Toward Railway Innovation

Ascent

Railway Technical Research Institute

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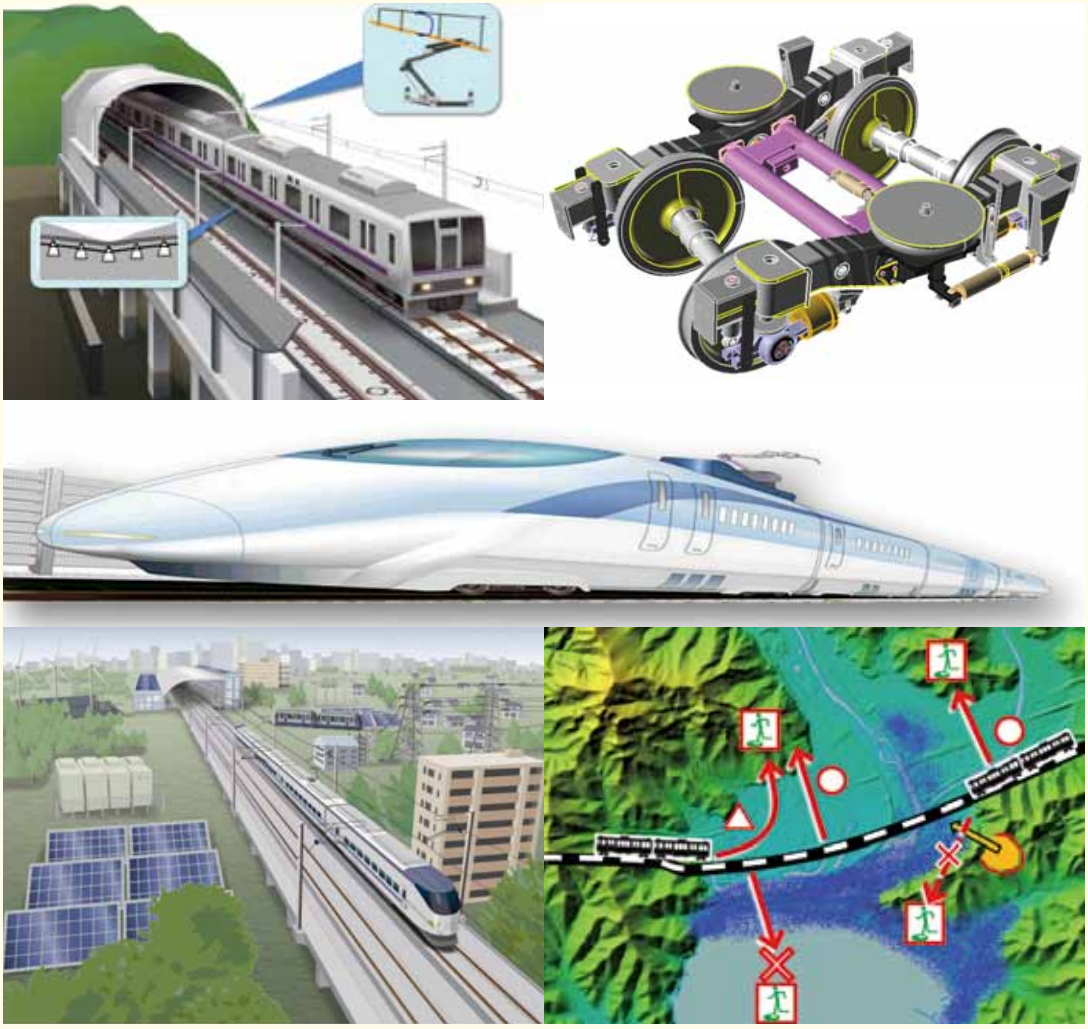

Both RTRI and Hitachi have a history of over 100 years. RTRI's predecessor organization, the Railway Investigation Center of the Imperial Railway Agency was established in 1907, and Hitachi was founded in 1910.

RTRI has described its vision as "develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society" and Hitachi's mission statement is "contribute to society through the development of superior, original technology and products."

RTRI took the initiative in technical development of the world's first high-speed railway Shinkansen and laid the foundation for the rapid development of high-speed railways around the world. Later on, RTRI has been addressing complicated phenomena in wide-ranging technical fields of railway systems with analytical approaches and contributing the improvement in railway's safety and operational efficiency by providing solutions to them.

In the meantime, Hitachi has been constantly engaged in manufacturing railway products such as electric locomotive from the early days. In developing Shinkansen, it has also contributed to the success of Shinkansen

by manufacturing AC power feeding systems and vehicles for Shinkansen. Furthermore, as a general electric manufacturer, Hitachi has accumulated a wide range of element technologies covering electronics, mechanical engineering and information and communications and integrated them into railway vehicles, operation control systems such as COMTRAC, Computer Aided Traffic Control System, signaling systems, and seat-reservation systems, what we call MARS, Multi Access seat Reservation System. By providing these products and systems to railway operators, Hitachi has also been playing a key role in achieving the safety and efficiency in today's railway operation.

RTRI and Hitachi have been cooperating with each other in many fields of significant technical developments including Shinkansen technologies and MAGLEV, the Magnetically Levitated train systems, and the two companies have potentials to produce further synergy effects through combining their strengths.

RTRI and JR companies have celebrated the 30th anniversary of privatization this year. On this milestone opportunity, we have planned a top-leader meeting of Hitachi and RTRI with the theme "Building the Future of Railways."

At this meeting, their talks extend from the values of safe and high-quality railways, the impacts of the information revolution, the railway research and development for the year 2050 and the energy optimization for the entire society, and both leaders communicate the concept that connecting people by railways will contribute to the society. We hope their talks will interest all the readers.

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Building the Future of Railways

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4/2007	Vice President and Executive Officer of Hitachi, Ltd.
4/2008	President of Hitachi Power Europe GmbH
4/2010	Representative Executive Officer, President and Chief Executive Officer of Hitachi Plant Technologies, Ltd.
6/2010	President and Representative Director of Hitachi Plant Technologies, Ltd.
4/2011	Vice President and Executive Officer of Hitachi, Ltd.
4/2013	Senior Vice President and Executive Officer of Hitachi, Ltd.
4/2014	Representative Executive Officer, President & COO of Hitachi, Ltd.
6/2014	Director, Representative Executive Officer, President & COO of Hitachi, Ltd.
4/2016	Director, Representative Executive Officer, President & CEO of Hitachi, Ltd. (currently in office)

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7/1995	General Manager, High-Speed Rail Project, RTRI
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4/2009	Executive Director in charge of Business Promotion, RTRI
7/2011	Vice President in charge of R&D, International Affairs and Planning, RTRI
6/2013	President, RTRI (currently in office)

History of Railway Technology Development

RTRI in these 30 years

Kumagai: Due to the privatization and breakup of the Japanese National Railways (JNR) in 1987, the Railway Technical Research Institute (RTRI) was founded on December 10, 1986 and started operations as a research institute on April 1, 1987. Our mission is to conduct comprehensive research and development, and investigation of railway technologies and railway labor science, covering everything from basics to applications. We also took over the technological development of a superconducting magnetically levitated transportation system from JNR. One thing certain is that we collaborated with the six Japan Railway Companies and the Japan Freight Railway Company all the time.

The needs of the railways in the past 30 years resulting from social needs included the speedup of Shinkansen and conventional railways, and high-density train control as a means for reinforcing the transport capacity of urban railways. Other needs included cost reductions, particularly maintenance costs, which were driven by the need for management stabilization of the JR companies.

RTRI's rolling stock test stand has contributed to speed increase of Japanese railways

Just after privatization, the JR companies refrained from introducing newly manufactured cars in order to ensure management stabilization. However, they soon adopted a positive management stance in view of the strong Japanese economy at the time. This led to the policies for speeding up trains to gain a competitive edge against other means of transportation.

RTRI studied a wide range of underlying technologies for speedup, meeting many challenges such as running safety of rolling stock, reduction of aerodynamic noise, improvement of tracks, and advanced technologies for overhead contact lines. I myself served as the leader of a speedup project in RTRI.

On the other hand, there was a significant change in the efforts for improving safety due to the 1995 Hyogoken-Nanbu Earthquake. Fortunately, it struck before the first Shinkansen train of the day departed. However, I felt keenly the need to find ways to cope with natural threats when I saw that viaducts had actually collapsed. It became an opportunity to reconsider the efforts that we made in the past to improve safety.

Due also to other railway accidents such as those on the Fukuchiyama and Hibiya lines, we became aware that safety must always come first in railway technologies and that there must not be any lack of focus in our efforts for maintaining safety. Our recent challenge is to build up robust railways against natural disasters including strong winds and heavy rains.

Hitachi and railway

Higashihara: Hitachi started out with production of rolling stock such as electric locomotives and then developed various informatics systems such as the Multi-Access Reservation System (MARS) system for seat reservations and the traffic control system, based on specifications determined under the guidance of the JR group. I myself took direct charge of and got myself deeply involved in a system that you mentioned just now, a transport operation control system in the Tokyo metropolitan area, called Autonomous Decentralized Transport Operation Control System (ATOS). I put all my efforts into it. Later, Hitachi teams were also in charge

of smart card tickets and Suica cards (Super Urban Intelligent Card). In this sense, we walked hand-in-hand with the JR group these 30 years.

At Hitachi, we use the term SQDC (Safety, Quality, Delivery time, and Cost). Safety comes first and is invariably important, followed by quality and delivery time, and cost comes last. We at Hitachi have been trained to observe this order of priority. Another lesson I learned when I was in charge of ATOS is the concept or philosophy of safety through the "control" of railways, which starts with interlocks and ends with protective devices. I learned a lot from systems focused on safety, which were totally different from other systems. Of course, in the age of computers, we have technology architectures that ensure the reliability of computers such as redundant designs as seen in computers at banks.

However, the concept of safety used for railway systems seems to be exceedingly good. In particular, ATOS was an autonomous decentralized system. Even if it fails at one station, it can continue normal operations at other stations, and when the failure is fixed, it regains health. This system is based on an analogy to an ecosystem that has adopted an autonomous decentralized system that heals on its own when it gets injured. Another important thing about ATOS was that it took 20 years since 1996 to introduce the system to the major lines in the Tokyo urban area. This system was a distributed type also in the sense that it was enlarged in incremental steps. It seems to me that this distributed introduction was a good way to diversity risks, ensure control responses, and phase in a system. I can summarize my past 30 years as constant learning about safety and system development from the JR group.

RTRI's large-scale shaking table is capable of simulating seismic-intensity-7-level earthquake shaking

Autonomous Decentralized Transport Operation Control System of JR East (courtesy of JR East)

Technology inheritance and explicit knowledge

Kumagai: I agree that all of us should remember to give safety top priority. On that note, I feel concerned that some of the technologies required to maintain safety are not stored as written information right now. Such technologies are conveyed from person to person as empirical knowledge at present but, for the future we must devise a means for ensuring that the principles behind them are remembered for a long time to come. I believe that this empirical knowledge must be converted into explicit knowledge and conveyed as such in order to maintain the safety of railways in the future. For this purpose, I think that the trend of digital conversion will play an important role. A trend toward

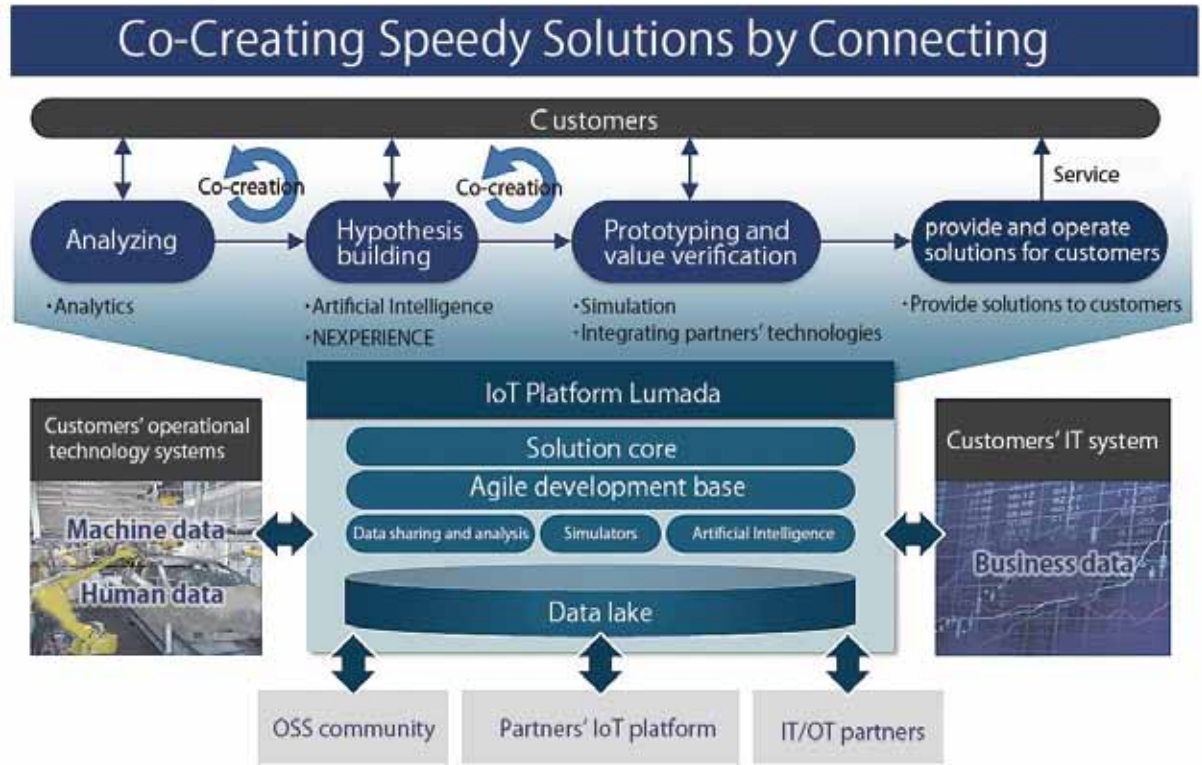
autonomous decentralized systems is taken for granted at present but, previously, concentrated systems were pursued. Like CTC, they were based on a concept that traffic control for trains is performed by a small number of personnel in a concentrated manner. When the systems adapted to the new concept of autonomous decentralized technology, however, they began to use numerical computation of safety parameters based on massive, high-speed data processing technologies.

Higashihara: Over time there has been a trend to repetitiously move from concentration to distribution and vice versa. When we change the architecture, therefore, we need to go back to the point of origin in order to carefully consider various aspects of safety. It is exceedingly important to consider the in-depth examinations made by our forerunners.

Kumagai: For example, we design rolling stock based on certain design criteria. Unless we accurately understand the meanings of values specified in the criteria, we might make mistakes when we change the values out of necessity. Therefore, understanding the meaning of values specified in criteria is also important.

Higashihara: "Externalization" of knowledge is exceedingly important. With a goal of becoming an Innovation Partner for the IoT (Internet of Things) Era in 2018, we at Hitachi have launched an IoT platform named Lumada, which collects Big Data and analyzes it with artificial intelligence to achieve externalization of knowledge. The development of such a platform will enable us to compare the know-how of experts with the behavior of novices to find and understand differences. We need to communicate and describe the world of experts, or rather, master craftsmen, together with their knowledge and skills as numeric values or digital data. In other words, we will progress in the direction (of explicit knowledge) that you mentioned earlier.

IoT platform "Lumada"



Safe and High Quality Railways

Importance of safety and quality

Kumagai: When thinking about future development of railways, one point to consider is how the advantages of railways can be increased. The Shinkansen had its 50th anniversary two years ago. The Shinkansen brought about an innovation in the transport of people. This innovation created not only new rolling stock and signalling systems but also new values of railways. These values were recognized not only in the socio-economic communities in Japan but also outside of Japan. So this technology was propagated to other countries and applied, for example, to the commercial service of TGV and ICE. People used to call railways a mature industry and said that high-speed railways were wasteful, but the Shinkansen shattered such ideas. In other countries, the introduction of high-speed railways is gaining momentum. In particular, the U.K. and U.S.A., where motorization has advanced, showed approval of high-speed railways. We also want to introduce further advanced railways to the world, using new technologies that we will develop. What were the circumstances in which Hitachi delivered a high-speed railway system to the U.K. and what were the requirements demanded by the U.K.?

Higashihara: The delivery of the system to the British railways was a rough passage. We started our sales activities around 2000 and our first cars, Class 395, came into service in December 2009. Nearly 10 years elapsed for this project. However, the Class 395 cars came to have exceedingly high reliability thanks to JR, which provided us with various information including the manufacturing technologies for rolling stock. It is snow-resistant. There were many interesting episodes, such as a case in which only the Class 395 cars were running when all the cars of the other manufacturer stopped. I believe that one of the strengths of Japanese manufacturers is that high priority is given to quality. Now that the IoT technology has advanced this much,

Class395 vehicle of UK

Class 395 cars have sensors on the body, which are collecting all the train status information as Big Data. Using the data, predictive diagnosis is under way to find when a component is likely to fail and whether it should be replaced soon. We have already developed a technology of raising the availability through combined uses of IT (Information Technology) and technologies for manufacturing rolling stock. In the coming age of IoT, we will be able to supply vehicles with high levels of safety and reliability. When IoT is more advanced, even physical security can be ensured by, for example, detection of explosives on board or discovery of passengers who are exhibiting abnormal behaviors.

Kumagai: I think that safety is based on the culture, consciousness, and custom of a country or nation. In addition, there are levels of safety to be maintained, and the same safety level must be maintained by all of the parties involved, including manufacturers of equipment, operators of railways, and research and development personnel. A year after I joined the former Japanese National Railways, I worked as a driver trainee and learned how high a priority was given to safety. The safety system of railways became very apparent to me when a driver drove the train through a station, through a crossing, and down a steep slope. I once wished that there were a system for advancing train safely when a distant signal light was invisible with mist. In this sense, a driver is also a safety checker who stands face-to-face with a safety system. All things including control of a

train or monitoring of the status of rolling stock and tracks are taken into consideration in driving operations. These considerations must be consistent with the principles of automated driving.

Safety in the era of AI (Artificial Intelligence)

Higashihara: I am originally a computer specialist but I don't think computers are panaceas for everything. I believe that, after all, the senses of a driver or the integration of human-based and computer-based systems are essential in improving safety.

Kumagai: Pardon me for going off the track. If artificial intelligence is to be used for automated driving of automobiles, it will give rise to new discussions about such things as how licenses and responsibilities for driving should be. We will need to cope with such issues as whether safety of driving is changed by new technologies and determine the directions for further improving safety.

Higashihara: At present, various IT manufacturers and automakers are performing considerable research on automated driving. It seems to me that the safety concepts developed by JR, i.e., control, interlock, and protection, are something that must be incorporated into automated driving and that development of laws in this regard will also be required. Technologies are also important. It will not be enough only to find a car ahead and calculate appropriate speeds and inter-vehicular distances. We must consider how the protective device should activate if the checking mechanism is broken. Checks performed by a third party will be required. Such systematic approaches still have many elements that must be studied. In this regard, I hope safety technologies for railways will be applied not only to the world of railways but also to the automated driving of automobiles in the future.

Kumagai: Development of artificial intelligence is an effort to give intelligence to machines and make them self-sufficient with pseudo-personalities, isn't it? I envision a world in which machines check each other. There will definitely come a time when computers either have complete control of trains or give support or protection to train control.

Higashihara: Alternatively, robots may be introduced to play a supplementary role for drivers and provide second opinions. That may be a starting point.

Kumagai: If human errors are known to occur at a certain probability, checks performed by machines may help reduce risks of human errors when conducting operations.

Higashihara: Yes, I agree.

Quality from manufacturers' point of view

Kumagai: As a manufacturer, what does Hitachi do to check safety?

Higashihara: We already have a checking system for quality control at a factory. Using a considerable number of installed cameras, the behavior of workers is checked to eliminate unsafe behaviors and ensure quality. Additionally, there is already "image surveillance" or image analysis technology that allows users to compare what old hands and novices do and use the result for training of novices. We will apply this technology although I don't know to what degree. In the case of

automobiles that we mentioned earlier, we can naturally prevent drivers from dozing off by installing a camera onboard. At present, GPS (Global Positioning System) is available to provide a function of sounding a warning beep if the vehicle is not taking a correct route.

Kumagai: I visited your Kasado Works in March 2016. At all the assembly lines, image processing was used frequently to prevent mistakes and automated measurements, and IT technologies were put to great use. Such efforts for improving reliability are improving the quality of Japanese products.

RTRI is also pursuing improvement of quality when working to provide the outcomes of railway technologies. We hope to further enhance the relationship of trust with research institutes, JR, private railways, and manufacturers. However, different organizations and individuals expect varying levels of quality and therefore we think that coordination of these organizations is an important task.

Higashihara: In the future, the Japanese railway technologies will be exported to other countries as one package including things that range from railway vehicles to signalling operations. When the word "quality" is used in such cases, there can be various discrepancies, such as assumption of different levels of quality between Japan and destination countries and, consequently, estimation of different costs. I personally believe that safety must be given top priority for railways and so I am basically against compromising with lower quality. Conversely, we must find a way to help the other party understand the high quality levels of Japan and not to let vehicles and systems be evaluated only by their initial prices or cost. I think that the total life-cycle cost should be used for evaluation, in consideration of how many failures occur after use for several decades. In a case of large package export from Japan, a system of price evaluation should be proposed by us. Otherwise, the true advantages of Japanese products may not be understood.

Kumagai: Regarding our products that are commercialized as a result of research and development, I think we need to describe how we think they should be evaluated not only by considering the initial cost but also the life-cycle cost including maintenance and investment effects.

However, it seems that low cost is often chosen over high quality when Japanese technologies are exported to other countries. I think we will have to show considerable evidence to promote understanding about the importance of quality. Mr. Higashihara, what were the difficulties you had in this regard?

Higashihara: I agree that the prices quoted by the Japanese manufacturers seem higher if only the initial prices are compared. In particular, the production in emerging countries offers lower costs because of economy of scale due to mass production. All is well if all of their products are high-quality and inexpensive but no such luck. We may have to spend five or ten years to achieve proper evaluation of our products but we do not have that much time to spare. In these last five years, I talked with various customers overseas and found that the quality awareness was rising in many countries. Recently, I visited several Asian countries and talked with customers and increasingly more of them said quality was more important after all. This trend is accelerating. I certainly would like to make the advantages of Japan known to the world.

Kumagai: Just after the WWII, Japanese products

WCRR2016 in Milan

were called inferior goods (Laughs). Then, the Japanese companies started to deliver high-quality goods and improved the productivity on their own efforts. I asked myself why this was possible and concluded that the industriousness, high level of education, craving for high quality on the part of the Japanese people were the causes for improving the quality of made-in-Japan products.

Higashihara: We must cherish these characteristics. I would like to publicize good Japanese characteristics such as craftsmanship in manufacturing and meticulous service in the service industry to let overseas customers properly understand and evaluate them.

Toward 2050

What Lies Ahead of Information Revolution

Higashihara: Our IoT platform called Lumada is currently in use for predictive diagnosis but we are considering in-house whether it can be put to more uses. We are thinking of using Big Data to analyze defects and troubles to find what kind of troubles occurred in what cases, what is the current trend if we analyze the time series, how defects are built into products and cause troubles as a result of remodeling, and so forth. So we started to consider applying AI and Big Data technologies not only to online predictive diagnosis but also to all kinds of data stored in-house.

Kumagai: Engineers who are going to be engaged in such new fields must be persons with totally different specialties. Those who studied mathematical and information sciences and specialize in analyzing complex and massive data, for instance need to have knowledge of different fields applicable to the technologies for building hardware.

Higashihara: We are certainly recruiting and fostering data scientists and data analysts from around the world, but it is not easy. It seems that someone who understands technologies really well look at things based on mathematical expressions and past experiences. On the other hand, the results of using AI only outputs correlations. Only "correlations between this and that events" are output. Only humans can associate them with each other. Humans consider why an event is associated with another and exhibit new points of views and perspectives, which is important. Serious thoughts are possible only when people with abundant engineering experience are faced with a correlation of A and X or B and Z for unknown reasons, rather than when a conclusion is reached using algorithms.

Kumagai: The defeat of a professional Go player by a system came as a shock to me. The system was created by a Google-owned company, not by a manufacturer. In the 19th century, the Industrial Revolution completely replaced horse and water power with mechanical power, specifically steam engines. In the same manner, ICT or information communication technology may cause a New Industrial Revolution if it is recognized as new motive energy for the industry.

Higashihara: The 5th Science and Technology Basic Plan published last year includes a keyword, "Society

5.0." I understand that Version 5.0 means that hunting life was succeeded by agriculture, then the Industrial Revolution and IT Revolution and that the next revolution has arrived. After the Information Revolution, I think that an age has come to pursue fusion of people and the Information Revolution, a human-centric society, and real improvement of QoL or Quality of Life using collected data, physical and cyber alike.

Kumagai: I understand that the 5th Science and Technology Basic Plan puts emphasis on connection between people. Another concept that we must consider is awe of nature, that is, changes of nature that sometimes pose threats to us should be included in the realm of life. I believe if we just continue human-centered thinking, we will pay for it heavily in the future. Severe hazards for railways such as earthquakes, rain, and wind cannot be prevented but can be mitigated. I think, at least, the directions of technologies will include the one of mitigating disaster damages as much as possible.

Research and Development with an Eye Toward 2050

Kumagai: I attended the World Congress of Rail Research or WCRR 2016 that was held in Milan in late May, 2016. I talked about three topics. Increasing the efficiency of R&D, digitalizing railways, and promoting energy innovation. Then, opinions were exchanged on these topics. I think railway digitalization is connected to IoT, Big Data, and AI. However, we at RTRI are thinking of determining targets for introducing AI or ways for approaching human behaviors by studying human errors, such as drivers failing to see a signal or opening doors on the wrong side, that is, the mechanism of brains and physiological changes in them in the process of making decisions in the transport operations. The other day, I had a chance to visit your medical facility office in Kashiwa and I was impressed with the advancement of your measurement technology for medical applications. We have just begun basic research on the possibility of digitizing signs and tendencies of human errors by keeping track of human physiological changes. The advanced measuring technologies that are utilized in your IoT and AI application strategies are widening the possibility of creating knowledge about complex and elusive things.

Higashihara: What draws our attention in particular? The best way to solve a problem or meet a challenge of, for example, preventing human errors is to create a simple mathematical model. However, this is rather difficult to do, so the important thing is an analogy or where to find similarity. I understand that the autonomous decentralized model you mentioned earlier is an analogy to an ecosystem, that is, a model of a system that heals on its own if it gets injured. Additionally, we are doing joint research with Kyoto University on herds of animals. We study questions like why herds of sardines do not collide with each other and the ecology of gorillas. Using a herd as a keyword, we are conducting research with a view to 2050 to gain wisdom on the ways of living of humans.

Abnormal weather is occurring frequently in these years. We are thinking of studying the technologies of sensing for mitigating the natural threats and disasters and detecting signs of them by dividing them into those to be achieved with short-term goals and middle- and long-term goals. For this purpose, we reorganized the our research laboratories, the Design Division and overseas research bases into three centers in fiscal 2015: the Global Center for Social Innovation, which implements social innovation projects in collaboration with customers; the Center for Technology Innovation;

Research and Development System of Hitachi for Fiscal 2016

and the Center for Exploratory Research. There are 2,700 researchers in total; of which 600 at the Global Center for Social Innovation, 200 at the Center for Technology Innovation, and 100 at the Center for Exploratory Research. Middle- and long-term research projects are conducted at the Center for Exploratory Research.

Kumagai: I understand that the concept of not pursuing near-sighted, short-term results forms the basis of study conducted at the Center for Exploratory Research.

Higashihara: We must look ahead as far as 2050. Otherwise, I suspect we may go off the track. If we keep on looking ahead to the world of 2050 from 2016, including such aspects as how the nature will be and how the technologies will change, I think we can maintain a correct direction of research.

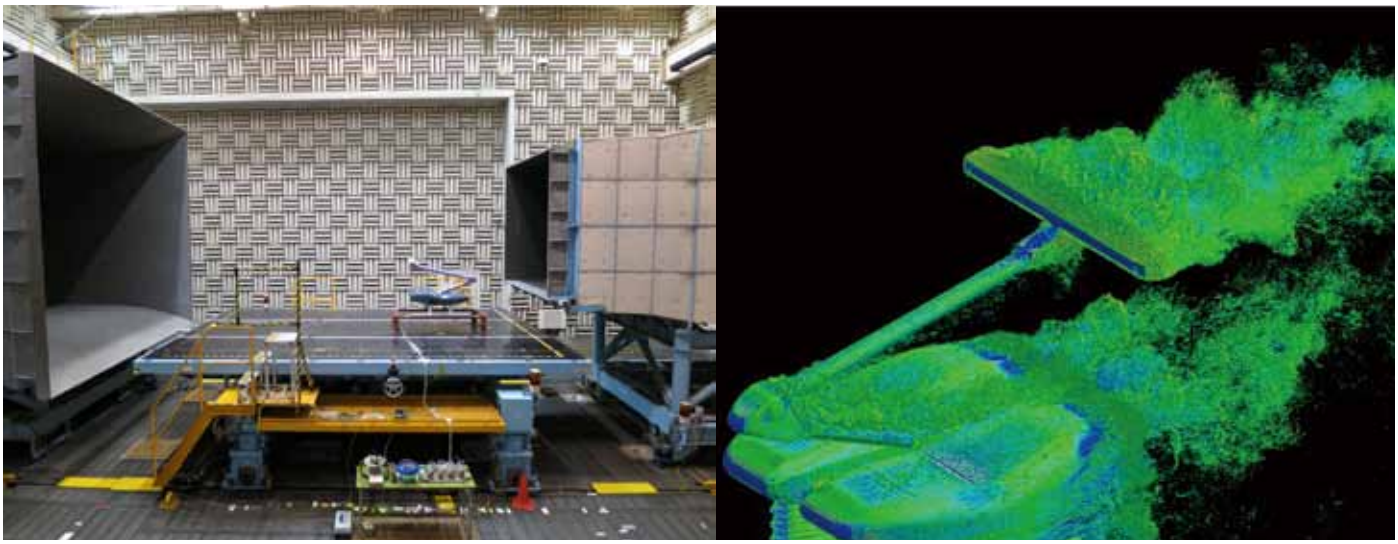
Kumagai: Our human resource team for research consists of 550 researchers. There is an important problem to solve in research management because research has two roles: middle- and long-term basic research and practical research that delivers solutions within three years. We are faced with a dilemma about whether to let all the researchers handle both or divide them into two groups, one handling basic research and the other addressing short-term, consulting-oriented issues. Currently we are operating based on the assumption that we should let researchers assume both of the roles as long as they can, because a sense of achievement resulting from practical application is important in keeping them more motivated.

Higashihara: I agree with you. I want to leave researchers to do their work freely. I don't think the management should squeeze them into fixed frames. If only immediate profits are something to be pursued, we can have all of them focus on somewhere close to activities on the front end and then short-term results can be achieved more easily, but this will surely weaken the middle- and long-term basic research. However, basic research is something on which we should place importance.

Kumagai: If the national government offers subsidies to universities ready to follow a policy of shifting to practical research, results will be achieved in 20 years but I think, on the whole, Japan's capability for basic research will be lowered.

As a corporate strategy, promotion of efficiency of R&D is a must. If there is a goal of realizing 360 km per hour in five years, for example, a research institute must make efforts to shorten the turnaround time in order to accomplish the mission of solving the aerodynamic and noise problems in two years. For problem solving, we conduct theoretical analysis, bench tests, and tests on commercial railway lines. However, the advent of advanced simulation technology using supercomputers has greatly contributed to reducing development periods and costs. In research and development, we are often unable to see events in reality. So the research processes by means of simulation-based visualization is indispensable. I expect computers and advanced simulations will have increasingly higher value from now on.

Higashihara: Yes, indeed. As you just said, use of supercomputers for development is exceedingly important. In business, simulation technologies are emerging one after another and we are collaborating with customers to find and correct problems. One example is traffic congestion caused by urbanization. If we run a tram, we want to know how much the traffic congestion can be alleviated at a certain vehicle occupancy and a certain minimum fare, or how soon the initial investment can be paid back. To discover answers, we can enter different parameters into computers to conduct simulations. Our tool for this purpose is NEXPERIENCE/Cyber-Proof of Concept. Using this simulation tool that we developed, we can conduct Proof of Concept simulations on computers to easily determine, for example, how the east-west and north-south lines should be laid out, how many stations should



Left: Testing aerodynamic performance of an actual pantograph in RTRI's large-scale wind tunnel
Right: Simulation of air flow by RTRI's supercomputer (courtesy of JR East)

be created, and whether a belt line should be formed. This trend of conducting feasibility study on computers is growing considerably stronger.

Kumagai: That's good because, in that way, we can expand the range of trials and shorten the required time. I assume that an objective numerical technique is also effective in quantifying effects of countermeasures applied to traffic congestion.

Higashihara: I agree. It will be useful in preventing traffic congestion and predicting flow of people when we plan urban development in the future. Using data collected from cameras, we can predict, for example, how women around 30 or children will move. Then, we can propose that a tenant in a certain position in a station building should be a boutique or a toy store. We are already in an age when we can easily simulate how many shoppers will come per week and multiply it with a purchase rate to know how much the sales will be.

Kumagai: The use of computer tools for the sake of systemization is expanding to a wider range of applications, isn't it?

Energy Optimization for the Entire Society

Kumagai: Railways are characterized by mass transportation capacity, high speed, punctuality, and high energy efficiency in comparison with other transport modes. We are thinking of promoting research and development on two topics: reduction of energy consumption of railways ranging from urban transport to high-speed train service; and achievement of zero emissions. Possible methods are regenerative brakes, use of renewable energy, linking of power supply in the user's network, use of fuel cells on railways, and introduction of no-resistance superconducting technology. Hopefully, a low-energy-consumption transportation society built using these methods will constitute one of the industrial foundations of Japan in the future.

Higashihara: Talking of zero emission, a society

dependent on automobiles will never be free from CO_2 problems. A society with focus on railways must be pursued. Fuel-cell cars and electric vehicles (EV) will increase in the future but railways will always be important in mass transportation. As for energy in the train service, we can introduce various power supply systems, use batteries for stable power supply to exploit renewable energy, or use regenerative energy of brakes for the next start. I expect that, in the next generation, there will be unification between a railway system and a town, which include buildings, tenant shops, and shopping malls, to achieve total energy optimization. Mutual exploitation of surplus power will be possible. Surplus power in a city will be used on railways and surplus energy on railways will be used in a city as electricity or energy.

Kumagai: That is the electric energy control.

Higashihara: Yes, electric and thermal power interchanges. I think it is a good way to promote energy saving and CO_2 reduction in an entire city.

Kumagai: Power interchange will be possible if there is a technology for stabilizing a wide range of power sources for everything from houses to railway companies. I want it to be a system that minimizes power supply and consumption via a network.

Higashihara: I said earlier ATOS took us 20 years, and this new system is also something that will probably take 20 or even 50 years to connect partial systems to achieve total optimization. I am dreaming of a day when we can do this.

Kumagai: Then, regenerative power can be interchanged regardless of substations of railway companies. In Tokyo, for example, the power consumption of all the railway companies in the metropolitan area can be controlled as one system.

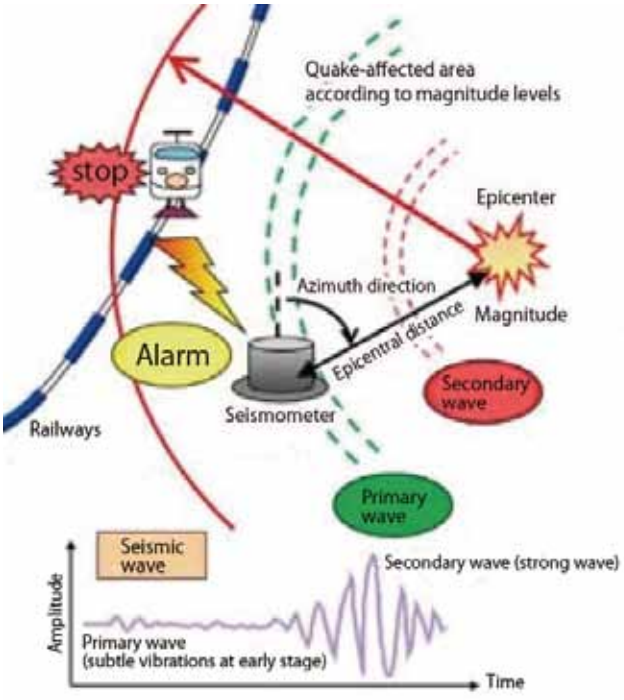
Higashihara: I believe such a day will come if we know what to select as the KPI (Key Performance Indicator).

Kumagai: For a railway company, lowering the power consumption is a positive factor for business because it accounts for up to 85% to 90% of the operating cost. Energy innovation is much required and will benefit both the global environment and the business result of an individual company. So we are going to put more effort into it. I hope we will be able to make the most of our collective strength to improve the energy efficiency by way of IoT and AI.

Railways for Connecting People

Kumagai: Two years ago, we created a vision statement, "We will develop innovative technologies to enhance the rail mode so that railways can contribute to the creation of a happier society." It was stipulated

Effective power distribution by Hitachi at Kashiwanoha Smart City



Left: Early Earthquake Warning System
Right: Earthquake Information Distribution System for Railways

on the assumption that the physically affluent society at present would pursue affluence with ties between people and spiritual connections.

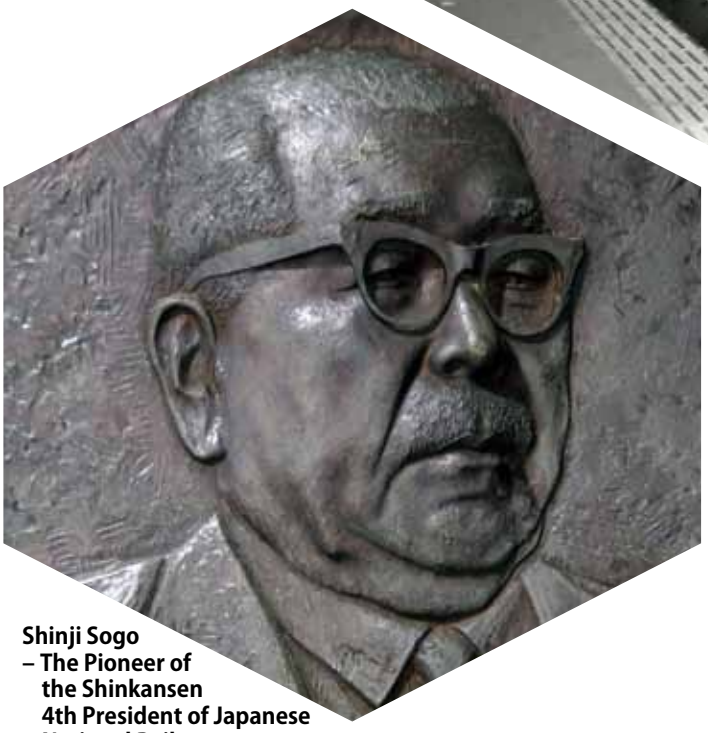
Higashihara: I had a chance of participating in a project of a national newspaper, where I asked readers how they thought IoT would be used in the future and received answers from them. In this project, I also had discussions with the coordinator. I said people would be able to record everything they want to do on their smartphone and, when they wanted to go to a movie, for example, digital signage would navigate them all the way to a movie theater. I wondered whether it was really convenient and something they wanted and whether it was an improvement of their QoL. Of course, some of the people think that way but spending more time with nature or having more time away from IoT is also an improvement of QoL. The important thing for us to pursue in the future is to allow each of the individuals to define a worthwhile lifestyle or real QoL for him or her and to respect different values.

Kumagai: There will be an increasingly stronger trend toward information exchange via SNS and smartphones in the future. However, people will invariably feel it necessary and important to transport themselves to meet other people in work or family situations. I expect that a wide variety of communication patterns including smartphones will come to be used. In the future as in the past, I hope railways will promote the concept of "connecting people."

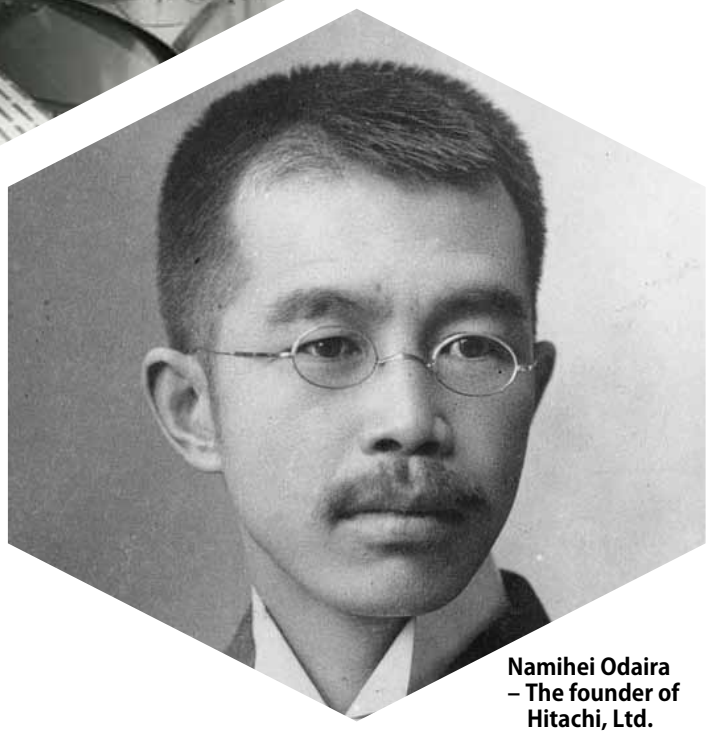
Higashihara: The important thing is that railways should be in a position to connect people, children and parents, and friends, isn't it?

Kumagai: In that sense, we are determined to ensure that railways will contribute to social innovations. I hope to welcome everyone's continued patronage of the railway sector.

First Generation Shinkansen
– 0 series



Shinji Sogo
– The Pioneer of
the Shinkansen
4th President of Japanese
National Railways



Namihei Odaira
– The founder of
Hitachi, Ltd.