Efforts of the Advanced Railway System Development Center in Building New Railway Systems

Koji Asano
Director of the Advanced Railway System Development Center, Research and Development Center of JR East Group

Introduction

The Advanced Railway System Development Center is made up of researchers in the fields of rolling stock, transport, and signal communications, and we are making efforts in R&D under the mission of “building new railway systems with integration of rolling stock and signal technologies as a base.”

Fig. 1 shows the technical research areas the Advanced Railway System Development Center is working on. In “Improving quality of the railway system” we are working on development to apply technologies to future railways in a broad range of areas such as operating the Shinkansen at faster speeds (one of the three major technical innovation items in JR East Group Vision V), improving vehicle cabin comfort, reducing environmental burden, and safety measures. And in “simplifying railway system structures,” we are going forward with improvement of wayside system structure, rolling stock structure, and work structure from the perspectives of low-costs, high reliability, and flexibility.

The following gives an overview of some of development themes being worked on at the Advanced Railway System Development Center.

Improving Quality of the Railway System

2.1 Operating the Shinkansen at Faster Speeds
(1) Wayside environment measures (reduction of aerodynamic noise from high-speed trains)

One important issue brought up for operating the Shinkansen at faster speeds is reducing noise at the wayside when running at high speeds. The major sources of noise with the Shinkansen are pantographs and bogies.

In the area of reducing pantograph noise, we are simulating flow around pantographs using CFD (Computational Fluid Dynamics) (Fig. 2). Based on CFD and wind tunnel testing, we are developing low-noise shapes of pantographs, and furthermore, we are working on development of overall noise-reduction measures in combination with sound insulation and absorption methods.

(2) Improving equipment reliability (development of double helical gears)

As running speeds of rolling stock become faster, how to secure reliability of rolling stock equipment, especially underside equipment such as bogies, is becoming an issue. Shinkansen driving devices previously used helical gears, but we developed double helical gears (Fig. 3) to handle high-speed running.

Double helical gears have benefits in being much quieter and not generating thrust loading. Gear cutting, however, is difficult, so we are studying methods of composing double helical gears (integral or divided), fabricating gears, reducing costs, and the like.
In order to develop seats that reduce vibration, we are building an analysis model that re-creates actual seat vibration (Fig. 6). Through analysis and studies using this model, we aim to develop seats for high-speed rolling stock where ride comfort is not adversely affected, even while making them lighter.

### 2.3 Environmental Burden Reduction

1. Environmentally friendly materials (bioplastic)

   Bioplastic is a material where vegetable oil replaces some raw materials, so it has little reliance on fossil fuels and the like in production. It features few CO₂ emissions in combustion gasses when being disposed of, and it is expected to reduce environmental burden.

   This material was applied to hand straps (Fig. 7). Basic characteristic tests, one year of tests on actual cars, deterioration confirmation, and the like were performed, and the possibilities and issues for application of bioplastic to railway rolling stock parts was verified.

### 2.4 Safety Measures

1. Countermeasures against earthquakes (lateral dampers for earthquake countermeasures)

   We have developed earthquake-countermeasure lateral dampers jointly with the Railway Technical Research Institute as a measure...
for rolling stock to improve safety by means such as preventing derailment in large-scale earthquakes (Fig. 8). These dampers maintain the performance of conventional lateral dampers in ordinary running, but they exhibit large damping force in earthquakes to prevent derailment.

In order to solve this issue, we are aiming to establish a mechanism whereby a level crossing system having faults could continue operation in fallback mode using information from adjacent level crossing systems by networking.

(2) Countermeasures against snow accumulation and falling
(bogie end covers with snow melting heaters)
Trains with through service between Shinkansen and conventional lines easily accumulate snow and ice around the bogies when traveling in conventional line sections. If the accumulated snow chunks fall off when traveling at high in Shinkansen line sections, they may damage wayside equipment, rolling stock, and the like. We thus developed bogie end covers with snow melting heaters as a countermeasure against snow accumulating. The snow melting heater employs Positive Temperature Coefficient (PTC) ceramics capable of self-temperature control, and it was provided with a structure where even temperature distribution can be gained without needing temperature sensors (Fig. 9).

(3) Faster train radio data transfer rates (train radio for the Shinkansen)
For future Shinkansen train radio (voice and data communication for train command), we are developing system architecture and radio transmission technologies. By utilizing leaky coaxial cable (LCX) already laid and applying multiple-input and multiple-output (MIMO, transferring different information simultaneously from both ends of the LCX), stable communications becomes possible across the entire line and data transfer speeds can be increased (Fig. 12).
3.2 Rolling Stock Structure

1) Adoption of Ethernet to train control system (development of INTEROS)
We developed a 100 Mbps-Ethernet-based next generation train control system, which is called INTEROS (Fig. 13). INTEROS is characterized by large data transmission capacity within the trainset and between INTEROS and wayside systems.

![Fig. 13 Overview of INTEROS](image1)

2) Highly reliable equipment structure (door operating equipment) (Fig. 14)
Electric door operating equipment for conventional line cars has much greater maintainability than past pneumatic door operating equipment. However, it is not easy to pull out luggage and the like if caught in doors, and there are more than a few issues from a perspective of malfunctions occurring and maintainability. We have developed improved door operating equipment with better safety, reliability, and maintainability and confirmed its basic performance and durability through stationary tests and in commercial operation.

![Fig. 14 Concept of Improved Door Operating Equipment](image2)

3.3 Work Structure

1) Crew work support system (crew work support)
We have developed a crew work support tool that enables faster timetable acquisition, automatic scrolling of timetables according to the section traveled on identified by GPS, and switching of horizontal and vertical display by computerizing paper timetables carried by crews for tablet display (Fig. 15). We are also considering measures to prevent errors such as departing before the scheduled time by giving wearable devices timetable information display and slowdown section display (with vibration) capabilities.

![Fig. 15 Crew Work Support System](image3)

2) Onboard platform monitoring
Current systems to support train crew to confirm passenger safety during boarding and alighting from trains are by transmitting and displaying video images from cameras set up on station platforms to monitors set up in the driver’s cab or to ITV on platforms. However, issues remain such as running cost for systems by equipment in stations. We are thus developing an onboard platform monitoring system to confirm passenger safety during boarding and alighting from trains by transmitting and displaying video images from cameras set up on the sides of trains to monitors in the driver’s cab (Fig. 16).

![Fig. 16 Overview of Onboard Platform Monitoring System](image4)

4 Conclusion

The Advanced Railway System Development Center is making efforts on various development themes with an aim of building new railway systems as introduced here. In order to realize railway systems that will satisfy customers, we will work on further technical development while continuing to keep an eye on trends in utilizing rapidly advancing ICT, AI, IoT, and the like, going beyond the boundaries of conventional railway technologies.