



Cross-ministerial Strategic Innovation Promotion Program

Cross-ministerial Strategic Innovation Promotion Program (SIP) Phase Two/Automated Driving (Expansion of Systems and Services)/Infrastructure Preparation, Advance Verification, and Maintenance and Management for the Metropolitan Expressway Routes Connecting Haneda Airport and the Waterfront City Area, etc.

FY2019 Report

Overview

Mitsubishi Electric Corporation

March 2020

[Table of Contents]

1. FOTs in the Tokyo Waterfront area - Overview of the Metropolitan Expressway FOTs

- 1.1. Overview of the FOTs in the Tokyo Waterfront area and scope of this commissioned project
- 1.2. Metropolitan Expressway FOTs area (Route 1(Haneda Line) Airport West (Entrance))
- 1.3. Metropolitan Expressway ETC gate passing/merging support information delivery FOTs verification items and targets

2. Contents of research and development related to infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

- 2.1. Background and objectives of this research and development
- 2.2. Implementation of FOTs and development of equipment necessary for verification
- 2.3. Infrastructure preparation for the Metropolitan Expressway - Equipment configuration and division of responsibility for equipment
- 2.4. Conceptual image of operation of the Metropolitan Expressway FOTs system
- 2.5. Overall process of infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

- 3.1. Overall view of infrastructure equipment (Metropolitan Expressway Airport West (Entrance))
- 3.2. Individual infrastructure equipment: Roadside sensors (NILIM, five companies in joint research)
- 3.3. Individual infrastructure equipment: Expressway test roadside wireless devices (for ETC gate passing support)
- 3.4. Individual infrastructure equipment: Expressway test roadside wireless devices (for merging support)
- 3.5. Individual infrastructure equipment: Outdoor units (containing information provision management servers and individual companies' roadside processing devices)
- 3.6. Individual infrastructure equipment: Cameras ((1) (2) (3): Roof of Metropolitan Expressway electrical maintenance building/(4): Near merging area)
- 3.7. Infrastructure equipment soundness confirmation: Confirmation of information provision area using radio signal measurement

4. Verification of installation conditions, etc., related to infrastructure equipment on Metropolitan Expressway

- 4.1. Verification of installation conditions of infrastructure equipment used to provide merging support
- 4.2. Verification of infrastructure equipment (merging support and ETC gate passing support) processing capabilities

1. FOTs in the Tokyo Waterfront area - Overview of the Metropolitan Expressway FOTs

1.1. Overview of the FOTs in the Tokyo Waterfront area and scope of this commissioned project


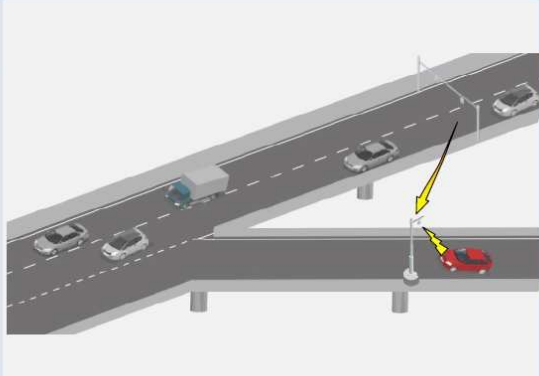
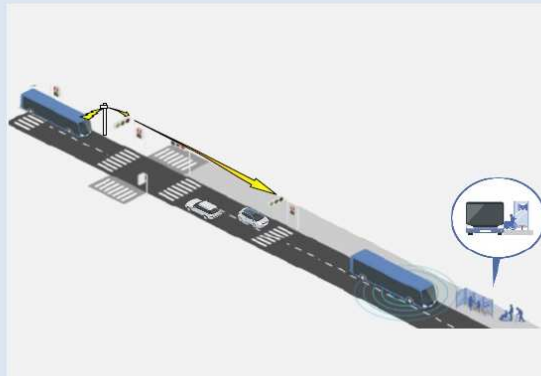
<p>Advanced automated driving on ordinary roads through distribution of traffic signal information by wireless ITS devices</p>  <p>(1) <u>Waterfront City area</u> (3) <u>Haneda Airport area</u></p>	<p>Advanced automated driving on expressways through distribution of driving support information and lane-level roadway traffic environments</p>  <p>(2) Expressway routes connecting Haneda Airport and the Waterfront City area, etc.</p>	<p>Advanced Rapid Transit (ART) using bus automated driving technology in mixed transportation environments through the use of infrastructure equipment by setting ODDs, advanced PTPS, etc.</p>  <p>(3) <u>Haneda Airport area</u></p> <p>Scope of this commissioned project</p>
--	--	--

Figure 1-1 FOTs in the Tokyo Waterfront area - Overview of cooperative infrastructure technology FOTs (from Cabinet Office materials)

1. FOTs in the Tokyo Waterfront area - Overview of the Metropolitan Expressway FOTs

1.2. Metropolitan Expressway FOTs area (Haneda Line, Airport West (Entrance))

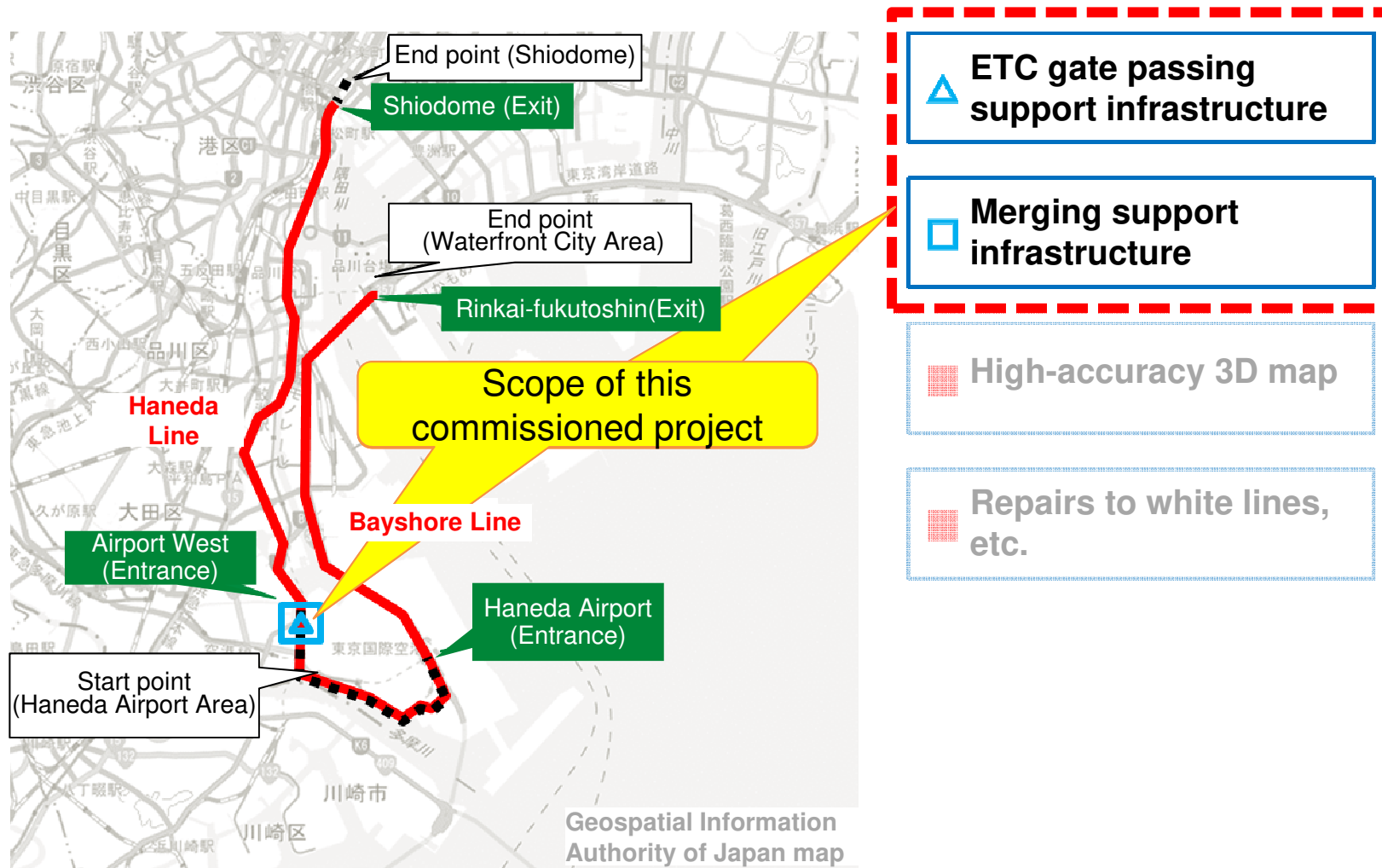


Figure 1-2 Metropolitan Expressway routes connecting Haneda Airport and the Waterfront City area, etc. - FOT area (from Cabinet Office materials)

1. FOTs in the Tokyo Waterfront area - Overview of the Metropolitan Expressway FOTs

1.3. Metropolitan Expressway ETC gate passing/merging support information delivery FOTs verification items and targets

Issues

- Smooth ETC gate passing support
- Support for merging with cruising lines based on actual cruising line vehicle speeds

Verification item

- **Appropriateness of operation** of cooperative infrastructure system
- **Effectiveness** of provision of support information to autonomous vehicles, etc.
- Verification of infrastructure installation conditions

Hypotheses regarding effectiveness of cooperative infrastructure technologies

- Support gate selection and passing by providing information
- Support adjustment of vehicles speeds in order to merge into cruising lines by providing information

Arrival target

- Examine infrastructure specification improvements
- **Derive infrastructure installation conditions** for Airport West (Exit/Entrance)
- **Clarify issues** in order to define specifications based on FOT*
- Identify need for infrastructure and identify **prioritization conditions***
*Coordination with NILIM (National Institute for Land and Infrastructure Management) is required regarding how to progress with later stage verification

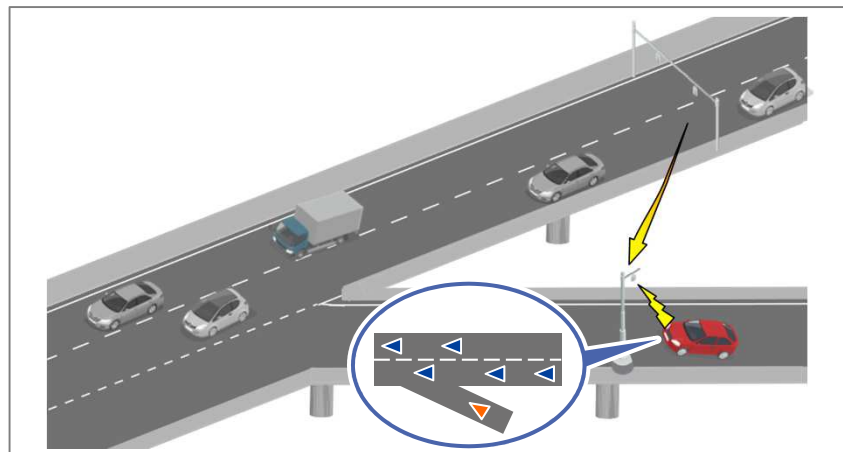


Figure 1-3 Conceptual image of merging support on expressways

Prepared by SIP

Infrastructure

- Expressway test roadside unit (for providing merging support information and ETC gate passing support information)
- High-accuracy 3D map

Test vehicle on-board equipment

- Expressway test vehicle on-board equipment
- High-accuracy 3D map and distributed information overlap display viewer
- Function for outputting to vehicle control
- Data logger (movement management)
- Drive recorder

2. Contents of research and development related to infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

2.1. Background and objectives of this research and development

[Background behind this research and development project]

- * SIP Phase 2 Automated Driving (Expansion of Systems and Services) establishes core technologies for collecting and delivering road traffic information, etc., as a collaborative area effort, and promotes the creation and societal implementation of a automated driving level 4 foundation
- * Since the March 2018 meeting of the Growth Strategy Council on Investment to the Future, government agencies and related industrial organizations such as JAMA have coordinated, conducting studies and investigations in preparation for the FOTs in the Tokyo Waterfront area.

[Objectives of the overall project and this commissioned project]

- * In Cross-ministerial Strategic Innovation Promotion Program (SIP) Phase Two/Automated Driving (Expansion of Systems and Services), FOTs are carried out with the objectives of building systems for utilizing roadway traffic environmental data such as traffic signal information and merging support information provided by traffic infrastructure and rapidly achieving the practical implementation of advanced cooperative infrastructure automated driving.

In relation to the above objectives, this commissioned project prepares the infrastructure environments necessary for FOTs on expressways, performs advance verification, and carries out maintenance and management



<Specific implementation items>

- (1) Development of infrastructure equipment necessary for implementing and performing verification of FOTs related to merging support and ETC gate passing support for expressways
- (2) Installation of actual environments on Metropolitan Expressway to enable test participants to perform automated driving technology tests
- (3) Verification of infrastructure installation conditions, etc., related to merging support and ETC gate passing support

2. Contents of research and development related to infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

2.2. Implementation of FOTs and development of equipment necessary for verification

Device structure of infrastructure equipment used to provide merging support

Device name	Role
Roadside sensor	Detect information regarding ordinary vehicles driving on expressway cruising lines (vehicle speeds, vehicle lengths) * Provided by joint research by NILIM. In this project, we prepared sensor mounts
Roadside processing device	Use the detection results of roadside sensors to calculate how long it will take for ordinary vehicles travelling on expressway cruising lines to reach merging points (* Provided by joint research with NILIM. In this project, we prepared the outdoor units that contain these devices.)
Expressway test roadside wireless device	Transmit merging support information to expressway test on-board equipment on test vehicles driving on merging lanes
Camera/recording device	Record video/images of expressway traffic conditions near test implementation sites

Device structure of infrastructure equipment that provides ETC gate passing support information

Device name	Role
ETC gate equipment	Acquire ETC gate operation status information in the form of gate open/close status (ETC, general, closed, etc.)
ETC gate open/close status data provision device	Receive ETC gate open/close information obtained from existing ETC equipment in toll booths and generate information to deliver to autonomous vehicles
Expressway test roadside wireless device	Transmit ETC gate passing support information to expressway test on-board equipment on test vehicles driving on ramps in front of toll booths

2. Contents of research and development related to infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

2.3. Infrastructure preparation for the Metropolitan Expressway - Equipment configuration and division of responsibility for equipment

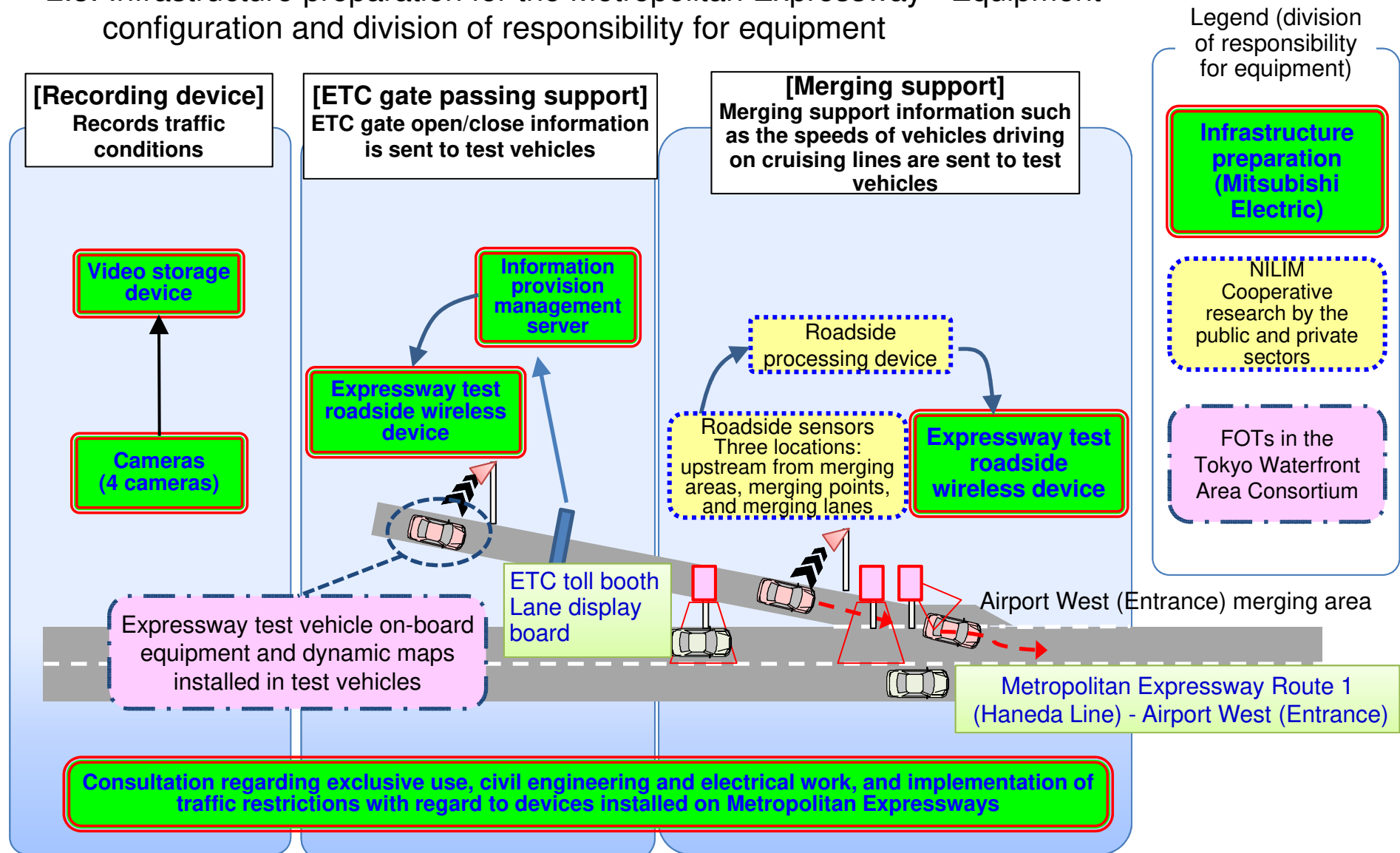


Figure 2-1 Configuration of test equipment in and around the Metropolitan Expressway Airport West (Entrance) and division of responsibility for equipment preparation

2. Contents of research and development related to infrastructure preparation, advance verification, and maintenance and management for the Metropolitan Expressway

2.4. Conceptual image of operation of the Metropolitan Expressway FOTs system

Roadside wireless devices that transmit ETC gate passing support information also detect the passage of test vehicles.

Roadside wireless devices that send merging support information only transmit information when they detect that a test vehicle is passing. When they do not detect passing test vehicles, they turn off their radio signal output.

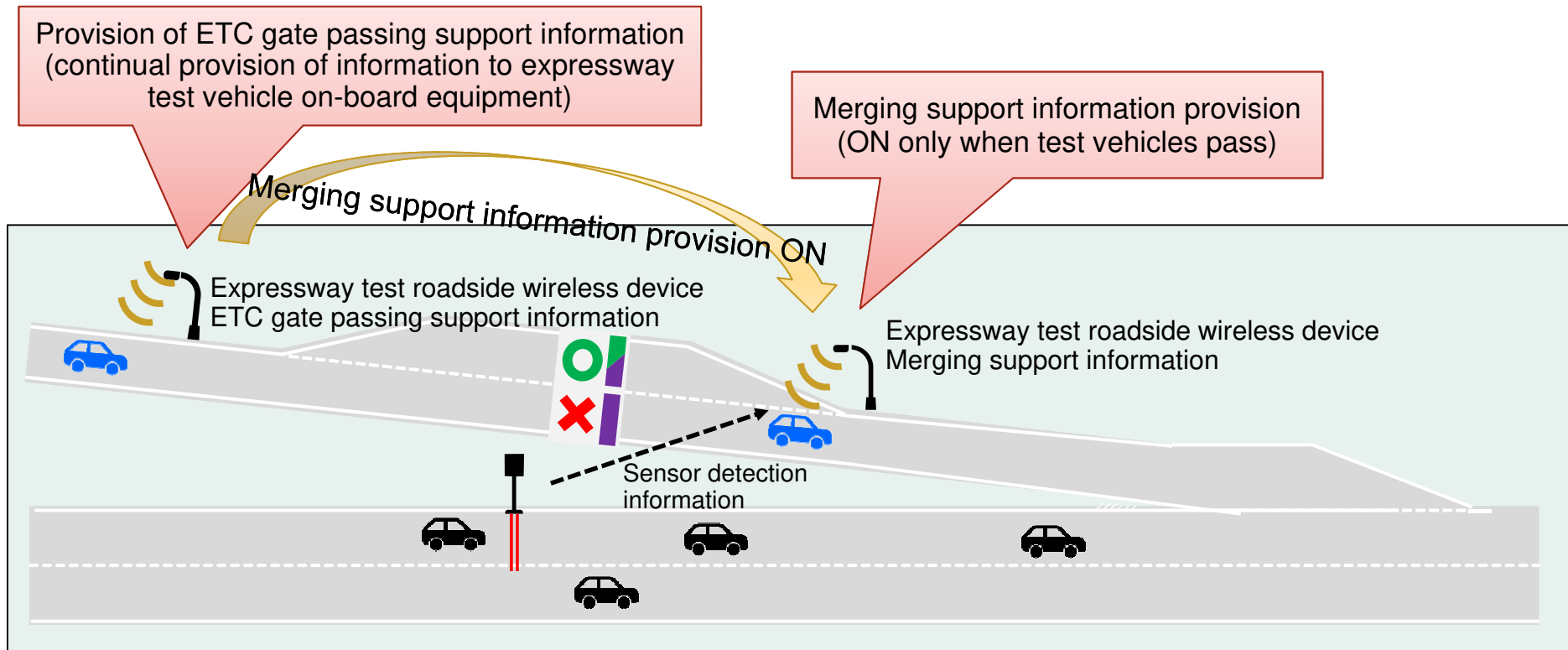


Figure 2-2 Conceptual image of system operation at the Metropolitan Expressway Airport West (Entrance)

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.1. Overall view of infrastructure equipment (Metropolitan Expressway Airport West (Entrance))

Installation of the equipment necessary for conducting FOTs at the Airport West (Entrance) was completed as shown below.

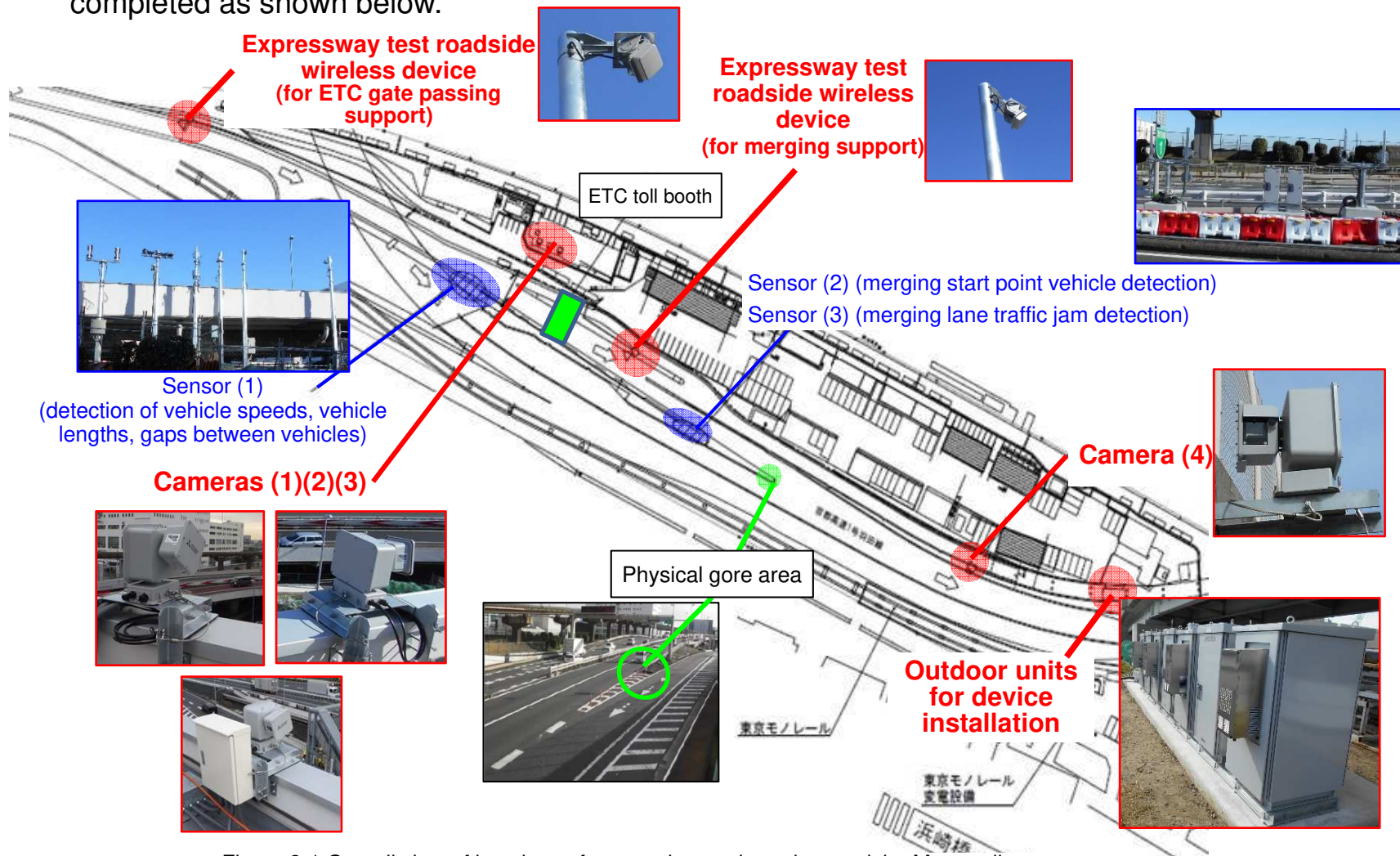


Figure 3-1 Overall view of locations of test equipment in and around the Metropolitan Expressway Airport West (Entrance)

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.2. Individual infrastructure equipment: Roadside sensors (NILIM, five companies in joint research)



Figure 3-2 Sensor (1) installation (roadside sensors of five companies in NILIM joint research)

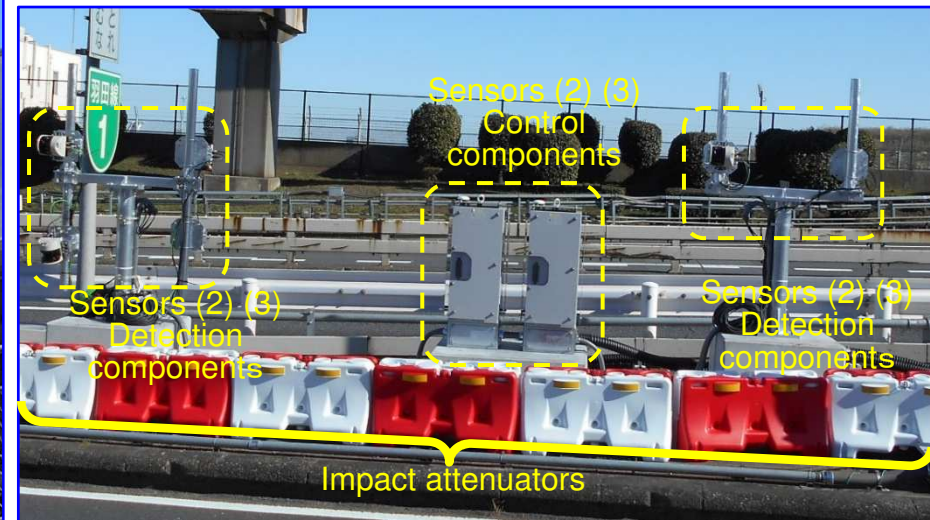


Figure 3-3 Sensors (2) (3) installation and appearance of impact attenuators

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.3. Individual infrastructure equipment: Expressway test roadside wireless devices (for ETC gate passing support)

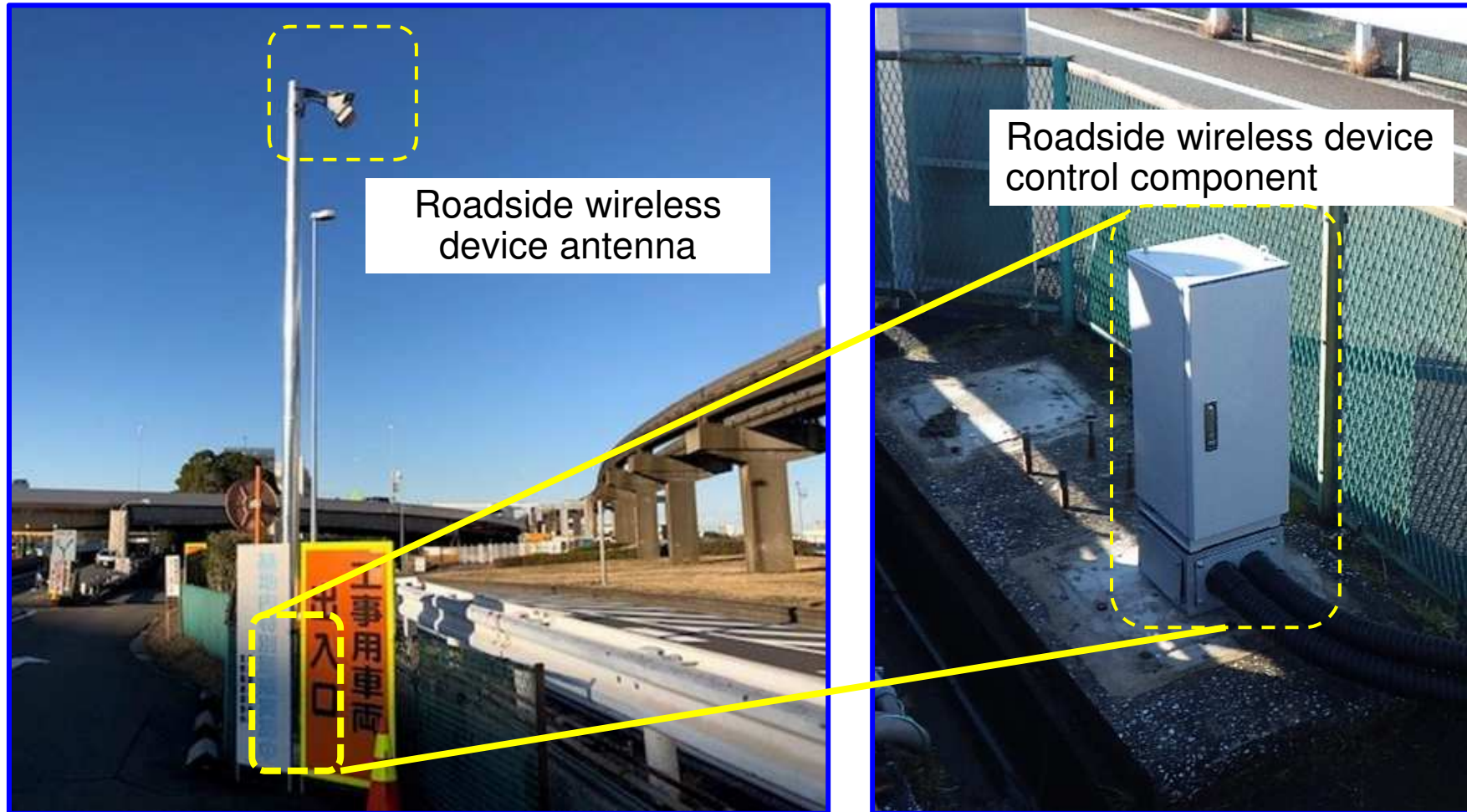


Figure 3-4 Expressway test roadside wireless devices for providing ETC gate passing support information 12

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.4. Individual infrastructure equipment: Expressway test roadside wireless devices (for merging support)

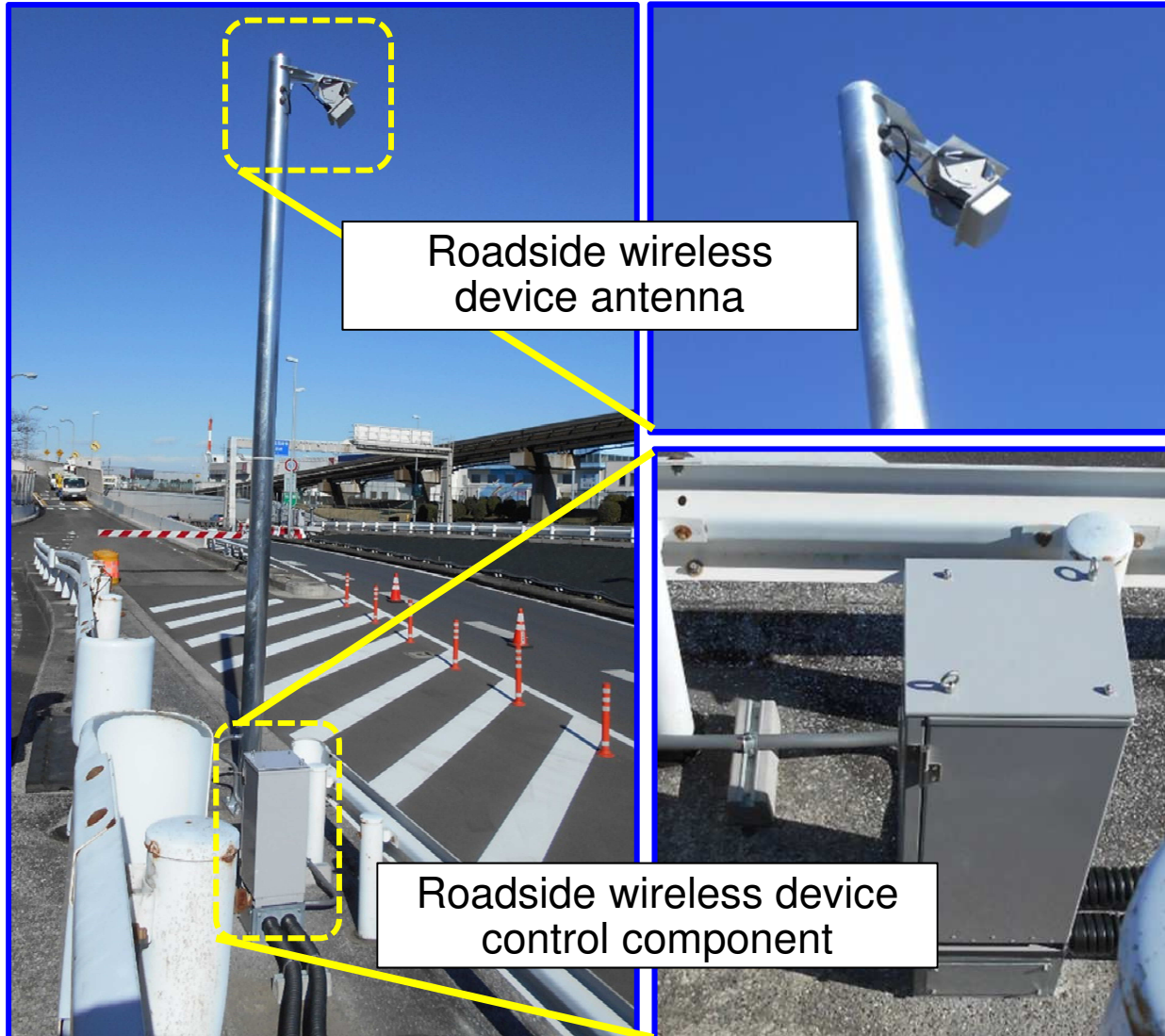


Figure 3-5 Expressway test roadside wireless devices for providing merging support information 13

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.5. Individual infrastructure equipment: Outdoor units (containing information provision management servers and individual companies' roadside processing devices)



Figure 3-6 Appearance of outdoor units that house ETC gate passing support information provision management servers and roadside processing devices of individual sensor manufacturers

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.6. Individual infrastructure equipment: Cameras ((1) (2) (3): Roof of Metropolitan Expressway electrical maintenance building/(4): Near merging area)

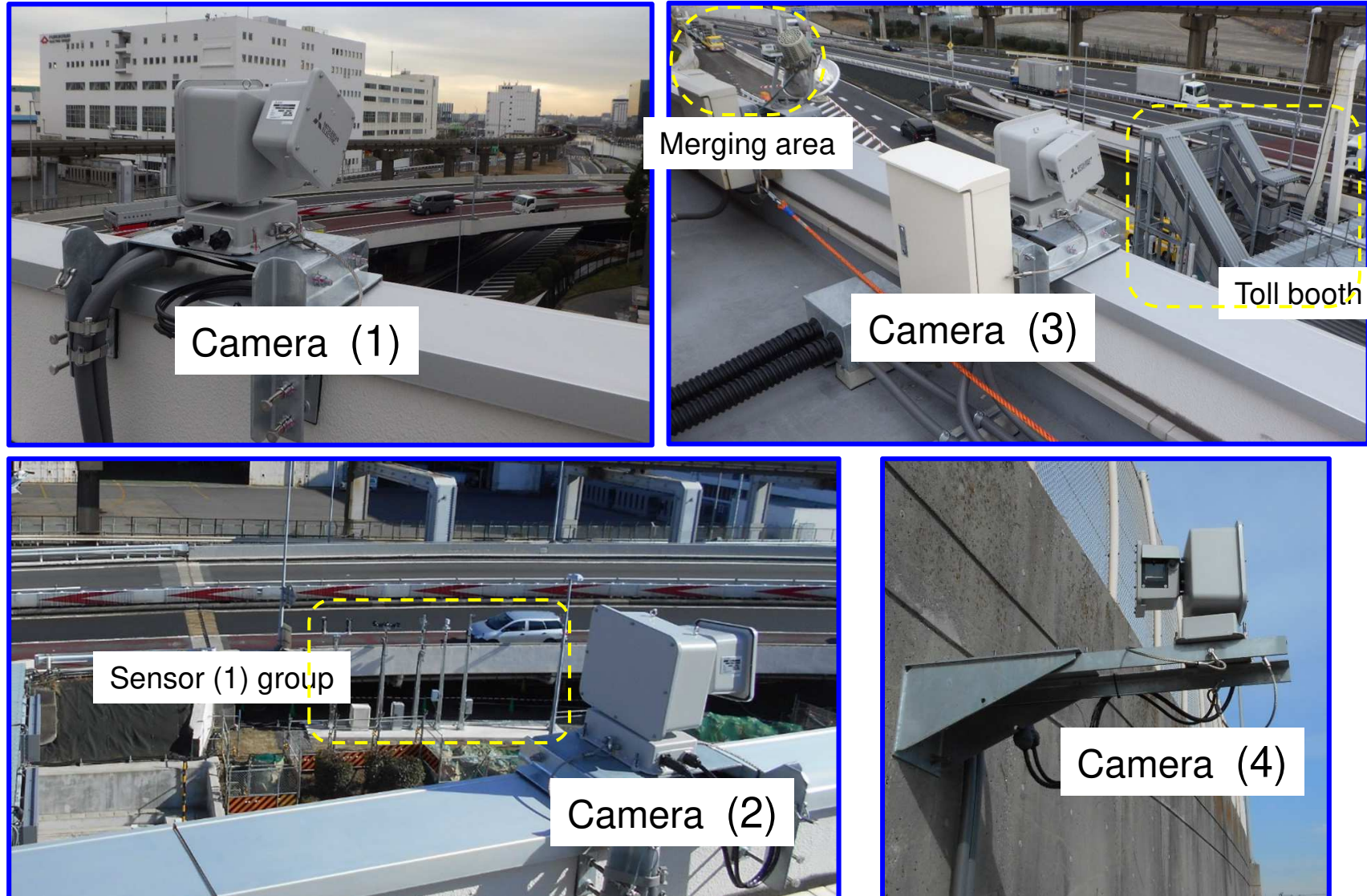


Figure 3-7 Cameras used to film traffic conditions on cruising lines and merging area

3. Metropolitan Expressway - Preparation of FOTs infrastructure equipment

3.7. Infrastructure equipment soundness confirmation: Confirmation of information provision area using radio signal measurement

To confirm that radio signals sent out by installed test roadside wireless devices do not affect existing expressway facilities, a third party (Shutoko ETC Maintenance Co., Ltd.) performed the following radio signal measurement drives.

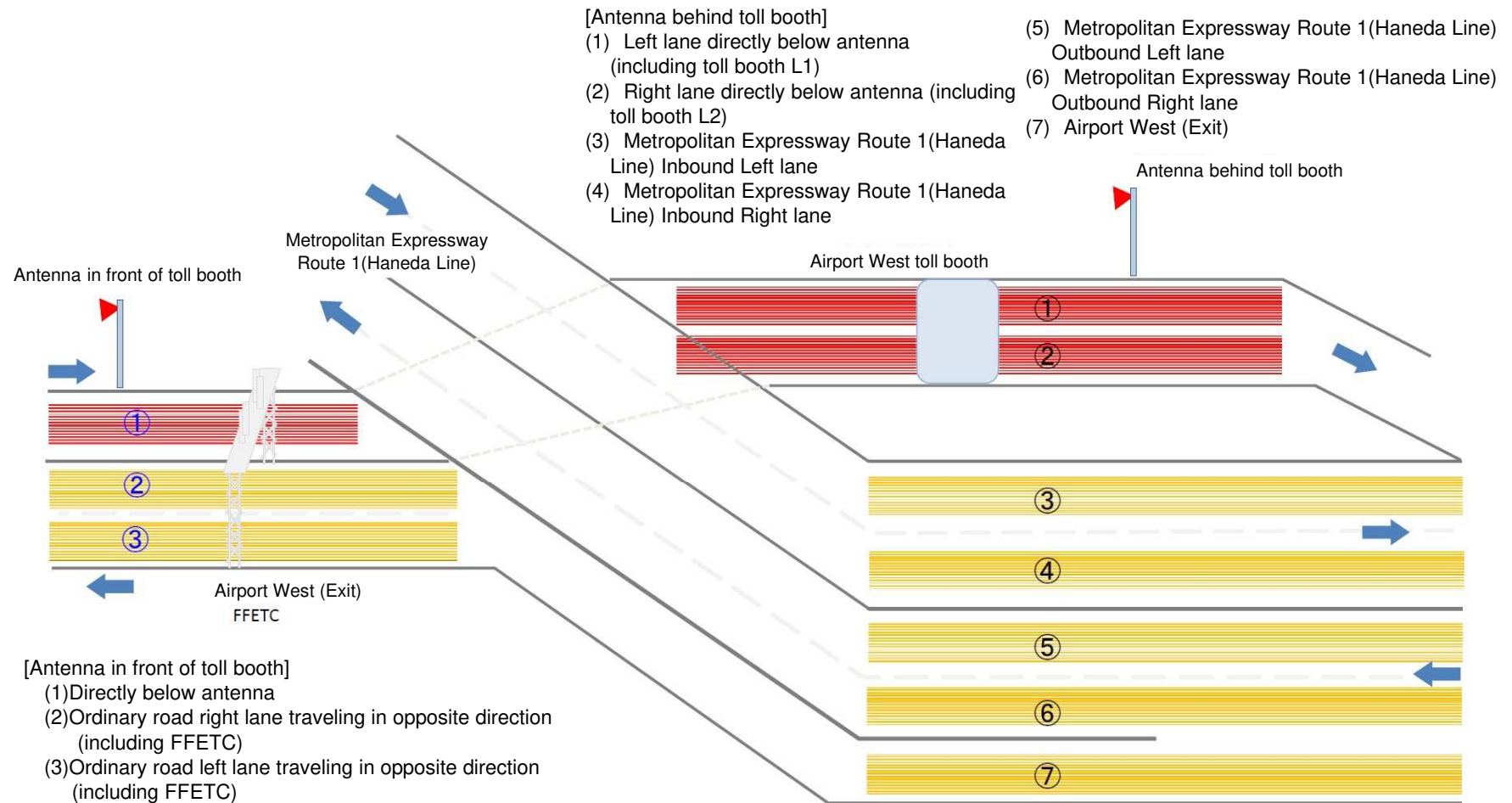


Figure 3-8 Radio signal measurement lanes on the Metropolitan Expressway Airport West ramp

4. Verification of installation conditions, etc., related to infrastructure equipment on Metropolitan Expressway

During FY2020, the installation conditions of ETC gate passing support and merging support infrastructure will be evaluated and the infrastructure's processing capabilities will be confirmed.

Content of verification of infrastructure facilities of Route 1(Haneda Line) Airport West (Entrance)

<Evaluation of infrastructure installation conditions>

Evaluation performed by comparing merging support information provided under the FOTs' installation conditions against actual cruising line vehicle driving conditions

<Evaluation of infrastructure processing capabilities>

Confirmation of required processing time for processing and transmission sequences of individual infrastructure devices

4. Verification of installation conditions, etc., related to infrastructure equipment on Metropolitan Expressway

4.1. Verification of installation conditions of infrastructure equipment used to provide merging support

[Issue]

Cars wishing to merge are provided with information such as expected arrival times for vehicles on cruising lines. This information is calculated with the assumption that the vehicles will maintain the same speed as the speed measured by sensor (1). The assumed constant driving speed varies depending on the location of sensor (1).

[Verification method]

Multiple points in the FOT's installation environment were used to evaluate merging area arrival times assuming that the speeds measured at those points were maintained

(1) Lap time data analysis

We examined the validity of the sensor installation position using the following procedure: for the section of road from sensor (1) and the sections immediately before and after it to the merging start point, we compared (A) the required transit time when assuming constant speed and (B) the actual required time calculated based on lap time measurement data.

Lap time data was calculated using video from cameras (1), (2), (3), and (4).

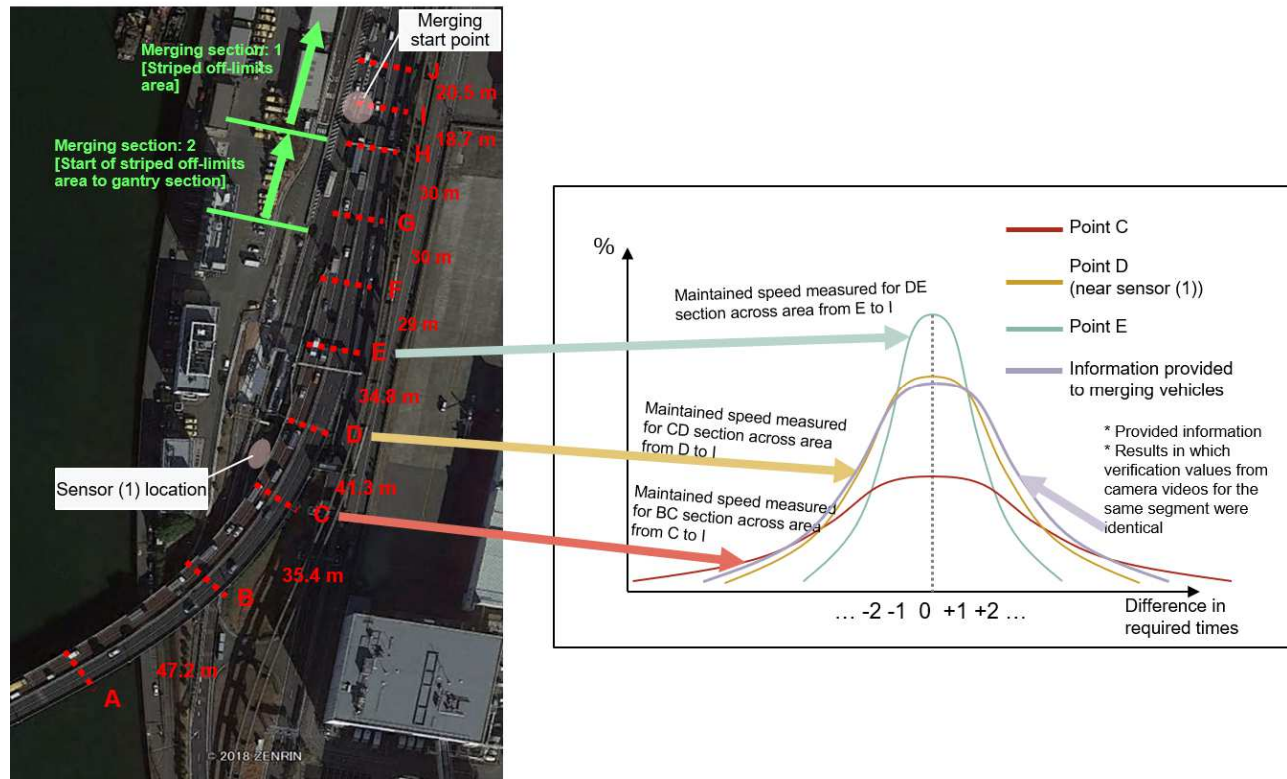


Figure 4-1 Overview of lap time analysis performed to verify the validity of the position of the sensor used to provide merging support information

4. Verification of installation conditions, etc., related to infrastructure equipment on Metropolitan Expressway

[Reference] Video recorded by four cameras

The vehicle driving time was recorded for each of the locations indicated with a letter. The recorded times were used to calculate the speeds of each vehicle and its respecting arrival time at the merging area.

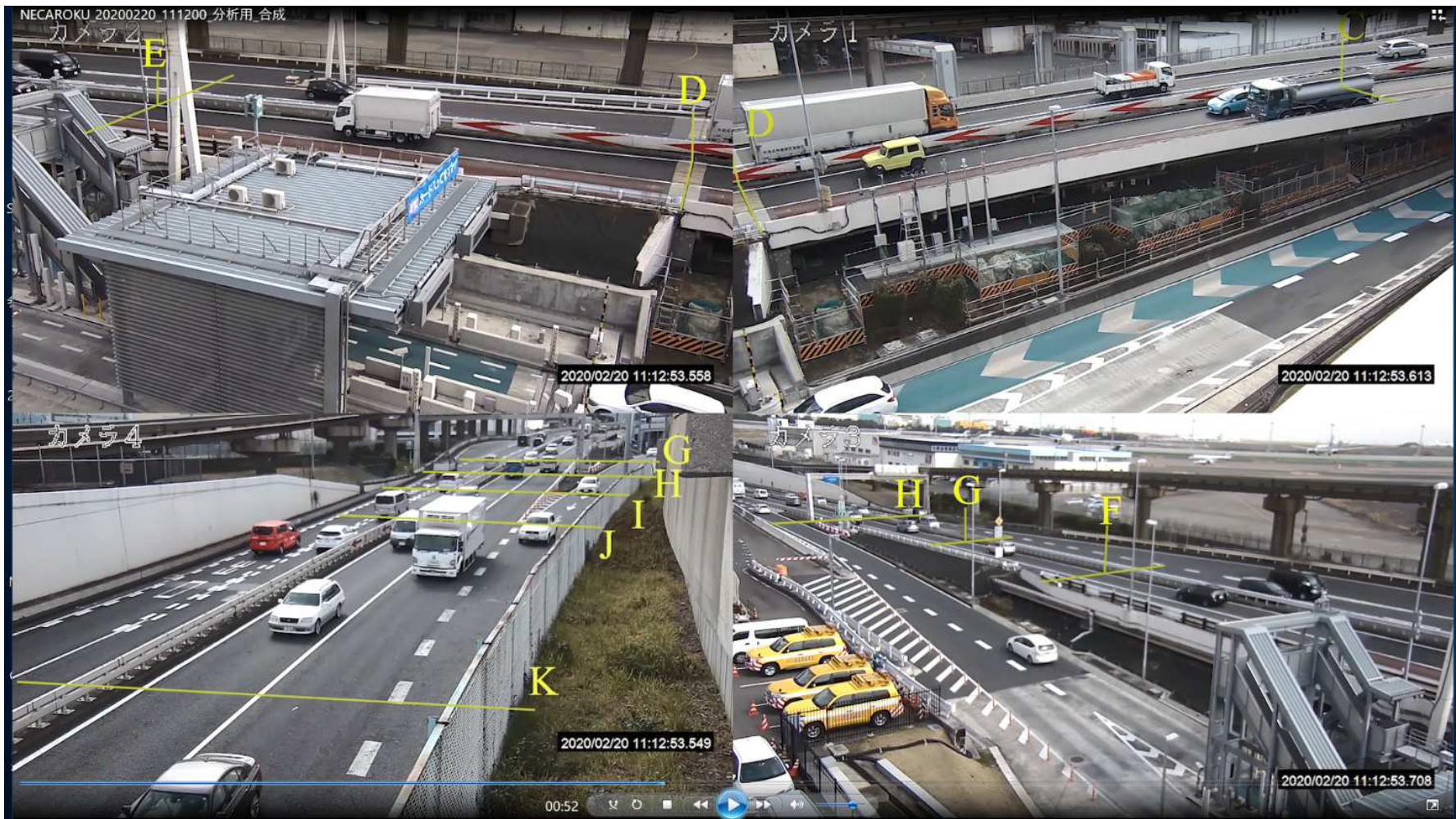


Figure 4-2 Videos recorded by cameras

4. Verification of installation conditions, etc., related to infrastructure equipment on Metropolitan Expressway

4.2. Verification of infrastructure equipment (merging support and ETC gate passing support) processing capabilities

[Issue]

We evaluated how long it took for vehicle CAN output to be performed after ETC gate passing support and merging support information were generated.

[Verification method]

(1) Log data analysis

We confirmed how long it took between the acquisition of information by roadside sensors (such as vehicle detection and ETC gate information) and transmission completion (road-to-vehicle communication by expressway test roadside wireless devices to test vehicles and completion of CAN output).

Confirmation of the amount of time required for this process was done by calculating average times based on log information from individual devices.

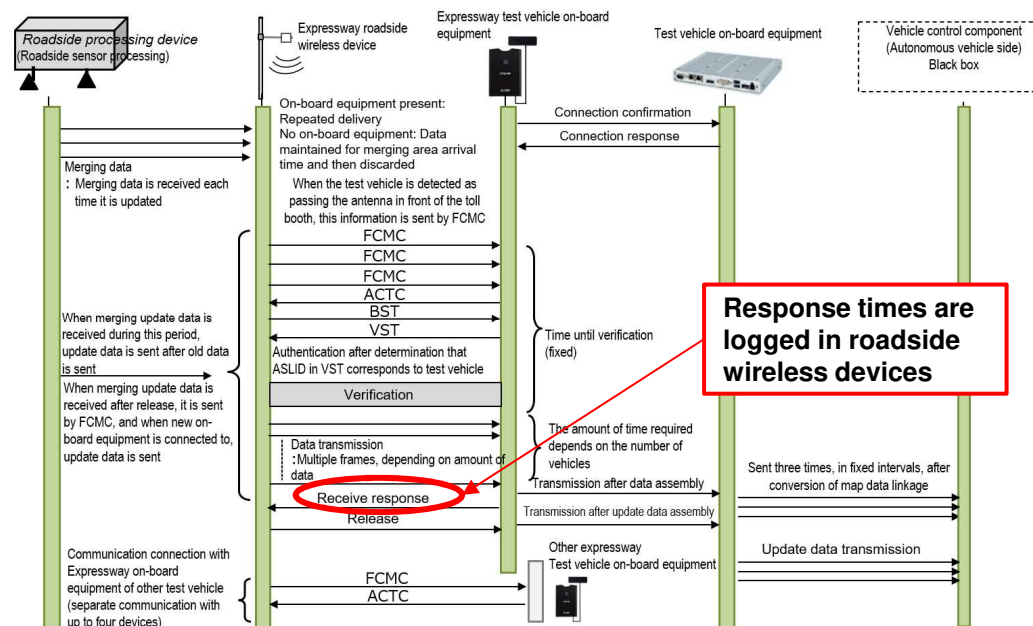


Figure 4-4 Example of transmission sequence between devices (merging support)