Technotalk

# Use of Advanced Technologies to Develop Railway Systems for the World

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*Able to provide high capacity with a low load on the environment, railways are drawing attention for their potential as a form of transportation infrastructure that can deal with such challenges as global warming and the urbanization of populations. The international railway market, meanwhile, is looking forward to ongoing progress, with plans for high-speed rail and new commuter services being developed around the world. Given the background of these international trends, Hitachi is expanding its railway business into markets in the UK and throughout the world, supporting innovation in various different aspects of railway systems, including maintenance services and transportation management systems as well as rolling stock. Along with incorporating the IoT and other advanced technologies into its extensive technology platform built up over time, Hitachi is helping achieve social innovation in Japan and elsewhere through its solutions for transportation infrastructure.*

## Consistent Use of Advanced Technology in Railways

**Mitsudomi:** Given a background of global environmental problems and the urbanization of populations, considerable work is going into the construction and upgrading of railway infrastructure around the world. To take advantage of this momentum and to contribute to further progress in railway systems, Hitachi is taking steps to utilize new technologies such as the Internet of Things (IoT) as well as engaging in collaborative creation with customers globally.

As director of the Advanced Mobility Research Center at the Institute of Industrial Science, The University of Tokyo, Professor Suda, you have undertaken a variety of innovative research into urban transportation. Please tell us about the objectives of this work.

**Suda:** More advanced transportation systems, including cars and trains, are essential elements for creating a sustainable society. The Advanced Mobility Research Center is also known as the Intelligent Transport Systems (ITS) Center because we engage in a variety of research that contributes to the realization of ITS, including making travel more comfortable, alleviating crowding and congestion, and providing easier access for mobility-impaired people as well as improving the safety of transportation systems and reducing the load on the environment. While ITS has to date been mainly thought of in terms of enhancing road transportation, focusing mainly on cars, related fields are now expanding considerably and we see our work as being "technologies that use telecommunications to link people, infrastructure, and vehicles to help improve safety and security, environmental performance and efficiency, and comfort and convenience, and the social innovations they bring about."

My own background is in mechanical engineering and my main involvement with rail has been in the areas of vibration control and dynamic control. However, ITS requires knowledge from a wide range of fields, not only mechanical and control engineering but also civil and transportation engineering; information and communications engineering that encompasses the IoT, big data analytics, and artificial intelligence (AI); psychology; and biomedical measurement. The ITS Center was established to work on cross-disciplinary research linking all of these fields.

**Mitsudomi:** The improvement of social infrastructure through its integration with information technology (IT) is set to become an increasingly important topic. As a railway vendor, Hitachi has contributed to the ability to provide higher-density services, more extensive passenger services, and improvements to safety and reliability by incorporating IT into systems such as those for transportation management of the Shinkansen and other trains as well as enhancements to the rolling stock itself. Recently, we have also

been working on the application of big data analytics to valuable data, the collection of which has been made possible by the adoption of digital control with enhancements being made in conjunction with customers, using this for next-generation railway services and to make operation more efficient.

**Suda:** Having started out using steam engines, rail can be thought of as having progressed by always using advanced technology. For example, while progress is being made on the use of probe data from automobiles, whereby location, acceleration, and other data are obtained from sensors on individual vehicles, the railway industry has had the ability to obtain position data from early on, and its coordination between rolling stock and other infrastructure is also progressing. Differing circumstances prevent generalization, but I believe that there are many things to be learned from the railway industry when it comes to enhancing road transportation. It is anticipated that the IoT will transform how vehicles and infrastructure are maintained, and this is another area where rail is further ahead.

**Mitsudomi:** The high-speed railways in the UK in which Hitachi is involved are adopting remote maintenance whereby sensors are used to continuously monitor equipment, with wireless communication between maintenance facilities and in-service rolling stock. Our intention is to introduce advanced preventive maintenance practices, including collecting and analysing this data to detect potential faults and to deal with them at an appropriate timing.

**Suda:** Innovations in maintenance like this may well spread to the automotive sector.

**Mitsudomi:** In addition to the use of IT, railway operators in Japan are also actively involved in activities like urban development and regional revitalization, particularly with regard to railway stations. As the scope of their businesses expands beyond rail transportation to encompass lifestyle services, I anticipate that working with other forms of transportation such as automobiles will become increasingly important.

**Suda:** This is also of interest to me. Looking at recent trends, including the use of probe data for management, the growth of car sharing, and advances in autonomous driving vehicle technology, it seems that automobiles are steadily becoming more like public transportation. In this respect, opportunities for coordination may arise that did not exist in the past.

## Achieving an even Higher Level of Energy Efficiency

**Mitsudomi:** In terms of energy and the environment, rail is already a highly energy-efficient means of transportation, and we have worked to reduce the load on the environment in collaboration with customers. Examples of what we have already done include the use of silicon carbide (SiC) semiconductors to make inverters more efficient, and hybrid locomotives that combine internal combustion engines with batteries. What do you think we should be doing to further improve energy efficiency?

**Suda:** The advantage of rail lies in its ability to make efficient use of electric power from overhead lines, and while one idea is that we should be reducing our dependence on infrastructure due to the effort and cost

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Graduated from a graduate school at the University of Tokyo in 1987 with a doctorate in engineering. After working in roles that included associate professor at Hosei University and the Institute of Industrial Science, The University of Tokyo, and guest associate professor at Queen's University in Canada, he was appointed professor at the Institute of Industrial Science, The University of Tokyo in 2000. He is currently head of the Advanced Mobility Research Center and of the Chiba Experiment Station. His research work includes vehicle control dynamics. He is a board member of ITS Japan, a board member/fellow of the Society of Automotive Engineers of Japan, and a trustee/fellow of The Japan Society of Mechanical Engineers.

involved in maintenance, other possibilities include seeking to build hybrid railcars that use batteries or more advanced versions fitted with fuel cells.

Along with more efficient drive systems, making rolling stock lighter overall is another good way to achieve energy efficiency. Aluminum rolling stock, as typified by Hitachi's A-train, are great for providing lighter weight without compromising strength and also ease of recycling, and it may be that carbon fiber will be used more widely in the future.

More efficient energy management is also essential. Optimization through integrated management of train operations and electricity supply should improve the efficiency of energy systems overall and enable good use to be made of regenerative electric power.

**Mitsudomi:** In the case of regenerative electric power, Hitachi has commercialized a system that reduces power consumption by using it to charge batteries installed on the wayside so that the power can be reused to drive traction. Hitachi also has advanced technologies for electric power grids, including stabilization systems for regional grids, and monitoring and control systems for electricity transmission and distribution. We are looking at how to optimize energy management at a society-wide level by integrating these with railway power systems.

**Suda:** As railway power systems are excellent direct current (DC) networks, new possibilities should open up if you consider utilizing them with other infrastructure.

**Mitsudomi:** As you say, to expand the potential of rail, it is certainly important to consider interoperation that takes in other sectors. Hitachi is putting a lot of effort into collaborative creation with the aim of working with customers to overcome challenges and create new value, and we also intend to press ahead with collaboration and the fusion of knowledge in ways that transcend traditional boundaries in terms of both business and technology development, including in the railway sector.

**Suda:** As ITS itself is an endeavour that covers multiple fields, we too are putting a lot of effort into working with industry and the public, as well as joint research with other disciplines and exchanging information with overseas researchers. We are also working with particular regions, one example being the establishment of the Kashiwa ITS Promotion Council to run a joint ITS demonstration project in Kashiwa City in Chiba, which is conducting research aimed at next-generation transportation that takes the environment into account. In Tohoku, as part of a reconstruction project, local companies and the ITS Center are working together on joint research and other activities in which Tohoku University is playing a central role, and the aim is to set up a research facility for creating a next-generation automotive industry. In Hiroshima, we are involved in the practical implementation of research and development work that includes a public trial of world-first vehicle-vehicle communications between trams and automobiles to help develop advanced safety vehicles (ASVs).

## Consideration of Comfort from a Variety of Perspectives

**Mitsudomi:** The future technologies for which expectations are on a par with those for energy efficiency are improvements to vehicle interior comfort,

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Joined Hitachi, Ltd. in 1982. After being assigned to the national railway department of the sales division and working on railway sales in Japan, he was appointed head of the overseas railway section of the overseas railway sales department in the railway systems division in April 2004 where he worked in overseas railway sales. Appointed CSO and head of the commercial planning department at the Railway Systems Company in April 2012 and director, global CSO for the railway systems business, and CSO of the Rail Systems Company in April 2014 (stationed in the UK from June 2014 to March 2016). He took up his current position in April 2016.

including use of the IoT for more advanced information services, safety improvements, and better ride comfort. Hitachi is seeking to satisfy the diverse needs of the era of the IoT by developing Lumada, an open platform with broad application that provides new solutions through the integration, visualization, and analysis of data collected in the form of big data.

**Suda:** Applying the latest technologies to make all aspects of urban transportation easier to use will be a major theme in the future. Recently, smartphone apps have become available that provide timetable information and current train locations. In fact, I myself participated in their development (laughs).

**Mitsudomi:** Is that right? In an environment in which people carry computers around with them, there is no excuse for not using them to deliver information. The use of push communications to give people early warning of timetable disruptions means they can react accordingly, such as by avoiding the affected line or changing their travel time, thereby minimizing congestion at railway stations. The outcomes of this extend beyond shorter downtime and convenience, and in the wider sense I believe it also boosts reliability and improves operational efficiency.

**Suda:** The appropriate provision of information not only avoids the irritation of not knowing what is going on, I also believe it is a major factor in ITS and essential for changing behaviour whereby, as you noted, people use it to find things out and choose routes that avoid congestion.

When it comes to interior comfort, improvements to vehicle layouts can be expected to be of some benefit. Of course, things like techniques for reducing noise, providing a more stable ride, and reduced vibration provided by better suspension are also important, but there is a limit to what can be done by engineering alone. We have also been using brain and other biomedical measurements in our research to analyse driver stress levels, and it may be these kinds of techniques for quantitatively measuring comfort and other parameters will be needed in trains as well.

**Mitsudomi:** It is important to consider comfort from a variety of perspectives. With wireless signalling and control systems being adopted with the advancement of IT, it is likely that looking for ways to provide flexible operation in response to demand for more accurate signalling and control will become one of the areas of research that lead to improvements in passenger comfort.

## Need for Ideas that Overturn Accepted Wisdom

**Mitsudomi:** While there is a tendency to think of railway technology as having matured, your comments lead me to believe that there are still many possibilities for innovation.

**Suda:** A fundamental challenge for railways in my opinion is performance on curves. While railways are characterized by the low rolling resistance between wheels and rail, resistance increases on curves, resulting in losses of speed and energy. Along with the development of things like steerable bogies, which

have low friction when traveling around curves, and controlled-friction modifiers, another concept is to use negative conicity wheels in which the design of the wheels themselves has been changed such that their diameter increases in the outward axial direction (opposite to normal conicity).

Meanwhile, the widespread adoption of light rail transit (LRT) for urban transportation will require technical innovations to reduce the turning radius to around 10 m. I believe that we will need to adopt ideas and technologies that overturn accepted wisdom if we want to further increase the value of rail.

**Mitsudomi:** Looking at markets around the world, it may be that new concepts of mobility will be needed, involving not only high-speed rail but also urban transportation systems, which have scope for development.

**Suda:** We have developed a number of different types of urban transportation with low installation costs that are designed to be good for people and the environment, including an energy-efficient system that is based on the same principle as a roller coaster. It is important to take a somewhat broader perspective rather than just extrapolating from existing railways.

**Mitsudomi:** That's right. To build sustainable railway systems in Japan and elsewhere, we need to have a diverse range of solutions that take account of culture, economic conditions, and other local factors in the country or region concerned. In international terms, Hitachi is uniquely positioned among the railway industry players in that we have IT, electric power, and other technologies. In addition to working within Hitachi like this, we also intend to sustain innovation in railway systems and to contribute to the world by taking on more industry-academia partnerships with researchers like yourself so that we can more quickly incorporate the results of advanced research into actual systems.

**Suda:** Let's work together on social innovations that are derived from transportation systems.

**Mitsudomi:** Thank you for the many thought-provoking ideas you have contributed today.