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.

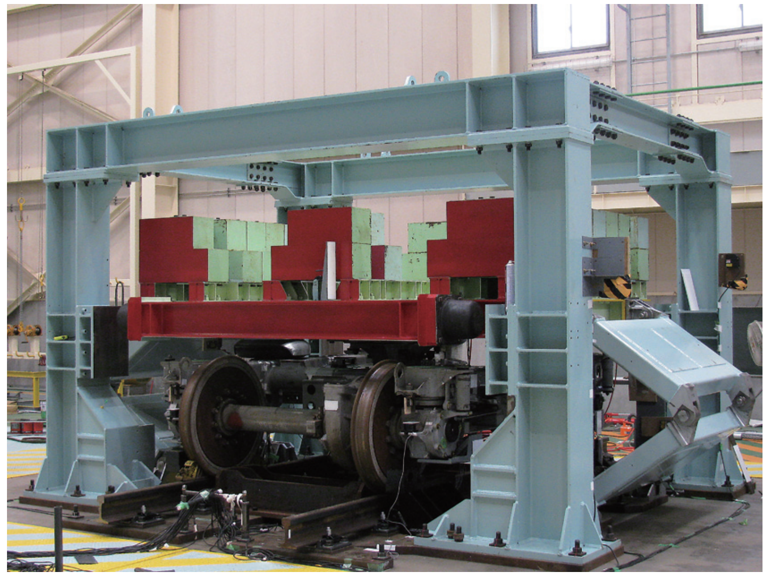
Due also to other railway accidents such as those on the Fukuchiyama and Hibiya lines, we became aware that safety must always come first in railway technologies and that there must not be any lack of focus in our efforts for maintaining safety. Our recent challenge is to build up robust railways against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