IN BRAZIL

From the 1980s to the early 1990s, Brazil was a heavily indebted nation that suffered from a devalued currency and hyperinflation, with the annual inflation rate reaching as high as several thousand percent. As a result, many Japanese companies were forced to withdraw from the market.

Fortunately, a turnaround in the nation's economy was achieved in the early 1990s through policies that included the Plano Real, public sector job cuts, tax increases, and the privatization and sale of state enterprises. This led to the repayment of debt to the International Monetary Fund (IMF) being completed ahead of schedule in 2005. Brazil also actively pursued international investment in the privatization of state enterprises and encouraged the growth of domestic industry.

Recent years have seen an expanding trade surplus due to steady growth in exports, economic liberalization, and liberalization of foreign exchange. These factors have functioned to increase per capita purchasing power in such a way that domestic demand has driven the state of the economy. This has manifested in the nation's annual gross domestic product (GDP) growth, which remained positive for most of the period since 2000 and reached a new high of 7.5% in 2010. This was the seventh GDP in the world in 2010.

Despite these favorable conditions for the Brazilian economy, GDP growth in 2011 was only 2.7% according to figures released by the Instituto Brasileiro de Geografia e Estatística (IBGE) in March 2012, significantly down on the previous year. This is believed to be a consequence of the European debt crisis and a loss of industrial competitiveness due to the high value of the Real. Despite this, the IMF is forecasting 3.0% growth in 2012 and the nation's

* FIFA is a trademark of Fédération Internationale de Football Association (FIFA).

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economy is on a slowly recovering trend due to policies such as cuts in the key interest rate (8.0% as of July 2012) by the Banco Central do Brasil since August 2011 and measures by the government aimed at bringing down the value of the currency. Moody's Investors Service, Inc., a rating agency, commented in January 2012 that there was the potential for an upgrade in the nation's credit rating to Baa1 at the end of the year provided certain conditions were satisfied. These included, (1) that the situation surrounding the European debt crisis became clear and the crisis would not have a large impact on Brazil, and (2) President Rousseff could achieve a more efficient and less corrupt government that can manage the nation's finances in accordance with the government's targets while also maintaining social policies.

In terms of political developments over recent years, the nation inaugurated its first ever female President, Dilma Rousseff, in 2011. Key issues facing the nation include: (1) Improving the quality of public education, (2) Provision of transportation infrastructure, (3) Improvements in the investment climate, including security measures and the taxation system, (4) Better financial management, and (5) Control of inflation and currency policy (see Fig. 1).

HITACHI'S HISTORY IN BRAZIL

Hitachi has long had business activities in Brazil and other parts of South America. Hitachi Brasil Ltda. celebrated its 70th anniversary in 2010 and the Brazil Hitachi Exhibition was held in 2011.

Activities in 1940s and Earlier

After receiving an order for a 3,300-kW Pelton water turbine for the Macabu Hydro Power Plant in 1939, Hitachi opened a Brazilian office in the following year (making it Hitachi's second oldest overseas office, after India). This order is recognized as being the first turnkey contract for export of an industrial plant from Japan. The turbine earned an excellent reputation, leading to a subsequent order for an additional unit and also the commencement of exports of telephones and exchanges.

Activities up to Recent Past

Another turbine and generator were exported for the Macabu Hydro Power Plant in 1950. This was Hitachi's first export contract for South America in the post-war era. Hitachi's activities expanded in the 1960s to encompass electric power, transportation, computing, and consumer products.

The flourishing of Brazil's steel industry in the 1970s on the back of government policy also led to an expansion of Hitachi's steel industry business. Hitachi (currently Hitachi Appliances, Inc.) also established a manufacturing plant in 1972. This plant was Hitachi's first in Brazil that is still in operation. Hitachi High-Technologies Corporation also established a plant in the same year.

Like many other Japanese corporations, the Hitachi's business activities in Brazil shrunk during the 1980s due to factors such as the debt crisis and hyperinflation. In the 1990s, however, Hitachi Data Systems Corporation, Hitachi Medical Corporation, and Clarion Co., Ltd. set up sales operations in Brazil one after the other. This business expansion continues with Hitachi Koki Co., Ltd. having set up a sales office in 2010, and Hitachi Kokusai Electric Inc. and Hitachi Construction Machinery Co., Ltd. having set up manufacturing plants in 2011 (see Fig. 2 and Table 1).

Overview of Federative Republic of Brazil in 2010

Population	190 million
Land area	8,510,000 m^2
GDP	\$US2.14 trillion
Per capita GDP	\$US11,089
Growth rate	7.5%
Balance of trade	\$US20.1 billion
Foreign exchange reserves	\$US287 billion
Number of Japanese companies	350

GDP rankings (2010)
1 USA
2 China
3 Japan
⋮ ⋮
7 Brazil
⋮ ⋮
10 India
11 Russia

GDP: gross domestic product

Annual GDP growth (%)

Year	Growth (%)
2000	4.3
2001	1.3
2002	2.7
2003	1.1
2004	5.7
2005	3.2
2006	4.0
2007	6.1
2008	5.2
2009	−0.3
2010	7.5
2011	2.7

Fig. 1—Macro Overview of Federative Republic of Brazil.
This macro overview of Brazil is for 2010 and is based on figures from the Japan External Trade Organization (JETRO)[1]. The annual GDP growth rate figures are from Instituto Brasileiro de Geografia e Estatística and are current as of 2012[2].

Fig. 2—Main Hitachi Products in Brazil.
These are some examples of the main Hitachi products in Brazil.

Hitachi's main businesses in Brazil at present include air conditioning equipment, storage and servers, car parts, electronic equipment, and high function materials.

NEAR-TERM OUTLOOK FOR HITACHI BUSINESSES

To accelerate the global deployment of its Social Innovation Business, which supplies social infrastructure supported by highly efficient and reliable information and telecommunications systems technology, Hitachi embarked on the development of its group-wide New Globalization Plan in 2010. This plan identified 11 key regions as likely to experience growing demand for the sort of Social Innovation Businesses to which Hitachi has dedicated itself. Brazil is one of these. In addition to strengthening its business development and global sales support and engineering functions, Hitachi is also working on establishing strategic partnerships to provide a platform for an approach that takes account of local needs.

Brazil Hitachi Exhibition

In October 2011, Brazil Hitachi Exhibition with a theme of "New Solutions for Better Business" was held in São Paulo and the Federal District of Brasília.

TABLE 1. Hitachi Group Companies in Brazil
Currently 10 Hitachi group companies have operations in Brazil.

	Company name	Established (year)	Business activities
1	Hitachi Brasil Ltda. (SAOHI)	1940	Marketing and sales support
2	Hitachi Air Conditioning Products Brasil Ltda.	1972	Production and sales of air conditioning and refrigeration equipment
3	Hitachi High-Technologies do Brasil Ltda.	1972	Import/export and agency business for electrical products, industrial machinery, and communication equipment
4	Hitachi Data Systems Computadores do Brasil Ltda.	1992	Import, sales, and servicing of storage products
5	Hitachi Sistemas Médicos do Brasil Ltda.	1999	Sales and maintenance of medical equipment
6	Clarion do Brasil Ltda.	2000	Import, sales, and servicing of car audio and navigation systems
7	Hitachi Koki do Brasil Ltda.	2010	Import and sales of electric power tools
8	Hitachi Kokusai Brasil Produtos e Serviços Eletricos Ltda.	2011	Consulting on broadcast cameras and related businesses
9	Hitachi Kokusai Linear Equipamentos Eletrônicos S/A	2011	Production and sales of electronic devices (mainly broadcast transmission systems)
10	Deere-Hitachi Màquinas de Construção do Brasil S.A.	2011	Import, production, and sales of hydraulic shovels

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Fig. 3—Scene from Brazil Hitachi Exhibition.
The Brazil Hitachi Exhibition held in October 2011 was the first group-wide exhibition for Hitachi companies in the Southern Hemisphere.

Fig. 4—Seminar at Brazil Hitachi Exhibition.
The seminars included one on cloud computing presented by staff from Hitachi Data Systems Corporation.

In addition to being part of the New Globalization Plan, this was the first time such a group-wide exhibition had been held in the Southern Hemisphere.

The exhibition featured a keynote address by a leading Brazilian journalist and exhibits of more than 40 products by numerous Hitachi group companies from Japan and America, including the 10 group companies with operations in Brazil listed above. Seminars were also conducted by Hitachi staff on seven topics: transportation, oil and gas, smart grids, education solutions, cloud computing, terrestrial digital broadcasting, and electric power tools. The exhibition was attended by a large number of people including senior management from Brazilian companies, senior government officials, representatives from Japanese companies, and embassy staff. The opening ceremony featured a guest speaker and a ribbon cutting. The benefits of the exhibition included building new relationships and strengthening partnerships between Hitachi and the people who attended the exhibition, and giving the visitors a deeper appreciation of Hitachi products by presenting a wide range of them using samples and display panels (see Fig. 3 and Fig. 4).

Examples of Recent Progress in Brazil

In 2011, Hitachi Kokusai Electric Inc. conducted a friendly takeover of Linear Equipamentos Eletrônicos S/A, a major Brazilian manufacturer of broadcast communications equipment, to form Hitachi Kokusai Linear Equipamentos Eletrônicos S/A. The size of the market for digital broadcast transmitters in Brazil over the five year period until 2016, when the transition to terrestrial digital broadcasting is scheduled to complete, is estimated at more than 50 billion yen. Linear Equipamentos Eletrônicos S/A had the largest share of the market for digital transmitters in FY 2010 (approximately 30%), and its target for FY 2016 is to expand sales by more than four times to achieve a market share of more than 50%.

Meanwhile, Hitachi Construction Machinery Co., Ltd. also established Deere-Hitachi Màquinas de Construção do Brasil S.A. in 2011, a joint venture with Illinois-based Deere & Company of the USA to produce and market hydraulic shovels. Hitachi Construction Machinery will supply its world-leading hydraulic shovel technology to the joint-venture, which will manufacture the machines locally. Marketing will be handled by Deere & Company, which has a well-established presence in the Brazilian market for agricultural equipment.

Since the two companies established a joint-venture manufacturing and sales company in North Carolina, USA in 1988, Hitachi Construction Machinery Co., Ltd. and Deere & Company have built up an important partnership in North, Central, and South America. This new joint venture in Brazil will allow the two companies to pursue further long-term growth opportunities.

FUTURE BUSINESS STRATEGY AND PROSPECTS

With Brazil due to host the 2014 FIFA World Cup and the 2016 Rio de Janeiro Olympics, it is anticipated that these events will bring extensive business opportunities, including event broadcasting and investment in infrastructure such as roads and other forms of transportation, electric power, ports, and airports. The provision of railway networks at the venues in time for these major events has become an urgent task, and the construction of environmentally conscious urban transportation systems in the nation's cities, including use of high-speed trains, is under consideration. In the case of high-speed trains, Hitachi is a member of a Japanese consortium (which also includes Mitsubishi Heavy Industries, Ltd., Toshiba Corporation, and Mitsui & Co., Ltd.). In the field of urban transportation, meanwhile, Hitachi is seeking to enter the market through the development of lightweight, low-cost monorail systems. Progress is being made on working with a Brazilian partner to establish local operations in readiness for monorail and other railway projects.

Also, a series of offshore oil and gas fields have been discovered in Brazil, primarily off the coast of Rio de Janeiro. The government is planning investment of more than 20 trillion yen in the period up to 2016, with the aim of developing the "pre-salt" oil reservoirs located below underground rock salt beds under the sea floor, which is itself more than 2,000 m deep. In addition to bringing together the capabilities of the entire group to offer total solutions, Hitachi is also expanding its businesses that focus on maintenance and other services as well as the supply of components. This includes Hitachi Plant Technologies, Ltd. and Mayekawa MFG. Co., Ltd. proceeding with the establishment of a maintenance and sales base for compressors.

CONCLUSIONS

This article has reviewed Hitachi's history in Brazil as well as its latest activities.

Brazil is recognized as an important market with expanding business opportunities, with growth anticipated not just in the infrastructure and consumer fields, but also in many other sectors such as mining and agriculture. In the future, while Hitachi has plans for business expansion in a range of different areas, it intends to focus initially on expanding its Social Innovation Business, which includes information and telecommunication systems, power systems, and railway systems, and its other core businesses such as air conditioners.

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Hitachi's Business Strategy in Russian Market

Dmitry Litovskikh, Ph.D.

OVERVIEW: In May 2012, Hitachi celebrated the 30th anniversary of its doing business in the Russian Federation. Hitachi, Ltd. Moscow Office was established on May 12, 1982. Its original function was to pioneer the market and create new business. Since that time, a number of Hitachi Group companies have established their own offices in Russia and CIS countries, and others are doing business through their distributors, which they manage from Japanese or European headquarters. High oil prices have been keeping the Russian economy steady and growing. A recent focus of the Russian government has been on innovative social projects, and it has initiated a number of high-profile projects in the past few years, including Skolkovo City, the APEC Russia 2012 summit in Vladivostok, Sochi 2014 Olympics, and 2018 FIFA World Cup Russia.

INTRODUCTION

THE Russian Federation is a fast growing country with significant gas and oil reserves, a territory of about 17 million km^2 (roughly 45 times that of Japan), and a population of about 143 million people. Russia is ranked number one by proven gas volume, and has a 28% share (50 trillion m^3) of world gas resources. Russia's territory extends from Europe to Asia and the country offers a unique combination of business possibilities as well as opportunities to participate in the development of a country-wide infrastructure.

Russian gross domestic product (GDP) growth in 2011 was steady at 4.3%, one of highest among Group of Eight (G8) member states. Russia's industrial production index grew by 8.2% in 2010 and 4.7% in 2011. The inflation rate of 6.1% is the lowest it has been for several years, and the government continues to target a reduction in inflation to 4%. At $US514 billion, Russia's foreign exchange reserves are the forth highest in the world after China, Japan, Saudi Arabia, and they helped maintain the stability of the Russian national economy during the recent global financial crisis.

The Russian economy is making extensive efforts to become better connected with the rest of the world.

Russia signed the final protocol to join the World Trade Organization (WTO) in Geneva in December 2011 and expects to achieve membership in mid-2012. A customs union signed between Russia, the Republic of Kazakhstan, and the Republic of Belarus in 2010 has eliminated the need for customs clearance for goods traded between these three countries. In November 2011, the presidents of the Commonwealth of Independent States (CIS) countries signed an agreement to simplify internal CIS trade operations in order to create a basis for a free trade zone. This will boost further development of Russia and neighboring countries. Meanwhile, there are plans to establish a Eurasian economic union by 2015.

To support development of new innovative industries, the Russian government introduced an "Economic Modernization Program" focused on energy efficiency, healthcare, space and communications, information technology (IT), and nuclear energy.

TABLE 1. Examples of Ongoing Infrastructure Projects in Russian Federation

These projects are suitable candidates for Hitachi's social infrastructure approach. The Russian Federation has a big demand for power equipment, water treatment, construction equipment, healthcare, and information technology (IT) infrastructure.

Year	Project name
2012	APEC summit (Vladivostok)
2013	Universiade (Kazan)
2013	Asia Pacific Parliamentary Forum (APPF) (Vladivostok)
2014	Skolkovo—innovative city (Moscow)
2014	Sochi Olympics (Sochi)
2014	Formula 1*1 Grand Prix (Sochi)
2014	G8 Summit (Moscow, Skolkovo)
2018	FIFA*2 World Cup (several cities)
–	New Moscow (expansion of Moscow territory)
–2025	Program of the Development of the Far East
–2025	Development of the Arctic Transport Route

APEC: Asia-Pacific Economic Cooperation G8: Group of Eight

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*2 FIFA is a trademark of Fédération Internationale de Football Association (FIFA).

During the last few years, the Russian government has launched a number of national infrastructure projects (see Table 1).

Elsewhere, various industries have their own significant infrastructure projects, usually led by state-owned corporations in the oil and gas, power, transportation, healthcare, banking, and other industries.

This article describes the state of the Russian economy and Hitachi's business activities in that country.

RUSSIA STRATEGY

Established in 1982, Hitachi, Ltd. Moscow Office celebrated its 30th anniversary in May 2012. Over that period, nine other Hitachi Group companies have established their own offices (see Table 2).

The overall objective of Hitachi Moscow is to help the Hitachi Group achieve its target of raising the ratio of overseas revenue above 50%. Hitachi Moscow covers the CIS and Russia, and its strategies are based on both territorial and product expansion.

Territorial Expansion

In seeking to expand the geographical scope of its business activities, Hitachi's initial focus is on the Kazakhstan market. In 2011, Hitachi appointed representative person for Kazakhstan to support an ongoing H-25 gas turbine project and to create a basis for new Hitachi businesses.

Kazakhstan is an oil rich country with proven oil resources ranked ninth in the world. It has a population of about 16.7 million and its economy is the most stable of all the CIS countries. GDP grew by 7.5% in 2011 to reach $US186 billion. Kazakhstan also has significant mineral resources, being among the top three nations in the world for zinc, lead, copper, silver, molybdenum, and rare earth metals, and having 21% of the world's uranium resources. Another important industry is coal, which includes large opencast coal mines and coal-fired power plants. The Kazakhstan government is undertaking a variety of infrastructure projects where it recognizes Hitachi's ability to assist in numerous different fields.

After Kazakhstan, Hitachi's next focus is on the Ukrainian market, which has a population of about 45.6 million and GDP growth of 5.2% in 2011. Key national industries are iron ore mining, steel making, and coal. Ukraine is a member of the Kyoto Protocol and is keen to introduce green and energy-efficient technologies for power, transportation, and social infrastructure.

Hitachi's Product Expansion

To open up new markets for Hitachi products, Hitachi Moscow assists group companies to establish new businesses in Russia, taking an approach that is based on developing customer-oriented complex solutions (see Fig. 1).

In the past few years, Hitachi Moscow has helped establish a number of new businesses in Russia and the CIS.

RECENT NEW BUSINESS DEVELOPMENTS

In spite of the financial crisis, Hitachi Group companies continue to develop new business in Russia (see Table 3). The following are some examples:

One example of a major new business is the card reader and cash recycling automatic teller machine (ATM) business established by Hitachi Omron Terminal Solutions, Corporation in 2011. This was the first time a cash recycling ATM had been used in the Russian market, and Hitachi Omron Terminal Solutions, together with its global partner has received certification for these activities from the Russian Central Bank. The first ATM equipped with a Hitachi finger vein authentication module will be delivered to Gazprombank in 2012. Gazprombank is the third largest bank in Russia.

TABLE 2. Hitachi Offices in Russia

Usually most Hitachi Group companies start doing business through local partners, which they manage from Japan or Europe. Once the business becomes established, this is followed by registering a representative office with local staff to create a local legal entity.

	Company name	Legal status
1	Hitachi, Ltd. Moscow Office	Representative office
2	Hitachi Construction Machinery Co., Ltd.	Representative office
	Hitachi Construction Machinery Eurasia Sales LLC	Legal entity
	Hitachi Construction Machinery Eurasia Manufacturing LLC	Legal entity
3	Hitachi Power Tools Netherlands B.V.	Branch office
	Hitachi Power Tools RUS L.L.C.	Legal entity
4	Hitachi Home Electronics	Representative person
5	Hitachi Data Systems GmbH	Legal entity
6	Hitachi Air Conditioning Europe SAS	Representative office
7	Hitachi Solutions, Ltd.	Representative person
8	Hitachi High-Technologies Corporation	Representative office
9	ZAO-Hitachi Svetlana Power Electronics	Joint venture
10	Hitachi Aloka Medical, Ltd. Moscow Office	Representative office
11	Hitachi, Ltd. (Almaty, Republic of Kazakhstan)	Representative person

Fig. 1—Hitachi, Ltd. Moscow Office Business Development Concept for Supporting Hitachi Group Companies.
Hitachi, Ltd. Moscow Office provides support and consulting for Hitachi Group companies from when they first enter the Russian market, including market investigation, identification of potential partners, local product certification, and the establishment of a local office.

Another example from the medical field is the planned start in 2012 of a linear accelerator made by AccSys Technology, Inc. of the USA, a Hitachi Group company, at the Bakoulev Center for Cardiovascular Surgery in Moscow. The linear accelerator will be used for positron emission tomography (PET). A project for a proton beam therapy (PBT) center in Russia is also in progress.

Taking a complex approach, Hitachi Moscow creates projects in the power sector (smart grids), social infrastructure (smart cities and water solutions), oil and gas, healthcare (PBT and PET), IT, automotive businesses, and other industries.

Hitachi Moscow has developed good relations with Russian national companies like Open Joint Stock Company Gazprom [oil and gas projects, including technical cooperation on mini liquefied natural gas (LNG) plants and equipment for pipelines], Federal Grid Company of Unified Energy System (FSK) and MRSK Holding (the national transmission and distribution companies), Skolkovo City and Moscow City administrations (smart city projects), regional governments, and federal ministries.

Cooperation with Gazprom

Russia's largest national gas company, Gazprom has an 18% share of the world's proven gas resources and operates approximately 161,000 km of gas pipelines. It has a special focus on the development of LNG plants. Gazprom's current share of world LNG production is 5%, and this figure continues to grow.

Technical cooperation between Hitachi and Gazprom includes the oil and gas industry and energy efficiency solutions. In November 2011, a delegation of 17 Gazprom people visited Japan for a regular meeting between Hitachi and Gazprom engineers. Gazprom is keen to cooperate on pipeline diagnostic and monitoring systems, mini LNG plants, gas turbines, and energy-efficient technologies.

Participation in Far East Development Program

In 2009, the Russian Government approved a social-economic strategy for the development of the Far East and Baikal territories until 2025. The Far East (about 36%) and Baikal region (about 9%) makes up about 45% of total Russian territory. Although the region is rich in natural and mineral resources, its low population density and under-developed infrastructure are a bottleneck to further growth. In the past, local people have left their native regions for the European part of Russia to find better working and living conditions. Nowadays, about 8% of the country's population lives in the Far East. To boost development in the Far East, the government has decided to provide extensive support through a number of projects. Through this strategy, government may spend up to $US230 billion by 2025, including infrastructural and industrial projects by national companies like Gazprom.

Hitachi has a special focus on this region, and, in 2012, participated in the promotion of smart grid and energy efficiency solutions for the Asia-Pacific Economic Cooperation (APEC) summit.

Table 3. Examples of Major New Business in Russia
Hitachi Group companies in Russia are embarking on new business in a variety of fields.

Company	Major activities
Hitachi Industrial Equipment Systems Co., Ltd.	Commenced sales and deliveries of electric screw air compressors in 2011.
Hitachi-Omron Terminal Solutions, Corporation	Established business in card readers and a cash recycling automatic teller machine in 2011.
Hitachi Solutions, Ltd.	Appointed a person in Moscow to support its satellite imaging business in September 2011.
Hitachi, Ltd.	Together with a Russian partner, Hitachi, Ltd. supplies electric traction equipment for metro trains used by the Sofia Metro (Bulgaria).
Hitachi Plant Technologies, Ltd.	Markets centrifugal compressors to gas & oil and chemical companies. In March 2012, received an order for six compressors for Rosneft.
AccSys Technology, Inc.	A linear accelerator for the positron emission tomography (PET) center at the Bakoulev Center for Cardiovascular Surgery in Moscow is scheduled to commence operation during 2012.
Hitachi, Ltd.	Promoting a proton beam therapy (PBT) center project in Russia.

Cooperation with FSK

In April 2012, Hitachi signed a cooperation agreement with FSK (see Fig. 2). FSK operates 121,700 km of transmission lines and 856 substations with voltages ranging from 35 to 1,150 kV. The agreement involves Hitachi increasing its cooperation in smart grid technologies, energy management systems (EMSs), distribution management systems (DMSs), switchgear, amorphous transformers, high-temperature cables, high-voltage direct current (HVDC), static synchronous compensator (STATCOM), and other fields.

Hitachi Construction Machinery Excavator Factory in Tver

Hitachi Construction Machinery Co., Ltd. entered the Russian market in 1978 and established a representative office in Moscow in 1992. In April 2010, the company established a sales office (a legal entity). One year later, in April 2011, Hitachi Construction Machinery Eurasia Manufacturing LLC was established in the Tver region (150 km from Moscow on the way to Saint Petersburg) (see Fig. 3). Seven months later, in November 2011, Hitachi Construction Machinery began construction of its Russian factory, which will start production in 2013 with an annual capacity of 2,000 excavators.

Skolkovo and New Moscow Projects

Skolkovo is a new innovative city linked to Moscow that will be built on a greenfield site. The planned population is about 27,000 people and the area under development is 4,000,000 m^2. The budget allocated for the first phase is around $US3 billion. The concept behind Skolkovo City is to create a scientific cluster, housing residents from foreign companies with a research and development focus. Hitachi is promoting a smart city solution, including

Fig. 2—Meeting with FSK in Japan.
Hitachi will support Federal Grid Company of Unified Energy System (FSK) on new projects, especially innovative smart grid technologies that increase the efficiency of the power grid and minimize power losses.

Fig. 3—Groundbreaking Ceremony in Tver, Russia.
By establishing a local factory, business in the Russian market will be strengthened.

Fig. 4—Map of New Moscow and Skolkovo.
Moscow consists of Moscow City (managed by the city mayor) and Moscow Region (managed by a governor). New Moscow includes land from Moscow Region, which was added to the territory of Moscow City. The map shows how Skolkovo is located near the old Moscow border.

a smart grid, water infrastructure, and transportation solutions.

In 2011 the Russian government decided to expand the territory of metropolitan Moscow, drawing on experience from Skolkovo Smart City. Moscow in its current form is an overcrowded city of 11.6 million people that suffers from extreme traffic jams. Major companies and affluent residents prefer to have offices or apartments in the city center. To relocate residents and traffic away from the center, the government decided to increase the area of Moscow City and move some government offices and financial institutions to a suburban area called "New Moscow." This will increase the area of Moscow City by 2.4 times and represents a new phase of extensive development for the city (see Fig. 4).

Brand Campaign

To increase awareness of the Hitachi brand, Hitachi undertakes brand campaigns in the Russian market. Advertisements that promote infrastructural, construction, and IT solutions are placed in the most popular business newspapers and magazines, on web sites, and in buildings.

CONCLUSIONS

This article has described the Russian economy and given an overview of the current business activities of Hitachi. A number of Hitachi companies have already established offices in Russia, and others are doing business through their local partners and distributors.

The stability of the Russian market is based on rich natural resources. At the same time, the government has undertaken a number of programs to support the modernization of the national economy. These programs are aimed at introducing innovative technologies in various fields, including energy efficiency solutions, improvements to healthcare, development of stable financial institutions, modernization of social and industrial infrastructure, and the creation of innovative centers for research and development like the Skolkovo City project.

Hitachi, Ltd. Moscow Office together with the International Strategy Division will continue their strong collaboration with Hitachi Group companies to provide a window into support for business development in Russia and CIS countries.

ABOUT THE AUTHOR

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