RTRI Develops Autonomous Train Operation System for Near-Future Train Operation

The Railway Technical Research Institute (RTRI) has developed an autonomous train operation system (hereinafter referred to as “this system”) that enables trains to autonomously assess the safety along the route based on operational information consolidated onboard. This innovative technology allows for the control of level crossings and other equipment while ensuring safe and flexible train operation. This is the world’s first system that automates the entire process from stopping the train to the decision to resume operation, which is performed exclusively onboard without relying on any ground signalling equipment. The implementation of this technology can achieve labor-saving railway operation by reducing workforce requirements and simplifying operation. Furthermore, some of the elemental technologies incorporated in this system can be leveraged to enhance the safety of driverless automatic train operation and to streamline current train operation management tasks.

1. Development of This System

RTRI has been promoting “autonomous train operation (autonomous driving)” as one of its key project-based research and development themes for the future of railways and has been engaged in research and development on this topic for over five years since fiscal year 2020.

We have been focusing on the development of a system that enables driverless trains to make operational decisions based on information related to obstacles on and along railway tracks, passenger flow, operational restrictions caused by maintenance work or disasters, and power consumption. This system aims to achieve safe and flexible train operation while remotely controlling ground signalling equipment (such as point machines and level crossings) via wireless communication from onboard.

2. Elemental Technologies Constituting This System

To build this system, we have developed five elemental technologies (Figure 1).
Technology (1): Detection of obstacles in front of the train, on and along railway tracks, using cameras and LiDAR (Light Detection and Ranging) sensors
Technology (2): Onboard automatic operational decisions, made based on information mapped on the Railway Dynamic Map, an information base that consolidates conditions on and along railway tracks and train status
Technology (3): Onboard control technologies for wayside equipment (point machines and level crossings) utilizing wireless communication
Technology (4): Automatic train operation management across wide areas, including train traffic rescheduling techniques to prevent the spread of delays and to enable early delay recovery during disruptions, and energy-efficient operation
Technology (5): Intertrain communication and information sharing technologies, utilizing

public communication networks with appropriate cybersecurity measures

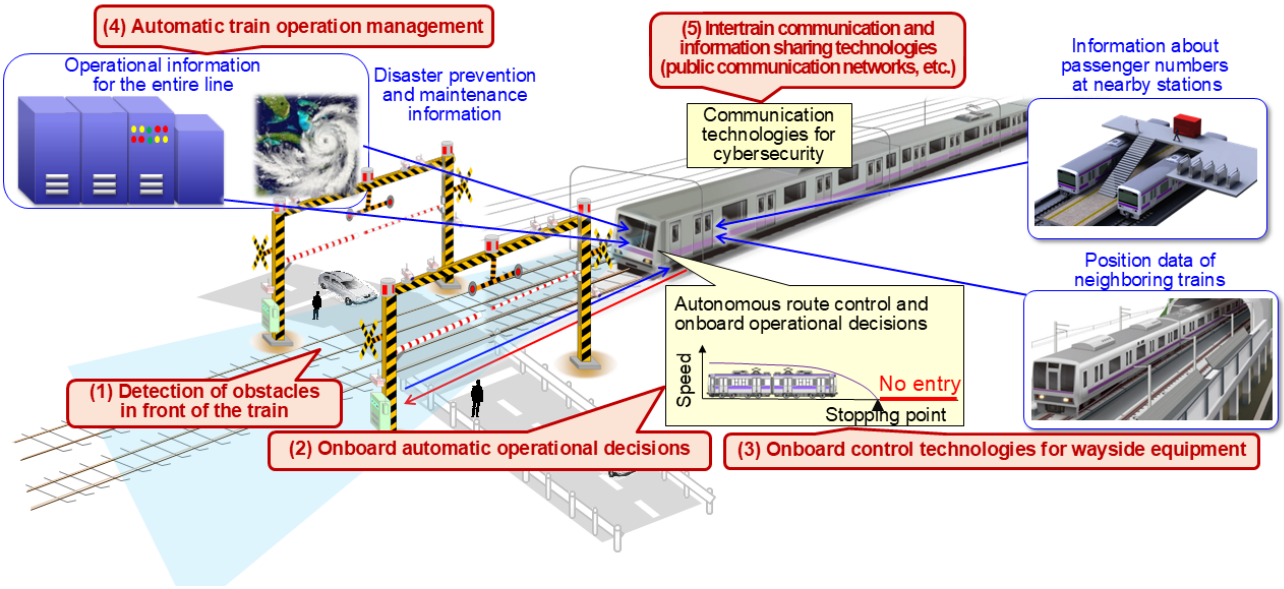

Figure 1: Five elemental technologies constituting the autonomous train operation system

3. Verification Results of This System

Demonstration tests of the prototype of this system were conducted on RTRI's test track by incorporating each elemental technology.

Through these demonstration tests, the following functions of this system were confirmed (Figure 2):

- The train can be automatically operated while controlling point machines and level crossings according to the predetermined speed profiles.
- Information about obstacles on the track detected by the train front obstacle detection system is mapped on the onboard Railway Dynamic Map, and based on this information, the onboard system determines whether the train needs to stop. If necessary, the train can be stopped before the obstacle to avoid a collision.
- After the removal of obstacles from the track, the onboard system automatically decides whether it is possible to resume operation, and if so, automatic train operation can be restarted.

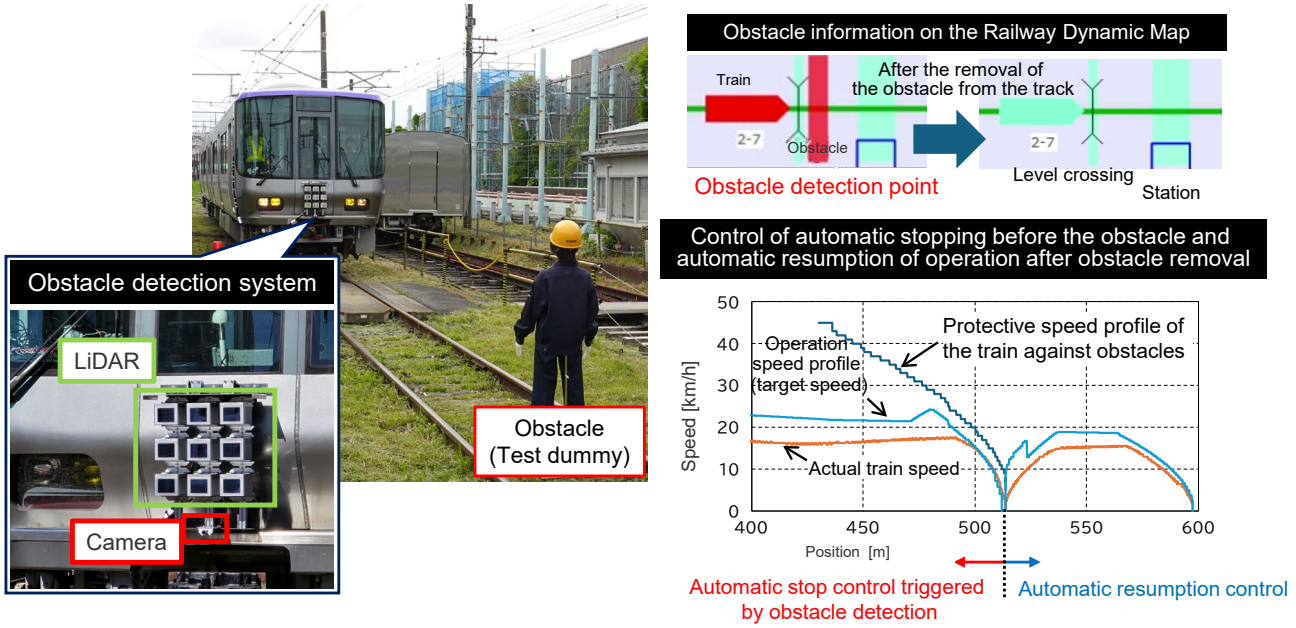

Figure 2: Example of automatic stopping and automatic resumption of operation triggered by detecting an obstacle in front of the train

4. Effects Achieved by Applying This System

The autonomous operation enabled by this system allows for automatic operational decision-making and automatic operation management on board the train. Consequently, it becomes possible to reduce the personnel required not only for driving operation but also for operation management tasks such as issuing dispatch instructions. Moreover, for small-scale regional railways with fewer trains and simple station track layouts, the system facilitates the reduction of facilities such as signal houses.

Furthermore, one of the elemental technologies, obstacle detection technology for detecting obstacles, can be utilized not only for autonomous operation but also as a technology to advance driverless automatic operation on conventional lines with level crossings. In addition, information sharing technologies and automation technologies for operational decision-making with the Railway Dynamic Map, as well as automation technologies for operation management, can be applied to reduce the workload of current train operation management tasks (Figure 3).

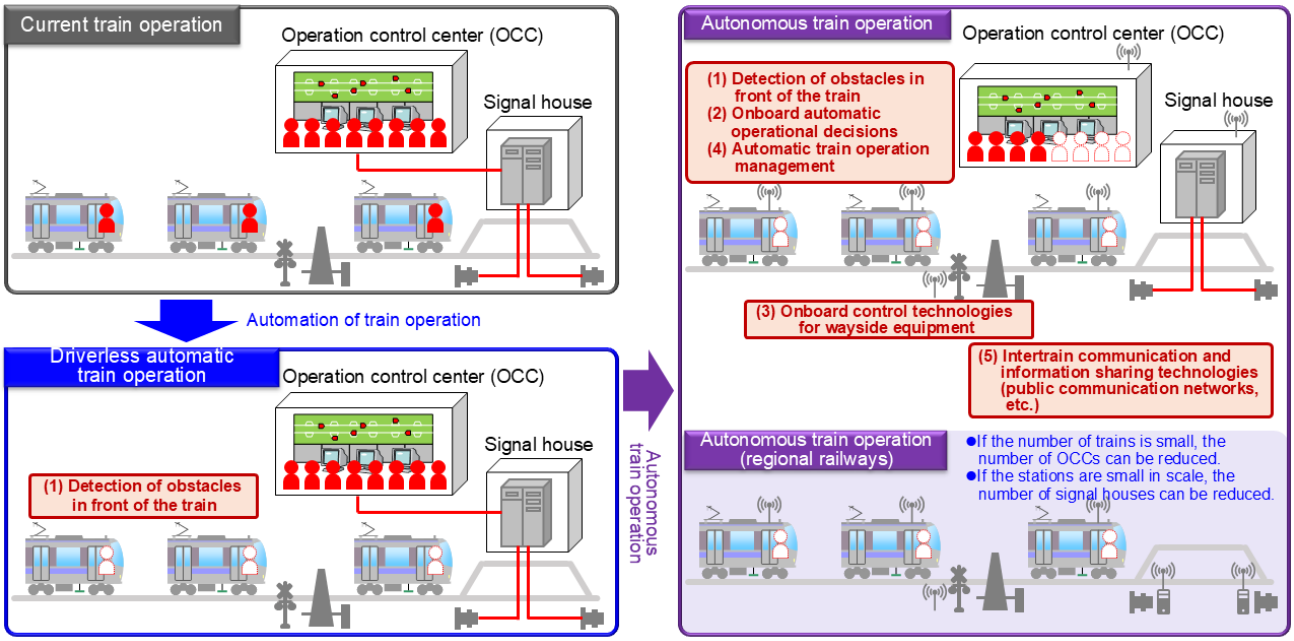

Figure 3 Image of labor-saving train operation through autonomous train operation (Comparison of current train operation with driverless automatic train operation)