"Merging Support Information System" for Autonomous Trucks

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In Japan, driver shortages are making it increasingly difficult to sustain logistics networks, raising concerns about a nationwide decline in freight transport capacity. With the establishment of limits on overtime work (such as 960 hours per year) in April 2024, solutions to maintain logistics while reducing working hours in the field are needed. To address this, infrastructure development, such as merging support for road-vehicle cooperative autonomous driving, is being promoted as a policy, taking into account road conditions unique to Japan. Mitsubishi Heavy Industries Machinery Systems, Ltd., which has a proven track record both domestically and internationally in the social implementation of road-vehicle cooperative systems such as automated toll collection system, is seeking to provide merging support information for the implementation of autonomous driving in Japan based on the expertise it has cultivated through these projects, including high-precision positioning, time synchronization, and roadside unit operation. This report introduces these initiatives.

1. Introduction

1.1 Road conditions of Japanese expressways

Expressways in Japan, in both urban and rural areas, are characterized by narrow lane widths and a limited margin for acceleration to reach speeds on the mainline, caused by factors such as uphill gradients on merging lanes and extremely short merging sections. Furthermore, another characteristic is the many Service Areas and Parking Areas (hereinafter referred to as SAs/PAs), resulting in a relatively high number of merging maneuvers needed to reach the mainline. These structural characteristics are factors that increase the cognitive, judgmental, and operational load at the time of merging (**Table 1**).

Table 1 Characteristics of Japanese expressways

Characteristic No.	Item	Description
1	High-density network	Japanese expressways form a high-density network spanning the entire country, efficiently connecting major cities. Due to short intervals between on-ramps and off-ramps, there are many diverging and merging points, which frequently leads to interference between vehicles on the mainline and those merging.
2	Toll system	Japanese expressways are mostly toll roads, with payment typically collected at a toll gate. Recently, Electronic Toll Collection (ETC) systems have become widespread, allowing for automatic toll payments via an ETC card onboard.
3	Service Areas (SAs) and Parking Areas (PAs)	Many SAs and PAs are located along expressways to provide rest stops for drivers, and include facilities for dining, shopping, and refueling.
4	Strict speed limits and traffic regulations	Expressways have strict speed limits, often set at 100 km/h or lower. In certain sections, these limits may be even more stringent. Traffic regulations are also strictly enforced, and driving safely is demanded.
5	Earthquake countermeasures	Since Japan experiences frequent seismic activity, earthquake-resistant measures are integrated into the design of expressways. Seismic structures are employed to ensure safe passage even in the event of an earthquake.

1.2 Challenges and solutions in the logistics industry

With the establishment of limits on overtime work in 2024, the number of hours of overtime work for truck drivers has been restricted to 960 hours, and on-duty hours have also been revised. It has been pointed out that this could accelerate mid- to long-term shortages in transport capacity. Consequently, social implementation of autonomous driving is gaining attention as a promising option to maintain logistics. However, for merging sections on Japanese expressways, obstacles such as noise barriers hinder the accurate recognition of traffic on the mainline by onboard advanced driver assistance systems (hereinafter referred to as ADAS) in autonomous trucks, which creates the challenge of an increased risk of sudden acceleration/deceleration and accidents.

As such, based on the "Roadmap for Cooperative Autonomous Driving Communication Methods," the Japanese government has outlined a policy to proceed with the additional allocation of 5.9 GHz band V2X communication while continuing use of the existing DSRC (5.8 GHz) and 760 MHz band antennas. This policy aims for a phased rollout of merging support and predictive information provision through the selective deployment of both roadside and onboard units.

2. Merging support information system

The merging support information system (hereinafter referred to as "the system") is an advanced road-vehicle cooperative system developed to support safe and smooth merging of autonomous trucks in the logistics in Japan (**Figure 1**).

The system centers on the integration of the roadside unit (RSU) system developed by Mitsubishi Heavy Industries Machinery Systems, Ltd. (hereinafter referred to as MHI-MS) and the onboard ADAS. To reliably capture information of vehicles traveling on the mainline which is necessary for merging, the system features a detection range covering a length of approximately 700 meters and a width of two lanes. To cover this extensive area, multiple 3D-LiDAR units are installed at intervals of approximately 100 meters (**Figure 2**).

These 3D-LiDAR units measure information such as position, speed, and length of vehicles on the mainline with high precision. Furthermore, when data sent from multiple 3D-LiDAR units is integrated by the roadside processing unit, time and vehicle information are used to identify overlapping areas. By continuously tracking and identifying the same vehicle, the unit can accurately identify the number of vehicles and their movement (**Figure 3**).

The high-precision vehicle data integrated in this manner is sent to autonomous trucks in real time at an extremely high frequency every 100 milliseconds via DSRC (5.8 GHz band) and 760 MHz band antennas. This high-precision detection and communication, performed every 100 milliseconds, enables safe and smooth merging decisions.

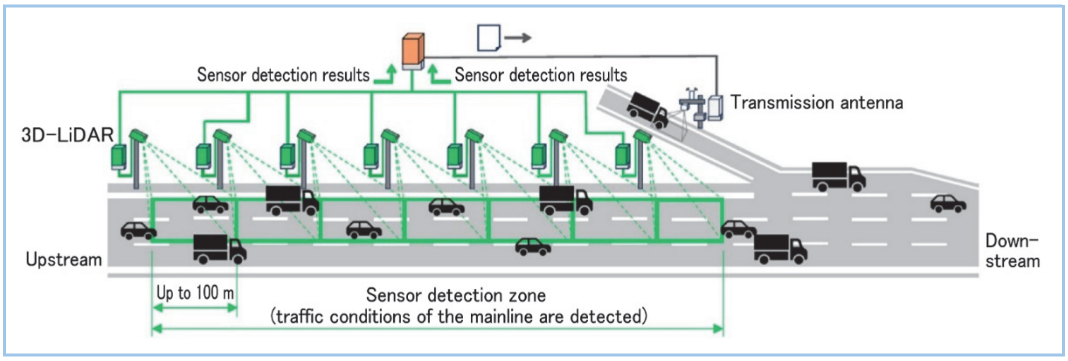

Figure 1 Merging support information system

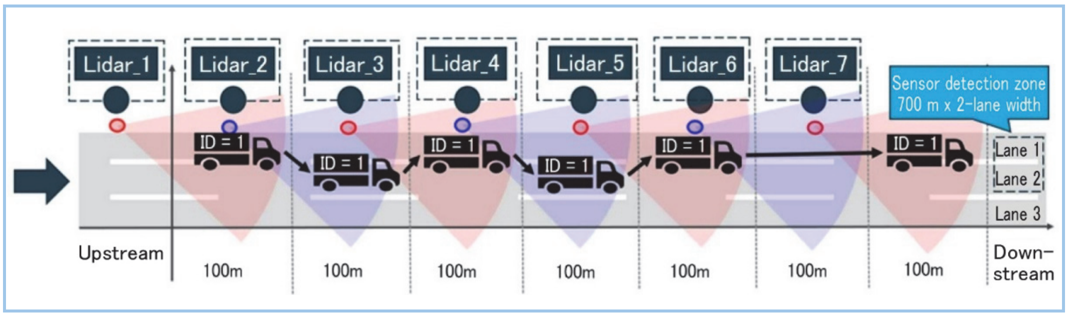

Figure 2　Sensor installation section

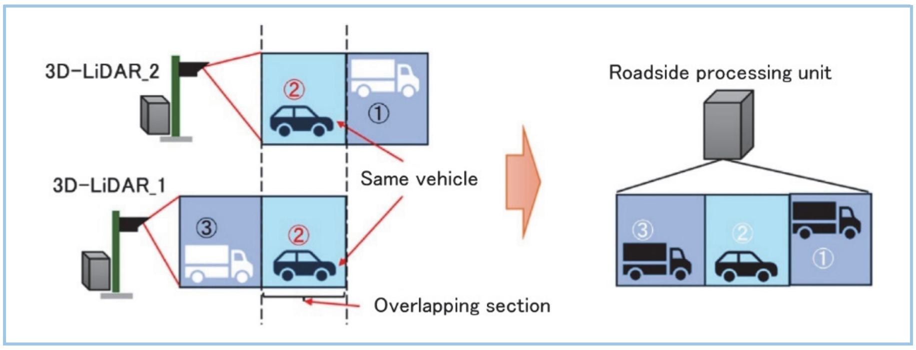

Figure 3　Same-vehicle identification method

3. Initiatives and challenges for social implementation of autonomous driving leveraging

MHI-MS's experience in constructing road-vehicle cooperative systems both in Japan and overseas, demonstration testing of the system is currently underway and is scheduled for installation at the following locations to realize the implementation of autonomous driving in Japan.

(1) Shin-Tomei Expressway (Surugawan-Numazu SA - Hamamatsu SA): Demonstration trial in progress (FY2025)

(2) Tohoku Expressway (Sano SA - Oya PA): Demonstration trial planned (FY2026 or later)

(3) Metropolitan Expressway (Yoyogi IC): Demonstration trial planned (FY2026)

4. Future developments

MHI-MS has a proven track record in the development of road-vehicle cooperative systems for toll collection and promoting their social implementation both in Japan and overseas. Technology required for toll collection and accurate identification of vehicle position and time is essential for the autonomous driving infrastructure. Leveraging its core strengths of high-precision positioning technology and extensive implementation experience, MHI-MS plans to contribute to the construction of the infrastructure that can support autonomous driving in Japan, and intends to actively pursue international expansion through collaboration with necessary partners.

Moreover, this merging support information system can be used not only for autonomous trucks but also in driving assistance for passenger vehicles. In the future, expansion of the functions into a system that supports the safe driving of all vehicles, including non-autonomous ones is planned. By deploying vehicle detection systems like this one, real-time traffic monitoring based on high-precision data will become possible, contributing to the identification of dangerous vehicles driving the wrong way and reinforcing more efficient overall traffic management.