TF3-22-094III6

"Cross-ministerial Strategic Innovation Promotion Program (SIP) Phase Two - Automated Driving (Expansion of Systems and Services) /Implementation of FOTs in the Tokyo Waterfront Area"

- SIP FOTs in the Tokyo Waterfront Area Results Report (for Four Year Period) Overview - 2019 to 2022

FOTs in the Tokyo Waterfront Area Consortium
Mitsubishi Electric Corporation (representative)

Aisan Technology Co., Ltd.
GeoTechnologies, Inc.
Sumitomo Electric Industries, Ltd.
Zenrin Co., Ltd.
Toyota Mapmaster Incorporated
Nippon Koei Co., Ltd.
Pacific Consultants Co., Ltd.
Pasco Corporation

March 2023

This report documents the results of Cross-ministerial Strategic Innovation Promotion Program (SIP) 2nd Phase, Automated Driving for Universal Services (SIP-adus, NEDO management number: JPNP18012) that was implemented by the Cabinet Office and was served by the New Energy and Industrial Technology Development Organization (NEDO) as a secretariat.

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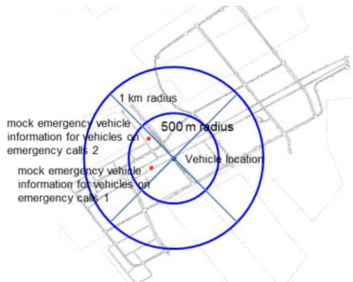
NOTE) Charts that use maps in this document that do not contain specific sources are based on one of the following.

Example 1-1:
Created by displaying high-precision 3D maps prepared by FOTs in the Tokyo Waterfront Area Consortium using general-purpose GIS softwares

p.51 Example of lower right figure

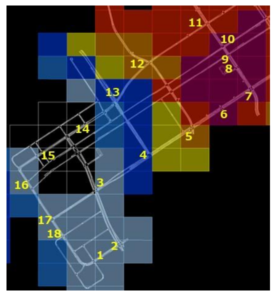
Example 1-2:
Created by displaying high-precision 3D maps prepared by FOTs in the Tokyo Waterfront Area Consortium using general-purpose GIS softwares
(Use electronic geographic map 25000 (Geographical Survey Institute) as background)

p.51 Example of left figure



Example 2:
Created by displaying high-precision 3D map data prepared by FOTs in the Tokyo Waterfront Area Consortium using viewer software prepared by FOTs in the Tokyo Waterfront Area Consortium

p.47 Example of lower right figure



1. Overview of the FOTs in the Tokyo Waterfront Area

1. Overview of the FOTs in the Tokyo Waterfront Area

(1) Implementation structure

- The implementation structures of the FOTs from FY2019-2020 and from FY2021-2022 were as shown below.

* Participated until FY2021

Cabinet Office/NEDO

FOTs in the Tokyo Waterfront Area Task Force

FOTs in the Tokyo Waterfront Area Working Group

FOTs in the Tokyo Waterfront Area Consortium

Test participants

FOTs in the Tokyo Waterfront Area Consortium

Mitsubishi Electric Corporation (representative)

Aisan Technology Co., Ltd.
GeoTechnologies, Inc.*
Toyota Mapmaster Incorporated*
Pacific Consultants Co., Ltd.*
Zenrin Co., Ltd.*
Pasco Corporation*
Nippon Koei Co., Ltd.
Sumitomo Electric Industries, Ltd.*

Other government agencies and related parties

FY2019-2020

	Japanese	Foreign
Automotive manufacturers	**9 companies**	**4 companies**
Component manufacturers	**3 companies**	**2 companies**
Universities	**5 universities**	—
Other	**5 companies**	**1 companies**
Total	**29 companies**	

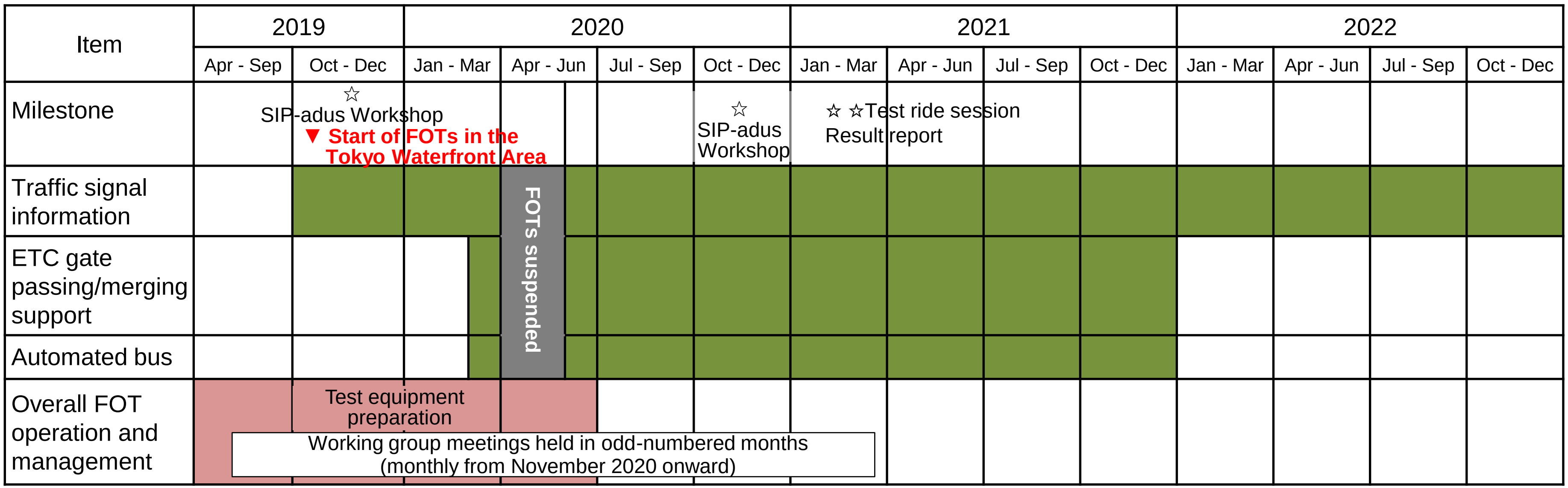
FY2021-2022

	Japanese	Foreign
Automotive manufacturers	**7 companies**	**2 companies**
Component manufacturers	**2 companies**	**4 companies**
Universities	**5 universities**	—
Other	**2 companies**	—
Total	**22 companies**	

1. Overview of the FOTs in the Tokyo Waterfront Area

(2) FOTs schedule ① FY2019-2020 (V2I)

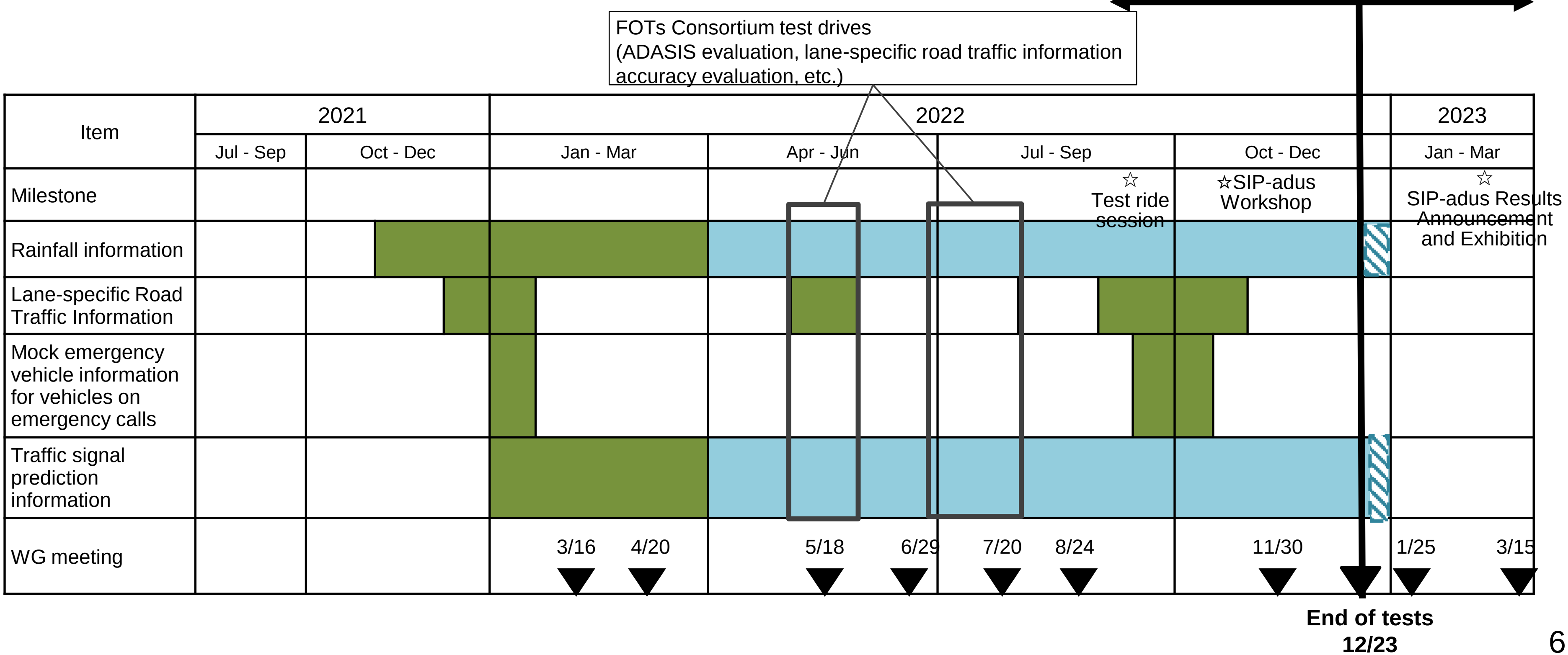
- The FOTs schedule was as shown below.
  - Due to the interruption of testing (for roughly two months) as the result of the state of emergency, the testing end date was pushed back two months to enable participants to secure sufficient data for their evaluation and analysis, so testing was performed until February 2021.



1. Overview of the FOTs in the Tokyo Waterfront Area

(2) FOTs schedule ② FY2021-2022 (V2N)

- The FOTs schedule was as shown below.
  - Rainfall information + traffic signal prediction information: Delivered until December 2022
  - Mock emergency vehicle information for vehicles on emergency calls: Delivered from September 29 to October 1, 2022
  - Lane-specific road traffic information: Delivered from April to May and September to October of 2022

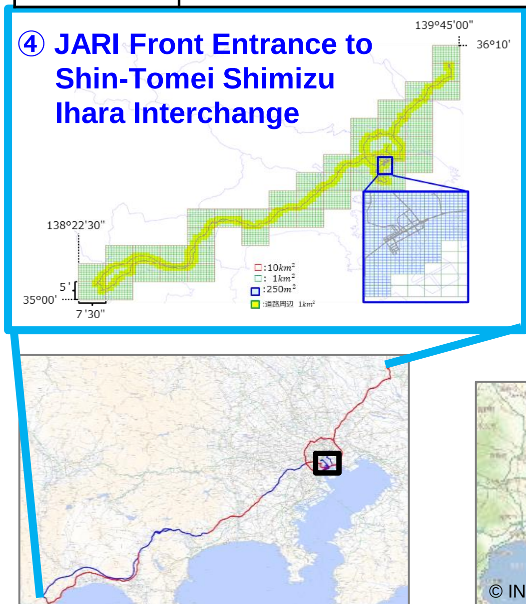


1. Overview of the FOTs in the Tokyo Waterfront Area

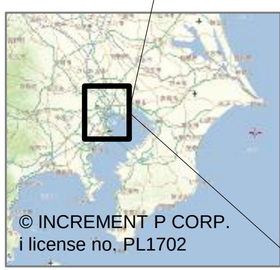
(3) FOTs area

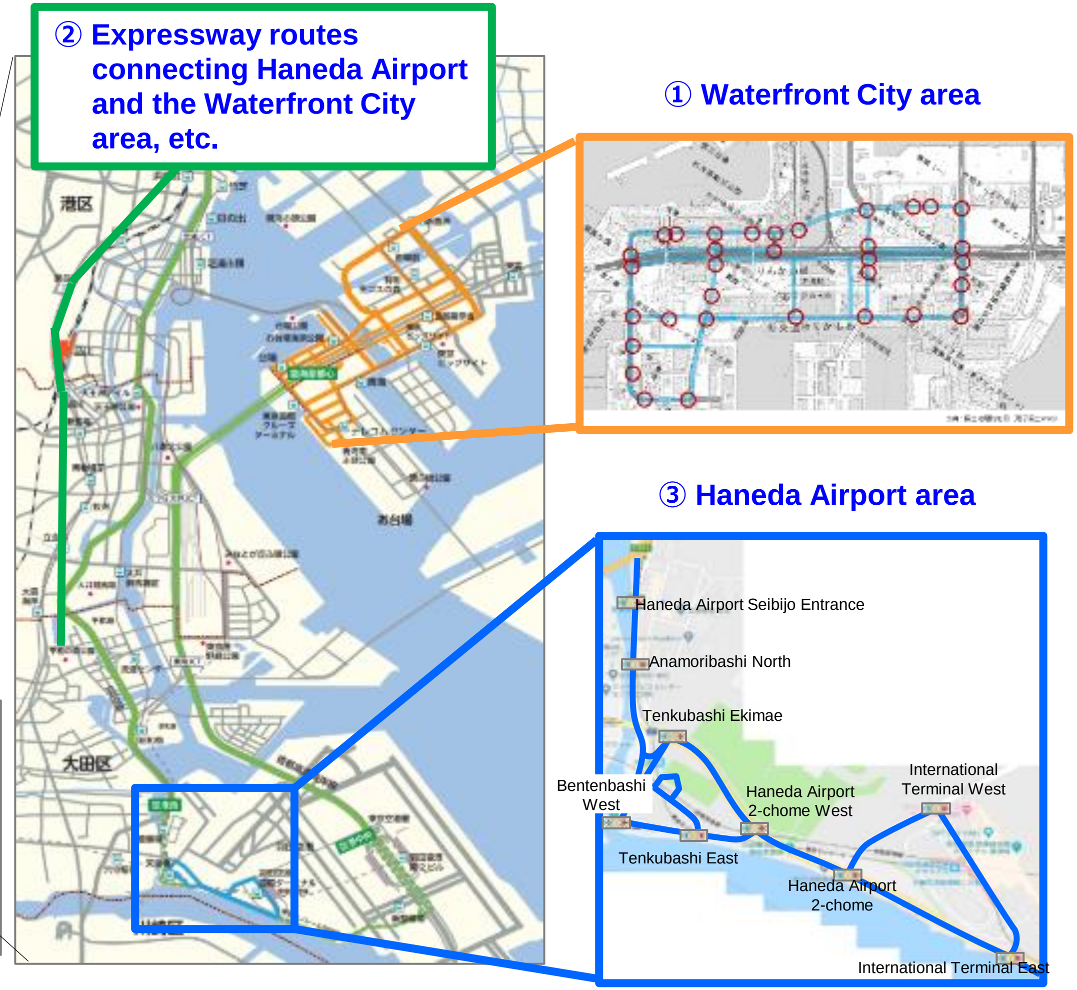
- The FOTs test areas were as shown below.

Period	Area
FY2019-2020	①Waterfront City area ②Expressway routes connecting Haneda Airport and the Waterfront City area, etc. ③Haneda Airport area
FY2021-2022	①Waterfront City area ②Expressway routes connecting Haneda Airport and the Waterfront City area, etc. ④JARI Front Entrance to Shin-Tomei Shimizu Ihara Interchange



※ Created using Geospatial Information Authority of Japan light color map



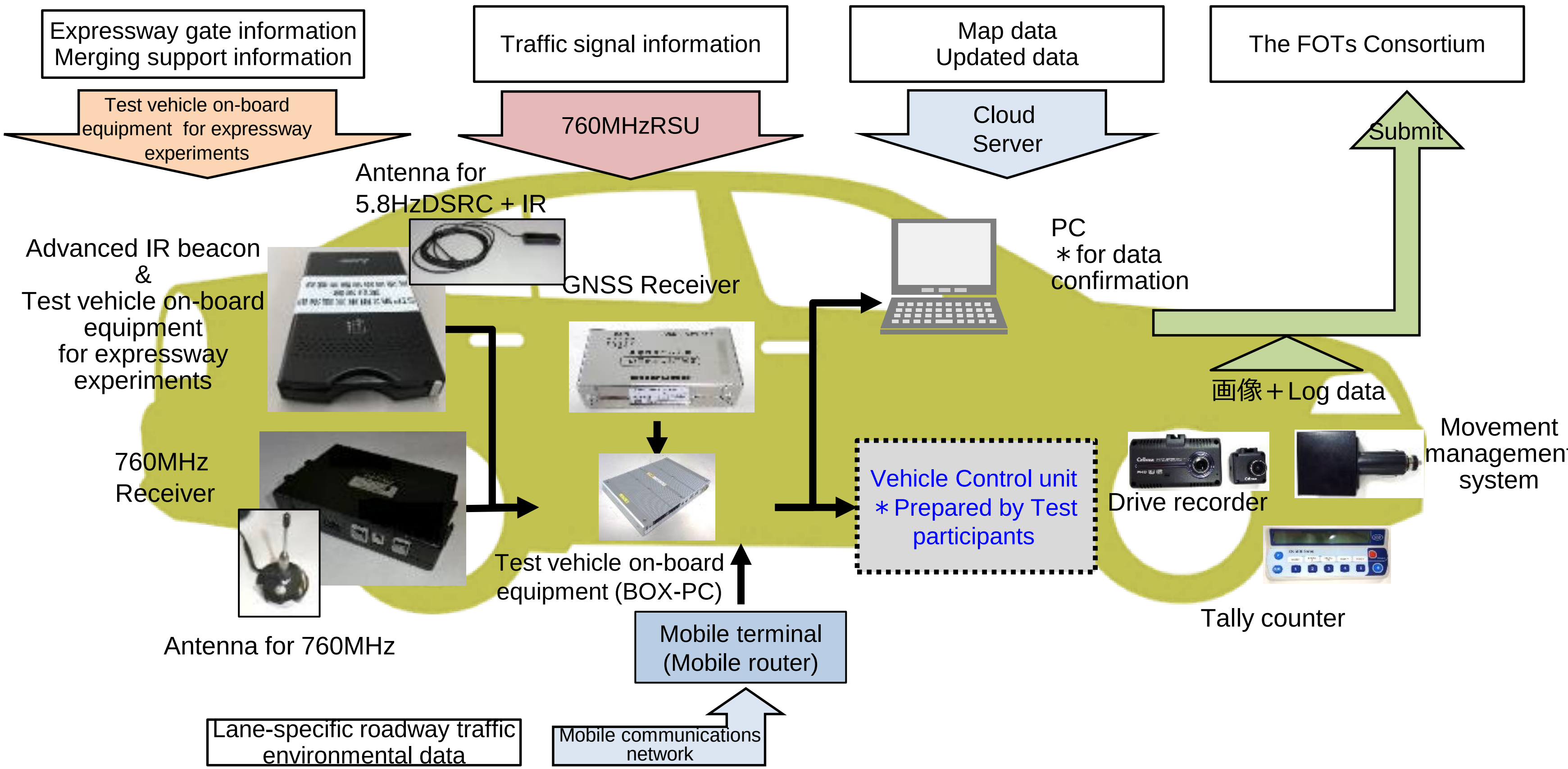


Source: Geospatial Information Authority of Japan map acquired on September 28, 2021.
https://maps.gsi.go.jp/#12/35.632884/139.810982/&base=pale&ls=pale&disp=1&vs=c0j0h0k0l0u0t0z0r0s0m0f0

1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ① FY2019-2020 (V2I)

- The test system structure was as shown below.
  - Wireless communication devices and test vehicle on-board equipment for infrastructure information reception were prepared and lent out to test participants
  - The tests used data and test equipment (transmission media) based on the four level dynamic map structure



1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ① FY2019-2020 (V2I)

- The data and transmission media used in the FOTs were as shown below.

Dynamic map structure
(Defined in SIP Phase 1)

Data	Data: detail	Media
(1) Dynamic	Traffic signal information Expressway gate information Merging support information	ITS wireless receiver for traffic signal information & ITS RSU(760MHz) Test vehicle on-board equipment and RSU for expressway experiments
(2) Semi-dynamic	Lane-specific roadway traffic environmental data	Mobile terminal & mobile communications network
(3) Semi-static	NA	NA
(4) Static	High-accuracy 3D Map data	Cloud Server
	High-accuracy 3D Updated data	Cloud Server

(4) Static information: High-accuracy 3D map planimetric features (defined in SIP Phase 1)

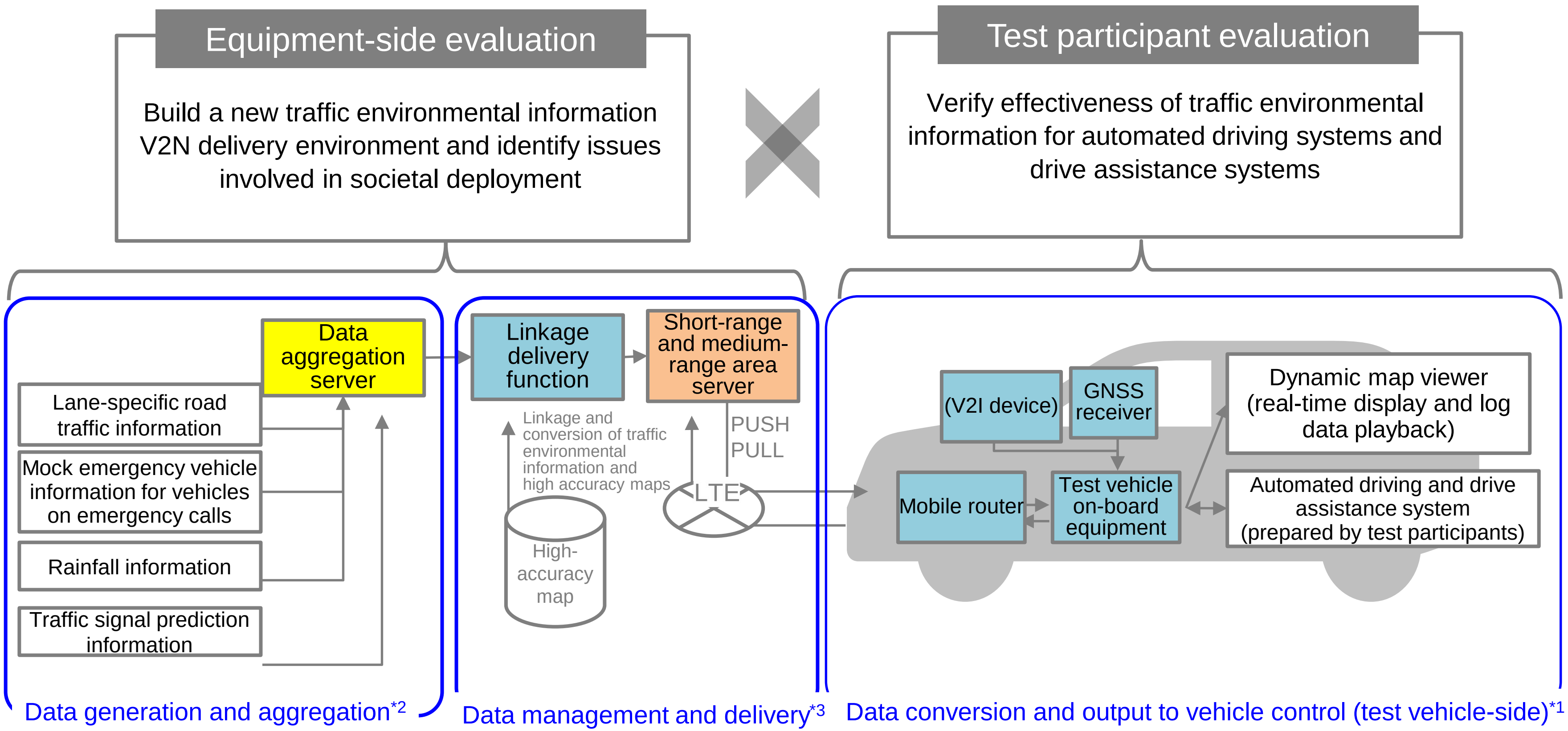
- Road shoulder
- Center line
- Lane line
- Carriageway edge
- Stop line
- Pedestrian crossing
- Road marking
- Traffic signal
- Road sign
- Road node linkage
- Lane link
- Intersection area
- Lane node linkage within intersection
- Lane node linkage within intersection
- CRP node

Area	Timing of release of high-accuracy 3D map update data		
Waterfront City area	October 2019	June 2020	January 2021
Metropolitan Expressway	October 2019	March 2020 (Haneda Route), June 2020 (Bayshore Route)	—
Haneda Airport area	—	June 2020	—

1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ② FY2021-2022 (V2N)

- The overall test system structure was as shown below.
  - A test system was created in conjunction with a contractor from another project, focusing on the perspectives of equipment-side and participant-side evaluation

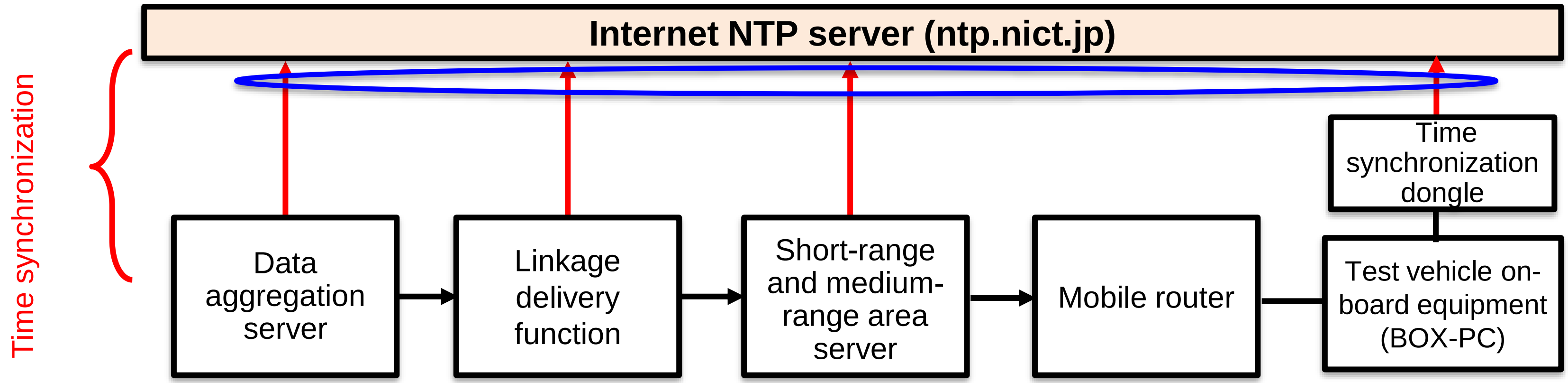


*1:Implementation of FOTs in the Tokyo Waterfront Area [FOTs in the Tokyo Waterfront Area Consortium (representative: Mitsubishi Electric Corporation]
*2:Examination and Evaluation of Automated Driving Control Technologies that Use Lane-specific Probes, etc. [Pacific Consultants Co., Ltd.]
*3:Research and Development on the Collection, Integration, and Delivery of Short-range and Medium-range Information [NTT DOCOMO, Inc./Mitsubishi Electric (order placement) (FY2022)]

1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ② FY2021-2022 (V2N)

- The structure of the system used in the measurement of transmission times was as shown below.
  - Device times were synchronized with an NTP server on the internet to achieve an average transmission delay of approximately 1.6 ms (max. ± 20 ms)



Device	Deviation (- ahead, + behind)	Flow of data
Data aggregation server	-47 µs to 52 µs	PUSH/PULL
Linkage delivery function	-3.17 ms to 0.6 µs	PUSH/PULL
Data distribution server	-1.72 ms to 16.4 ms	PUSH
Test vehicle on-board equipment	-14.8 ms to 16.4 ms	PUSH/PULL

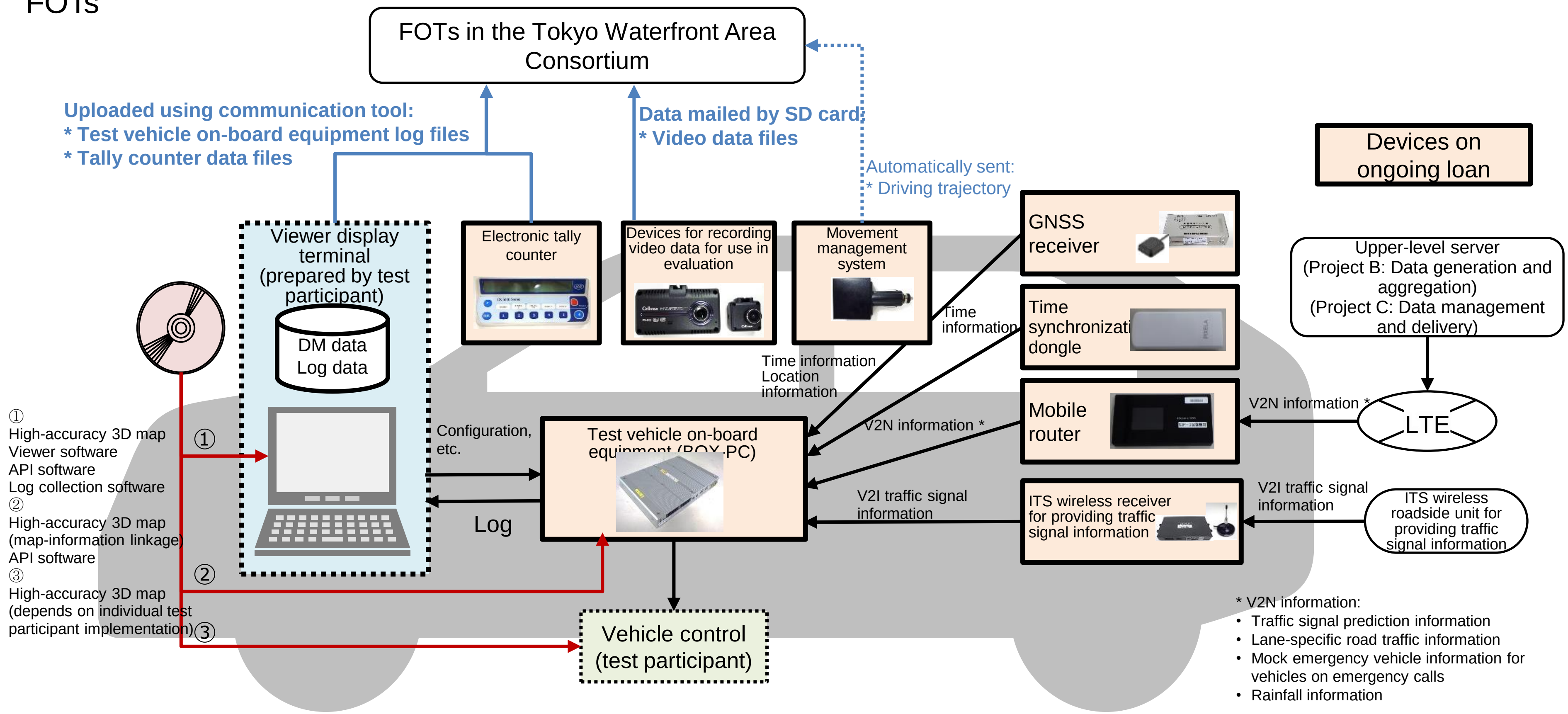
1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ② FY2021-2022 (V2N)

- The on-board system structure was as shown below.

- In FY2021-2022, a dongle for synchronizing the time with the mobile router was added to the on-board system

- Other than the above, the same equipment prepared and loaned in the previous year were reused for these FOTs



1. Overview of the FOTs in the Tokyo Waterfront Area

(4) Test system structure and transmission media ② FY2021-2022 (V2N)

- The data and transmission media used in the FOTs were as shown below.
  - Traffic environmental information, which consists of dynamic information, semi-dynamic information, and semi-static information, is delivered via V2N (LTE)

Data	Data details	Transmission media
(1) Dynamic information	Traffic signal information	V2I: ITS wireless receivers & ITS roadside units (760MHz) for providing traffic signal information
	Traffic signal prediction information	V2N: LTE
	Mock emergency vehicle information for vehicles on emergency calls	V2N: LTE
(2) Semi-dynamic information	Lane-specific road traffic information	V2N: LTE
	Rainfall information (short range)	V2N: LTE
(3) Semi-static information	Rainfall information (long range)	V2N: LTE
(4) Static information	High-accuracy 3D map data	Cloud server
	High-accuracy 3D map update data	Cloud server

(4) Static information: High-accuracy 3D map planimetric features

- Road shoulders
- Road center lines
- Lane lines
- Road edges
- Stop lines
- Pedestrian crossings
- Road markings
- Traffic signals
- Road signs
- Road node linkages
- Lane node linkages
- Lane node linkages within intersections
- Intersections
- CRP nodes

1. Overview of the FOTs in the Tokyo Waterfront Area

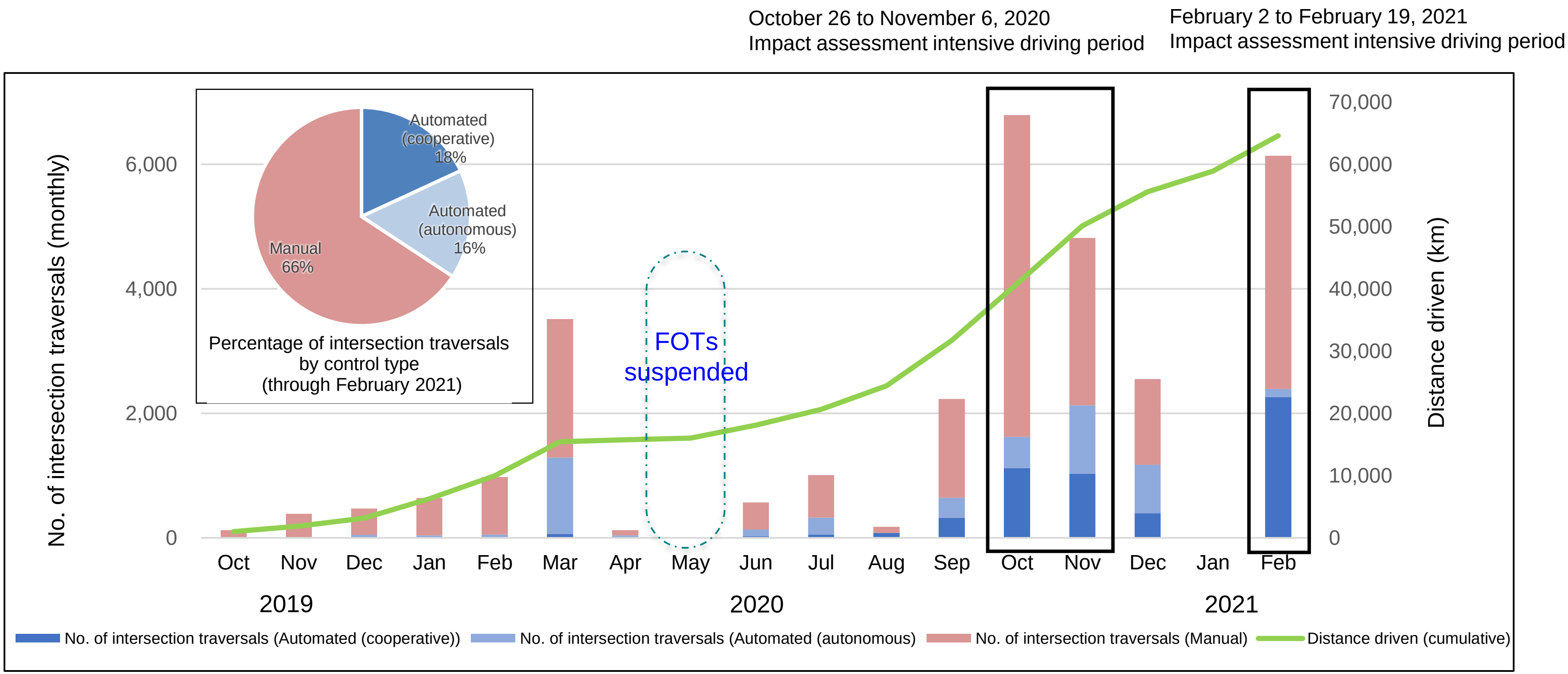
(5) Test participant driving results ① FY2019-2020 (V2I)

[Waterfront City area]

October 15, 2019 to February 28, 2021 (16 months)

: Approx. **64,591 km** (figures collected via movement management system)

The total mileage exceeded the planned 54,000km.



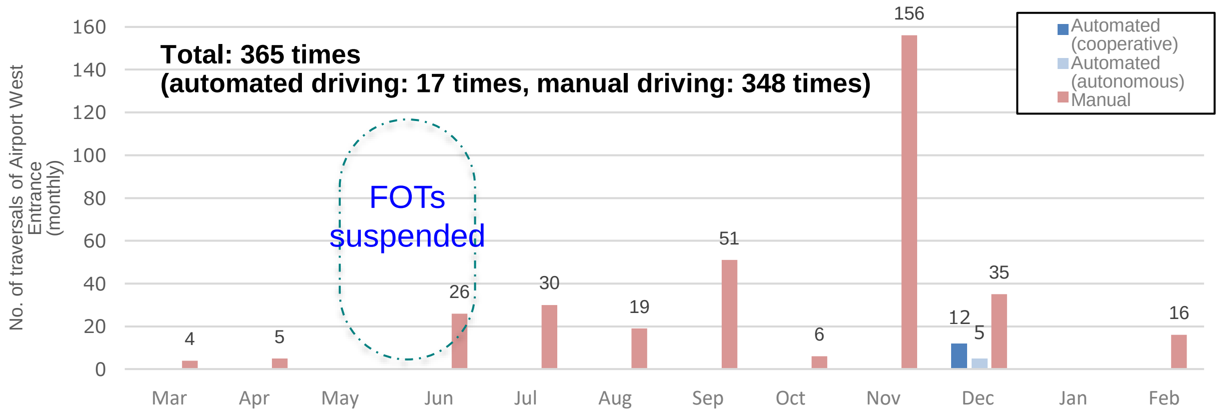
Driving results to data

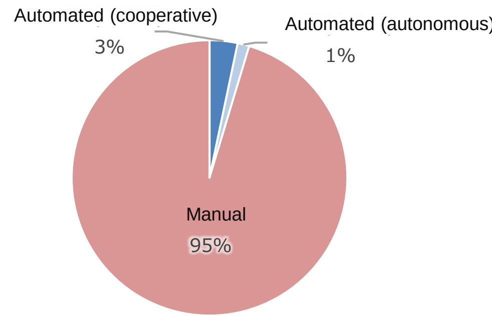
Driving performed with vehicle control that used traffic signal information provided by infrastructure has been tabulated as cooperative driving

1. Overview of the FOTs in the Tokyo Waterfront Area

(5) Test participant driving results ① FY2019-2020 (V2I)

[Metropolitan Expressway routes connecting Haneda Airport and the Waterfront City area, etc.]



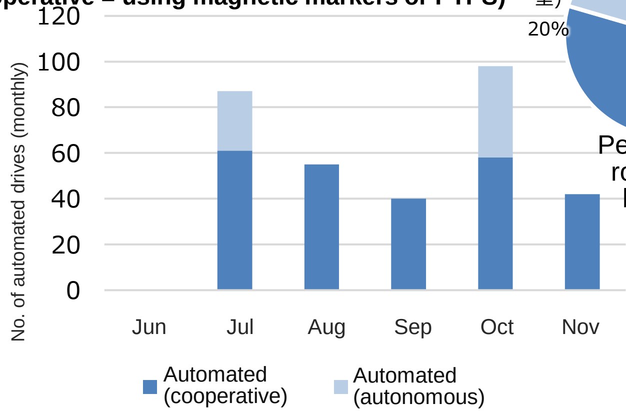


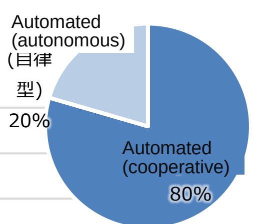
Percentage of Airport West entrance test drives by control type
ETC gate + merging
(through February 2021)

Driving performed with vehicle control that used ETC gate passing/merging support information provided by infrastructure has been tabulated as cooperative driving

[Haneda Airport area]

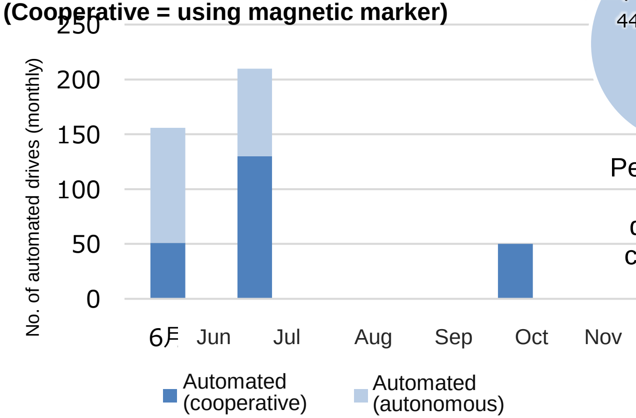
Route drives: 322
(Cooperative = using magnetic markers or PTPS)

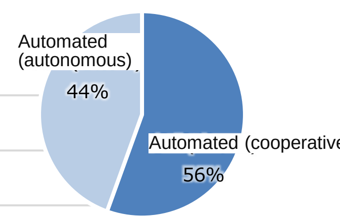




Percentage of route drives by control type

Precision docking: 416 times
(Cooperative = using magnetic marker)





Percentage of precision docking by control type

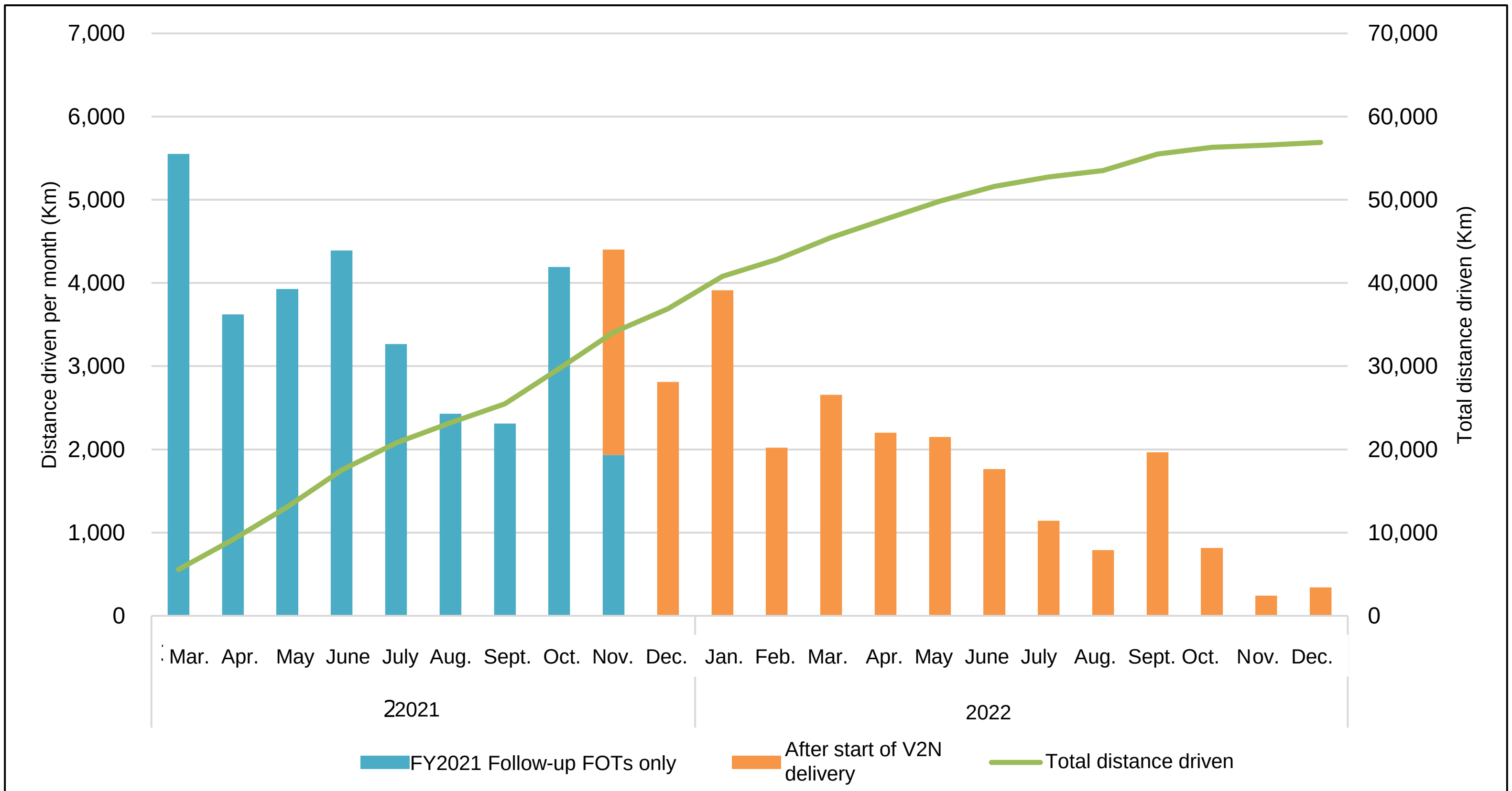
1. Overview of the FOTs in the Tokyo Waterfront area (V2N)

(5) Test participant driving results ② FY2021-2022 (V2N)

- March 1, 2021, to December 23, 2022 (22 month period): Approx. 56,888 km
  Of these, approx. 31,617 km of driving were performed between March 1 and November 14, 2021 (8.5 months, V2I only) and approximately 25,271 km of driving were performed between November 15, 2021 and December 23, 2022 (13.5 months, V2N+V2I)

[Ref.] Approximately 64,591 km of driving were performed between October 2019 and February 2021 (17 months)

- There were zero accidents during the entire test period (October 15, 2019 to December 23, 2022)



2. V2I delivery of traffic environmental information

Note) For details regarding V2I delivery of traffic environmental information, see the Cabinet Office website
https://www.sip-adus.go.jp/rd/
FY2020 Research and Development - Projects Reports - Development and validation (FOTs) of automated driving systems - Implementation of FOTs in the Tokyo Waterfront Area - Summary
(https://www.sip-adus.go.jp/rd/rddata/rd04/103s.pdf)

2-1. Traffic signal information

(1) Issues, verification items, and targets

Issues

- **Ensure reliability of signal recognition by vehicle**
- **Presence of dilemma zones* interfering with smooth traffic flow**

Benefits of cooperative infrastructure technologies

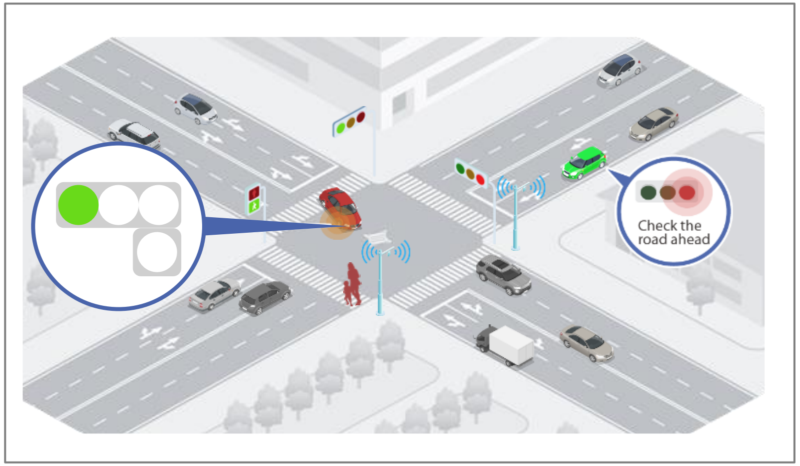
- Recognition improved by use of dual information systems
- Avoidance of dilemma zones* through use of predictive traffic signal information (number of remaining seconds)

Verification items

(1) Traffic signal information
(a) Effectiveness of traffic signal color information
(b) Effectiveness of traffic signal remaining seconds information
(2) Assessment of impact of automated vehicle driving on traffic flow and factors causing this impact

Target

- **Verify effectiveness of distributing traffic signal information**
- **Confirm specifications aimed at standardization and consensus by test participants**
- **Identify environmental conditions required for traffic signal information distribution**
- Clarify issues to be addressed in order to cultivate a sense of acceptability in society



*Dilemma zone definition
Region in which, when the traffic light turns yellow, the vehicle would not be capable of stopping before the stop line when decelerating at the normal deceleration rate but the vehicle would not be able to traverse the intersection (stop line) while the traffic light was still yellow if maintaining the same pace

2-1. Traffic signal information

(2) Summary

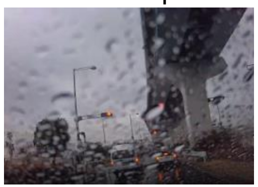
- We confirmed that providing traffic signal color information and remaining seconds information using Dedicated Short Range Communications (DSRC) infrastructure was effective at enabling automated vehicles to safely and smoothly traverse intersections with traffic lights on general roads.
- We confirmed conditions, such as road structures, under which infrastructure is necessary
"Roads with curves, etc., that result in traffic signals coming into view at short distances from the traffic signals," "roads with high speed limits," "intersections with traffic signals located near other intersections with traffic signals," "nonpermanent conditions (such as backlighting/direct lighting, rain, obstruction by preceding vehicles, nighttime driving, and blending into the background) under which it is difficult for on-board cameras to determine traffic signal colors"
→ Vehicle-infrastructure cooperation can be used to introduce and expand safe, smooth automated vehicle usage by preparing infrastructure covering entire areas after defining areas where automated vehicles, including those providing mobility services, will be used
- Although a consensus was reached with test participants regarding information distributed by ITS wireless roadside units for existing services (ISO/TS19091 specification compliant), there were requests that remaining seconds information for actuated traffic signal be confirmed earlier. The impact will be even greater for V2N, so future consideration will need to be given to the delivery of this information using V2N.

Backlighting

Direct lighting

Concealment/ obstruction

Raindrops

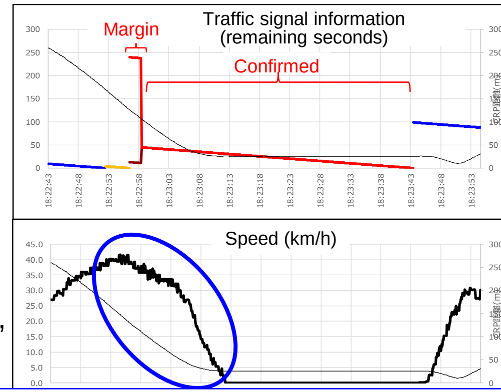


Blending into background

* From materials prepared by the Kanazawa University Promotion Committee

Nighttime

Providing traffic signal information was effective if enabling automated vehicles to safely and smoothly traverse intersections with traffic lights on general roads , even in environments where traffic signal identification is difficult.

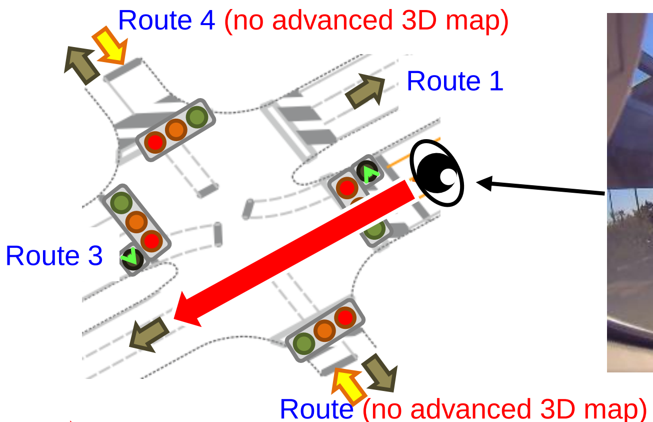


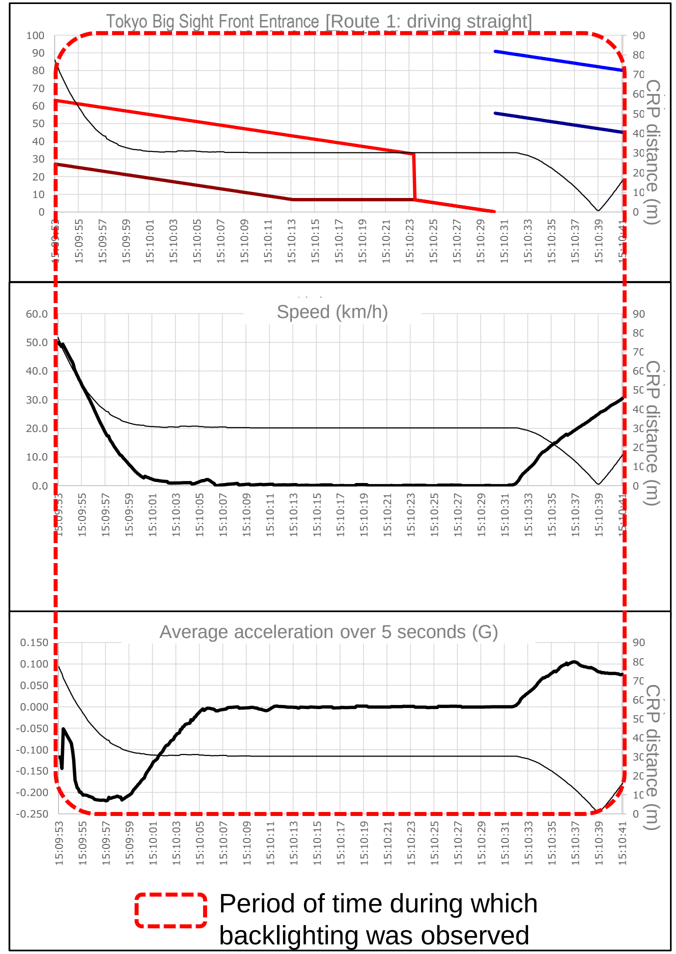
Camera-based traffic signal recognition functions were not used. **Instead, infrastructure information alone was used to identify red lights and stop safely.**

2-1. Traffic signal information

(3) Results of tests of "(a) effectiveness of traffic signal color information"

- Backlighting example: Vehicle behavior characteristics and system-side detection results for individual factors that interfered with traffic signal color recognition





Entry/exit route   Drive recorder images

Experiment date/time	Automated driving	Intersection no.	Name of intersection	Conditions	Entry route	Exit route	Traffic signal color	Camera recognition accuracy	Duration of decrease in camera recognition accuracy	Remaining seconds information used?
2020/11/5 15:10	Automated (Autonomous)	21	Tokyo Big Sight Front Entrance	Backlighting	Route 1	Route 3	Red → Green	Recognition accuracy fell slightly	Recognition accuracy fell slightly for a very short amount of time	No

[Results of signal color detection by test participant systems]

- The traffic signal color recognition accuracy of the camera dropped slightly for just a moment
- We confirmed several frames during which a distant red traffic signal was mistakenly identified as being yellow

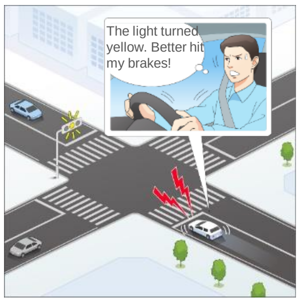
2-1. Traffic signal information

(4) "② Effectiveness of traffic signal remaining seconds information" - Factors causing differences in intersection traversal decision-making

- The follow factors caused differences in intersection traversal decision-making.

Stopping in traversal areas

Situations in which the vehicle sudden decelerates and stops when it could have traversed safely

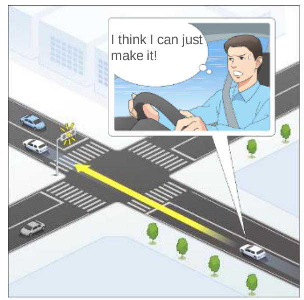


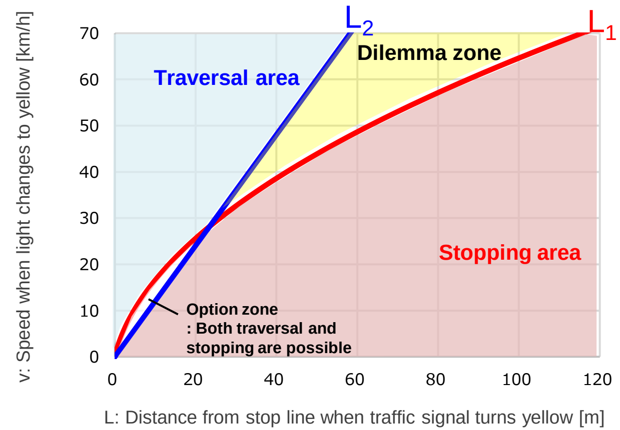
Encountering dilemma zones

Situations in which the vehicle cannot safely traverse the intersection or stop, and has difficulty deciding what to do

Traversal in stopping areas

Situations in which the vehicle should stop but instead traverses the intersection





Of the total of 29,728 intersection traversals, participants confirmed 127 cases of stopping in traversal areas,
12 encounters with dilemma zones, and 9 cases of traversal in stopping areas

Stopping in traversal areas	Encountering dilemma zones	Traversal in stopping areas
127 (0.43% of total)	12 (0.04% of total)	9 (0.03% of total)

Occurrence of differences in judgment when passing through an intersection in the entire test area

- Driving data for all intersections was used to evaluate the effectiveness of traffic signal remaining seconds information.
- Information was collected and organized for all intersections in the Waterfront City area for each factor that resulted in differences in intersection traversal decision-making.
- This is shown in 3.2 of supplementary material 3.

2-1. Traffic signal information

(5) "② Effectiveness of traffic signal remaining seconds information" - Test results [1/3]

For routes **with 4 second yellow lights,** the distributions of speeds and distances from stop lines were checked when lights turned yellow

- When driving was performed without traffic signal remaining seconds information, traversal and stopping were broadly mixed within the traversal area
- When driving was performed using traffic signal remaining seconds information (cooperative infrastructure driving), there was less mixing of traversal and stopping.

The distribution diagrams and parameters for both, for driving straight only, are as shown below
• Allowable deceleration: 0.2[G], reaction time: 1.0[s], yellow signal duration: 4.0[s]

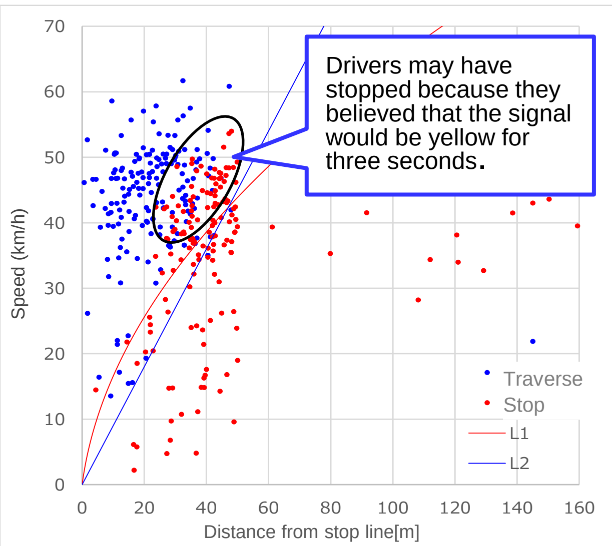


Fig.: Distribution of intersection traversal decisions during **manual driving**

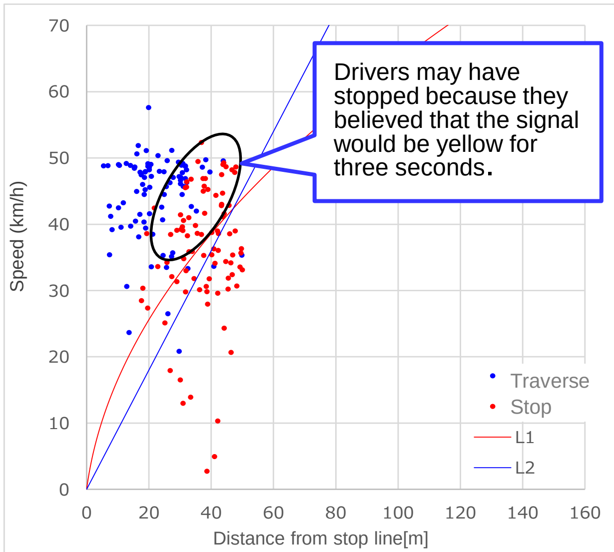


Fig.: Distribution of intersection traversal decisions during **automated driving (cooperative [no remaining seconds]/autonomous)**

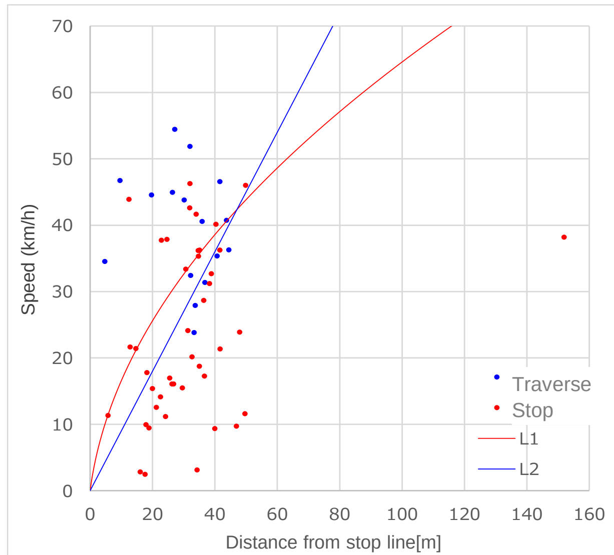


Fig.: Distribution of intersection traversal decisions during **automated driving (cooperative [remaining seconds])**

2-1. Traffic signal information

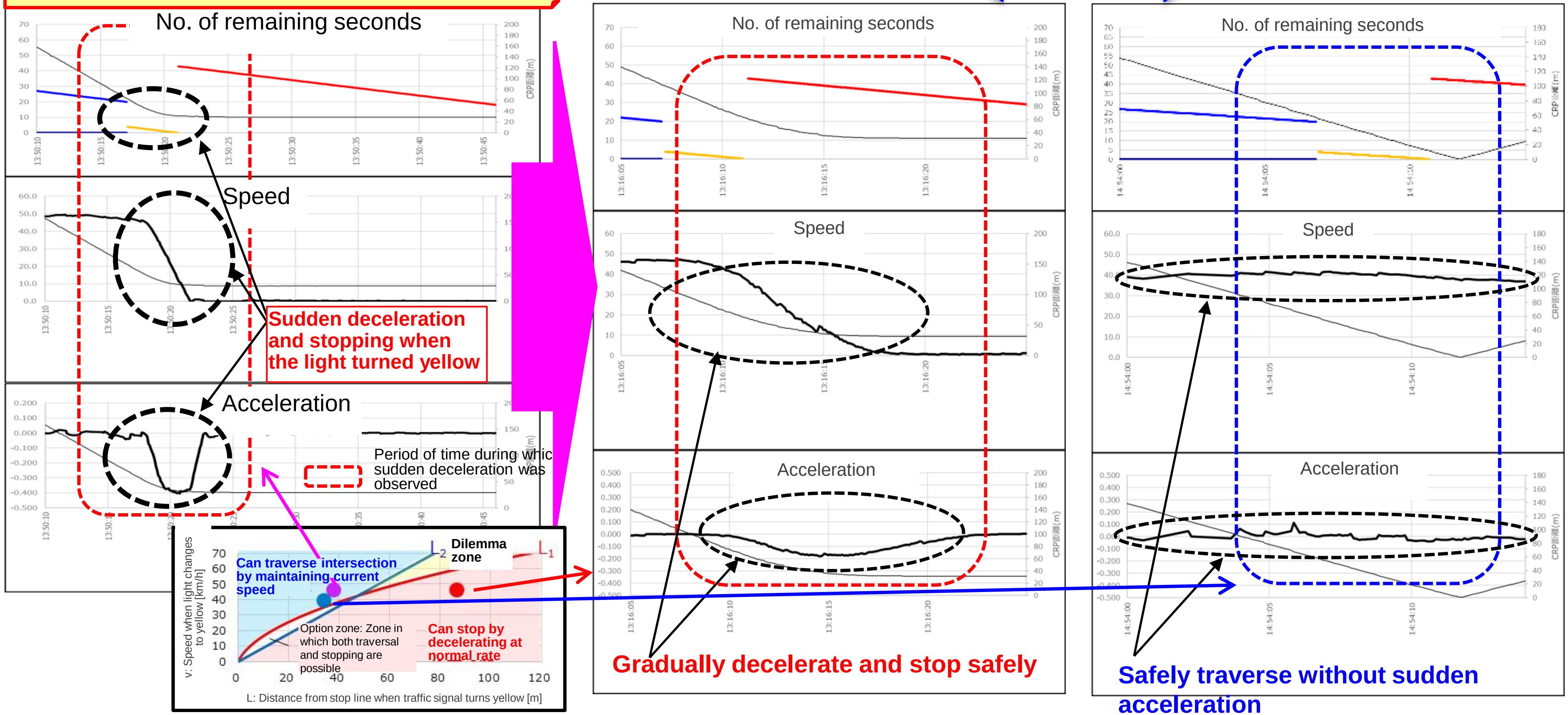
(5) "② Effectiveness of traffic signal remaining seconds information" - Test results [2/3]

b. Effectiveness of predictive traffic signal information (number of remaining seconds)

Use of traffic signal remaining seconds information for vehicle control (actual measurement data)

Cases of sudden deceleration and stopping in traversal area

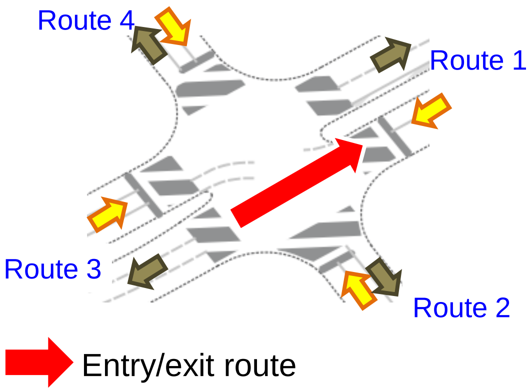
<u>Stopping</u> determined in advance to be possible ⟷ <u>Traversal</u> determined in advance to be possible



2-1. Traffic signal information

(5) "② Effectiveness of traffic signal remaining seconds information" - Test results [3/3]

- Routes with 4 seconds of remaining yellow light time: Infrastructure information (traffic signal remaining seconds) was used and preliminary deceleration was performed
  ➡When the light was yellow, infrastructure information was used to stop safely



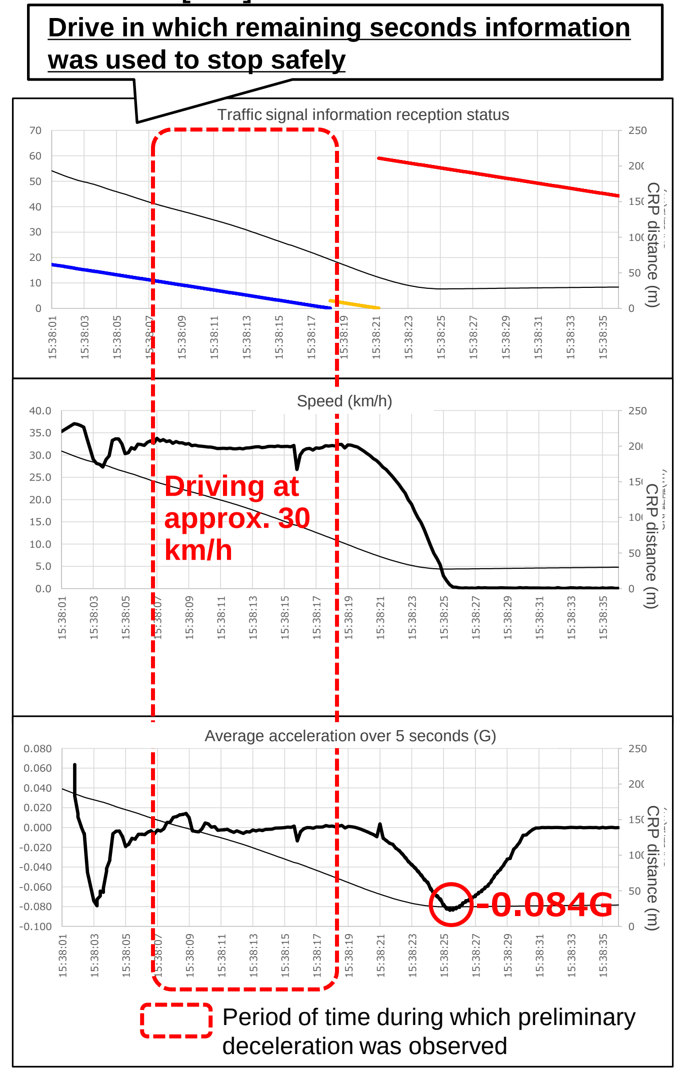
Name of intersection	Intersection no.	Entry route	Exit route
Telecom Station-mae	B	Route 3	Route 1

Driving speed		Type of remaining seconds
Entry route	Exit route	
50km/h	50km/h	Confirmed

Yellow remaining seconds	Impact on vehicle control	Deceleration following changing to yellow
3 seconds	The vehicle slowed and stopped	-

[Results of analysis of dilemma candidates based on test vehicle on-board equipment log data]

- We confirmed that traffic signal remaining seconds information was used to perform preliminary deceleration, causing the vehicle to gradually decelerate and come to a stop when approaching the Telecom Station-mae intersection from route 3.



2-1. Traffic signal information

(6) Recommendations: Environmental requirements for traffic signal information distribution (traffic signal color information, traffic signal remaining seconds information)

[Situations in which traffic signal color information is effective (findings based on test results)]

- Providing traffic signal color information to automated vehicles is effective in the following situations:
  - Backlighting: Times of day when sunlight from behind traffic signals (including light reflected by buildings) competes with light from traffic signals → occurs during certain times of day
    Traffic conditions in which the headlights of oncoming vehicles compete with light from traffic signals
  - Direct lighting: Times of day in which sunlight from behind vehicles competes with traffic signals
    → occurs during certain times of day
  - Concealment/obstruction: Traffic conditions in which traffic signal colors are concealed by nearby large vehicles, etc. → occurs during certain traffic conditions
    Road structures in which traffic signals are located in blind spots, such as immediately after curves and on crest vertical curves → occurs with certain road structures
  - Blending into background: Times of day and road structures in which traffic signals themselves blend into background buildings, etc.
  - Nighttime: Times of day in which multiple light sources reduce traffic signal color recognition accuracy
  - Raindrops: Weather conditions in which raindrops get on cameras and reduce traffic signal color recognition accuracy

[Situations in which traffic signal remaining seconds information is effective (findings based on test results)]

- Providing traffic signal remaining seconds information to automated vehicles is effective in the following situations:
  - Intersections located short distances from other intersections with traffic signals
  - Intersections on routes with high speed limits
  - Intersections with short yellow signal durations

Approach to determining for which intersections to prioritize traffic signal information delivery
= Derive based on traffic signal installation policy and the results of this FOT

2-1. Traffic signal information

(6) Recommendations: Environmental requirements for traffic signal information distribution (traffic signal color information, traffic signal remaining seconds information)

Traffic Signal Installation Policy (National Police Agency)

Requirements

- Secure sufficient width
- Secure sufficient space for crosswalk pedestrians to wait
- As a general rule, intersections on major roads traversed by 300 vehicles or more per hour during peak times, including traffic in both directions
- As a general rule, traffic signals must be 150 m or more from adjacent traffic signals
- Install on traffic signal poles that are visible to both drivers and pedestrians

Selectable conditions

- Number of accidents involving injury/death
- Proximity to elementary schools, junior high schools, etc.
- Main and minor road traffic volume
- Need for crossing by pedestrians

Source: National Police Agency "Traffic Signal Installation Policy" (Dec. 28, 2015)

Situations in which traffic signal information is effective (this FOT)

Factors impeding color recognition: Traffic signal color information

- Curves and crests (rising/falling sections)
- Backlighting/direct lighting
- Obstruction by large vehicles
- Arrow signals
- Raindrops, blending into the background
- Intersections located short distances from adjacent traffic signals

Differences in intersection traversal decision-making: Traffic signal remaining seconds information

- Intersections located short distances from other intersections with traffic signals
- Intersections on routes with high speed limits
- Intersections with short yellow signal durations

Traffic Signal Installation Policy (National Police Agency)
: Premises of infrastructure device installation policy

Features of intersections in which there are often factors impeding color recognition or differences in intersection traversal decision-making (results of FOT)

It would be best for traffic signal information to be provided for all intersections in sections in which automated driving is performed.
Traffic signal information also appears to be effective for providing driving assistance, so, if prioritizing installation, the following intersections should be prioritized:

- Intersections which cannot be seen past/fall outside of line of sight (curves and crests)
- Intersections on routes with high speed limits
- Intersections located short distances from adjacent traffic signals

2-2. ETC gate passing/merging support

(1) Issues, verification items, and targets

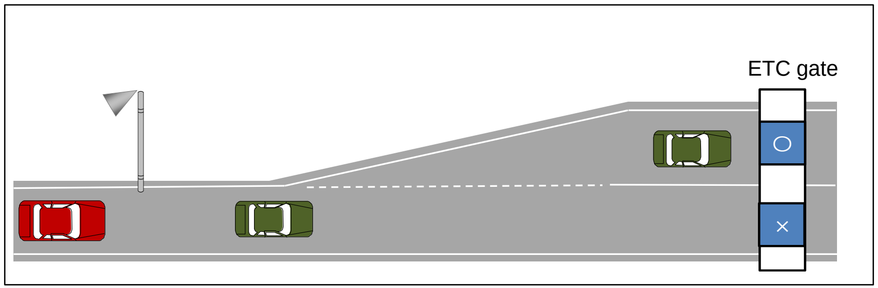
Issues

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

Verification items

(1) Appropriateness of operation of cooperative infrastructure system
  (a) Confirmation of the data received from roadside wireless units for expressway experiments and the data output to vehicle control
  (b) Measurement of transmission time between roadside wireless units for expressway experiments and test vehicle on-board equipment
(2) Effectiveness of support information provided to automated vehicles, etc.
  (a) Confirmation of the effectiveness of ETC gate passing support information
  (b) Confirmation of the effectiveness of merging support information

➡ Evaluation results are shown on the following pages

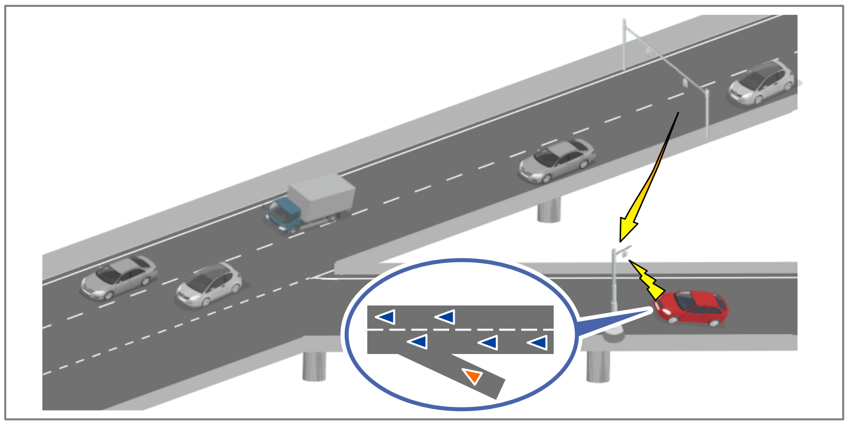


Benefits of cooperative infrastructure technologies

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

Targets

- **Investigation of infrastructure information provision specifications (including improvements)**
- **Identify infrastructure installation conditions for Airport West entrance**
- **Clarify issues in order to define specifications based on FOTs**
- **Identify need for infrastructure and prioritization requirements**

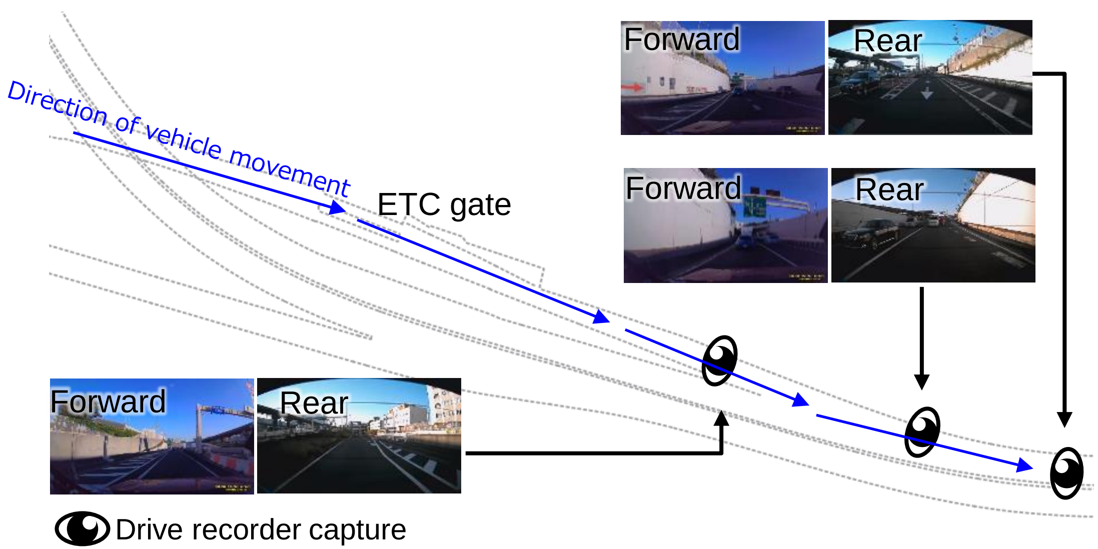


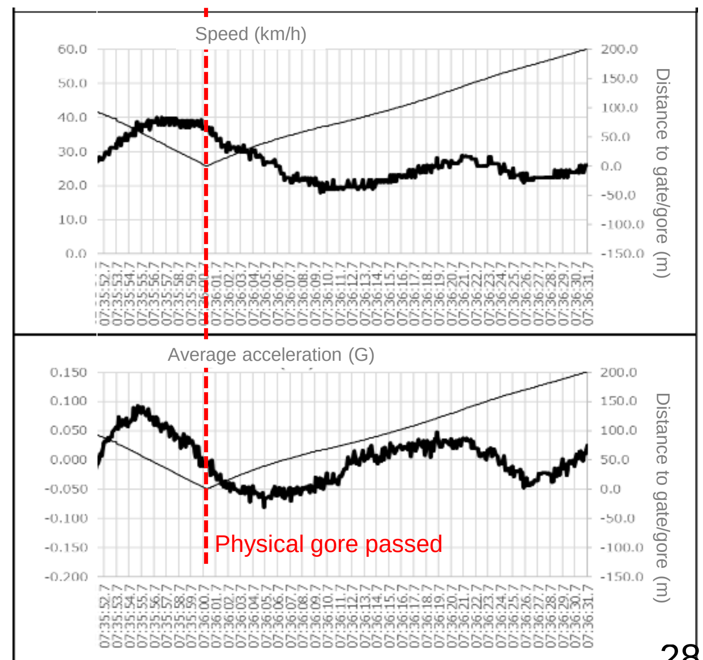
2-2. ETC gate passing/merging support

(2) Summary

- We verified that ETC gate passing support information provided at an early point via Dedicated Short Range Communications (DSRC) was effective not only for automated vehicle route planning but also as information that assisted drivers with smooth driving.
- Information regarding vehicles driving on cruising lines with poor visibility was provided via DSRC to merging vehicles, and we verified that it was effective for merging support provided by automated driving functions and as caution information for drivers.
- Information was provided on spot detection of vehicles on cruising lines, so we observed that the accuracy of the information fell when cruising line vehicle speeds were not consistent between detection points and merging points due to signs of traffic jams, etc.

Note) Based on the results of this FOT, consideration must be given to improving the accuracy of information in diverse conditions.





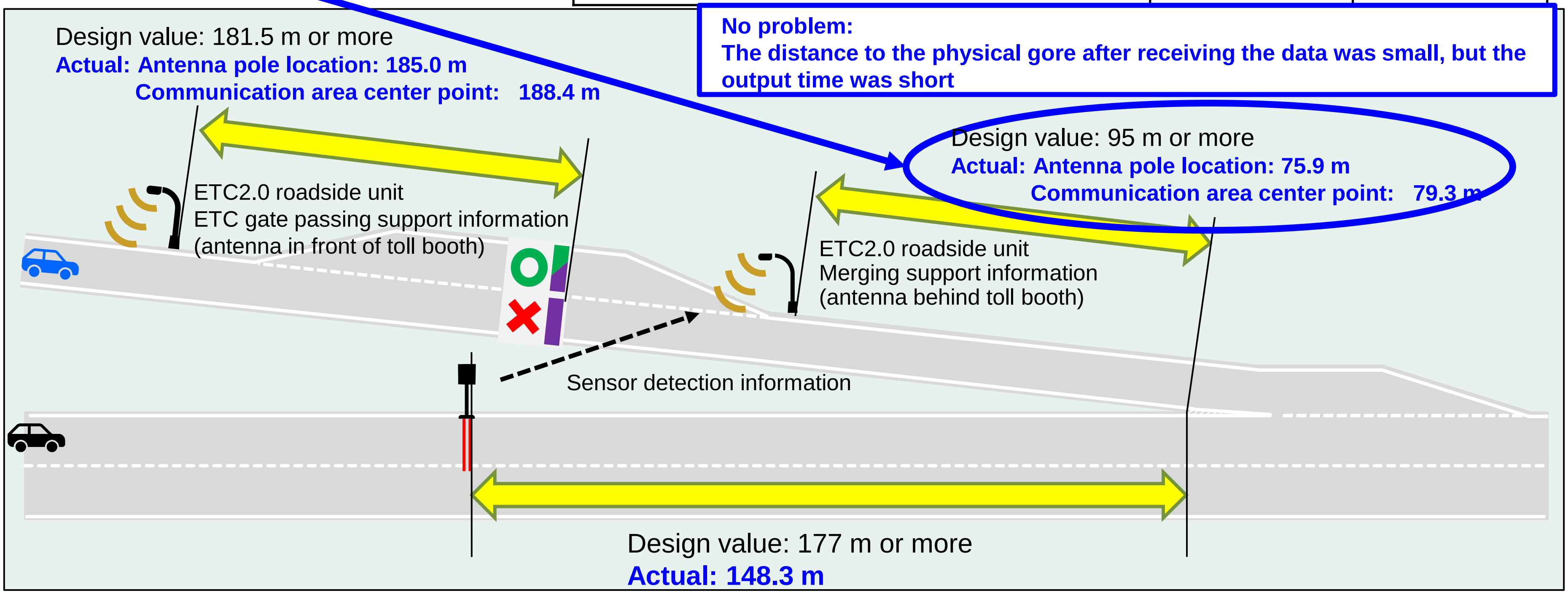
2-2. ETC gate passing/merging support

(3) Conditions

① ETC gate passing support information ②Merging support support information

NILIM design prerequisites
After receiving data on the vehicle side:
Time to CAN output=**1.3 seconds**
Measured value:**0.6 seconds**

Item	Design value (m)	Measured value (m)
Distance between antenna in front of toll booth and gate	181.5 or more	188.4
Distance between antenna behind toll booth and merging end (physical gore)	95 or above	79.3
Distance between vehicle sensor ① and merging end (physical gore)	177 or more	148.3



Note) The device locations when the system was designed by NILIM and the locations of the actual installed devices differ, so confirmation was performed from the perspective of ensuring sufficient time for automated driving control

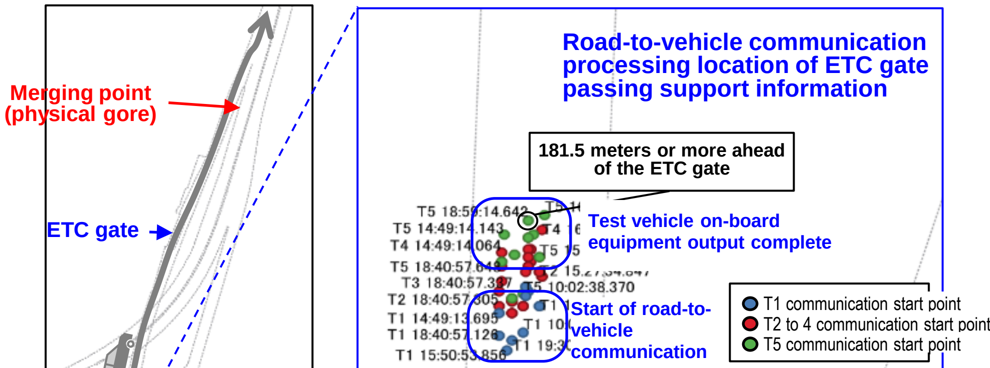
2-2. ETC gate passing/merging support

(4) Test results "① ETC gate passing support information"

- Measured and confirmed effectiveness of transmission time between roadside wireless units for expressway experiments and test vehicle on-board equipment
- ETC gate passing support information: Processing completed 181.5 meters*1 or more ahead of the ETC gate
- Automated driving situations involving the use of ETC gate passing support information were confirmed through test participant driving

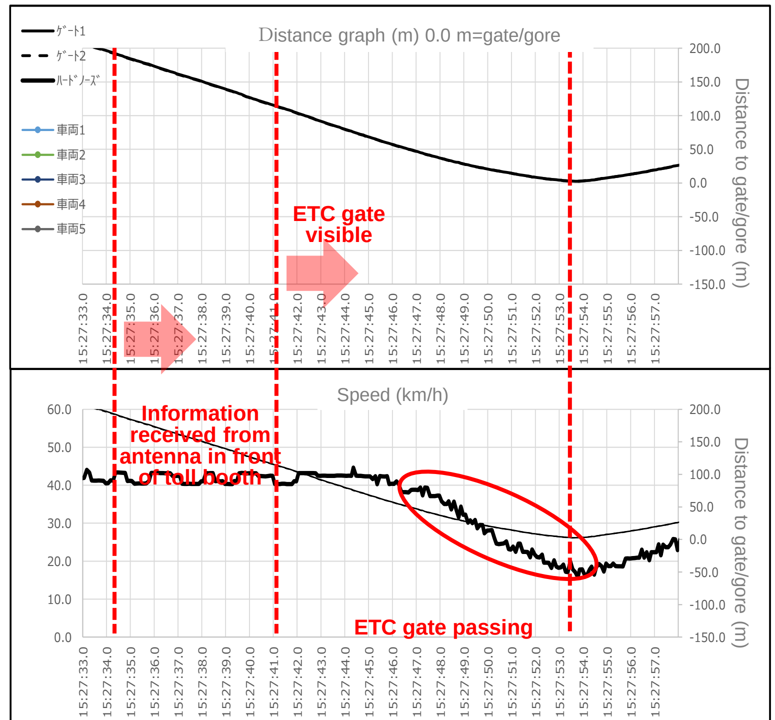
  ➡ Vehicles safely passed through usable ETC gates and **the effectiveness of ETC gate passing support information was confirmed**

*1JAMA requirement



Airport West entrance
(ETC gate to merging ramp)

Fig.: Information already received from antenna in front of toll booth, ETC gate not visible (left), ETC gate visible (right)

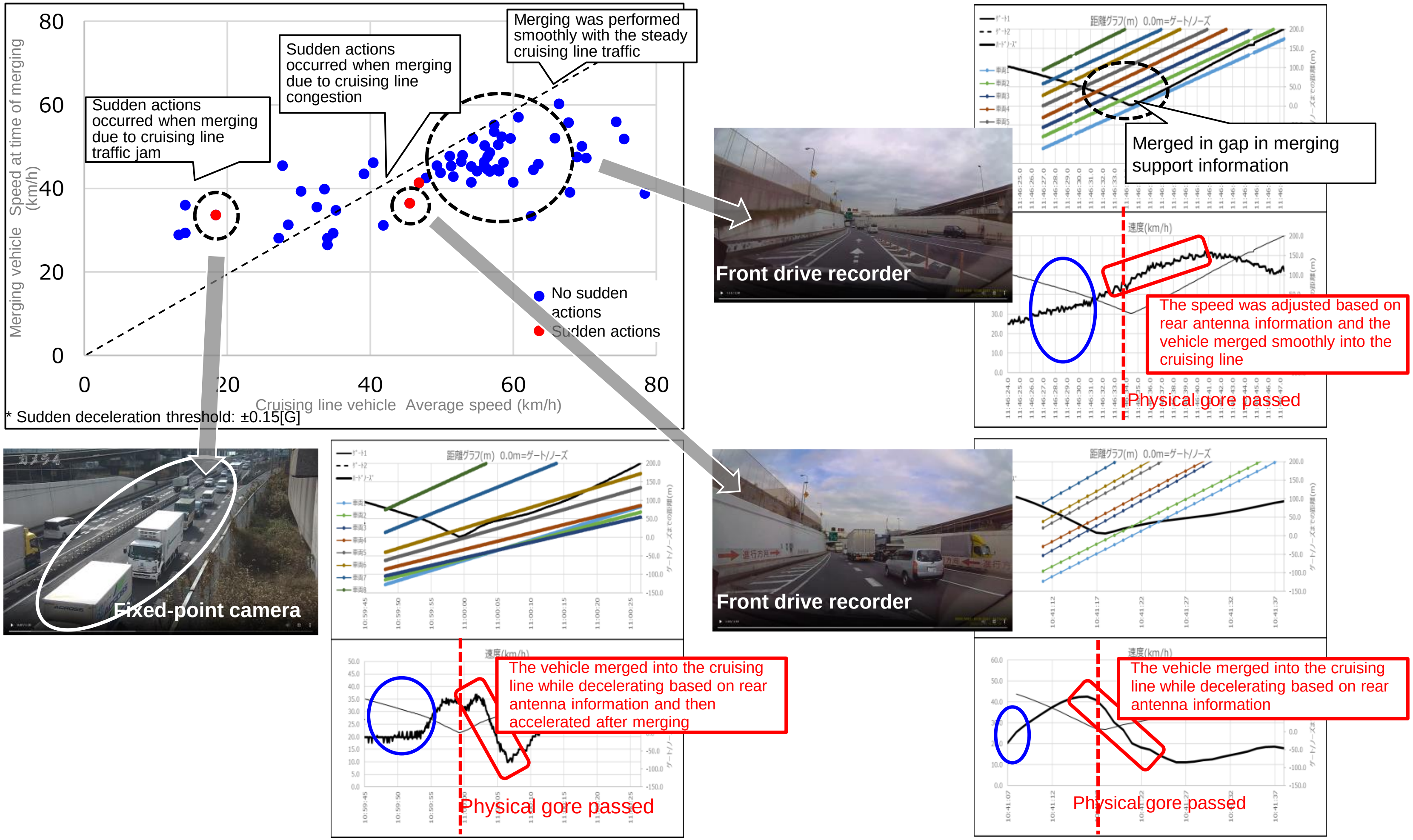


2-2. ETC gate passing/merging support

(4) Test results "② Merging support information"

- The behavior of individual vehicles was analyzed, taking into consideration the relationship between cruising line vehicle speeds and merging vehicle speeds when driving using cooperative driving

With cooperative driving：Driving using ETC gate passing/merging support information



2-2. ETC gate passing/merging support

(5) Recommendations: ① ETC gate passing support information

[Issues to be resolved in order to define specifications/related requests]

■ ETC gate passing support information

➡ Confirm transmission of accurate information to automated vehicles

➡ None of the participants indicated there were any issues to be addressed before practical implementation

➡ ETC gate passing support information could be used effectively as support information provided to the driver, etc.

➡ The following additional format request was made

- ✓ Request for cruising line traffic conditions to be added to gate passing support information (in order to rapidly determine if merging is possible)

Test result findings were arrived at and agreed upon based on the following

- ✓ Data provided by test participants (traversed Airport West Entrance 365 times (17 times using automated driving and 348 times using manual driving)
- ✓ Test participant evaluation questionnaire

2-2. ETC gate passing/merging support

(5) Recommendations: ②Merging support support information"

[Issues to be resolved in order to define specifications/related requests]

■ Merging support information

➡ The FOTs system may work when cruising line traffic is steady

➡ Merging support information could be used effectively as support information provided to the driver, etc.

➡ Changing cruising line conditions cannot be conveyed with one-time information, so smooth merging may be difficult especially in borderline traffic and when there are traffic jams

➡The following additional format requests were made

- ✓ Predicted arrival times and vehicle speeds are inferred based on the assumption that cruising line vehicles will travel at constant speeds. However, requests were made for acceleration/deceleration information and information regarding speed upon arrival →improvement of the reliability of delivered information
- ✓ Continuous delivery of cruising line vehicle location information was requested → improvement of the reliability of delivered information
- ✓ Cruising line traffic status information (overall speed of traffic flow, degree of congestion, average time between vehicles, etc.) was requested when delivering gate information → in order to rapidly determine if merging is possible
- ✓ Information regarding lane speeds beyond the merging point was requested→ for prior determination of the need for acceleration or deceleration after merging
- ✓ Information regarding the cruising lane and the passing lane were requested → for predicting the need to change lanes after merging

Test result findings were arrived at and agreed upon based on the following

- ✓ Data provided by test participants (traversed Airport West Entrance 365 times (17 times using automated driving and 348 times using manual driving))
- ✓ Test participant evaluation questionnaire

2-2. ETC gate passing/merging support

(5) Recommendations: ① ETC gate passing support information ②Merging support information Proposed infrastructure installation conditions

[Proposed infrastructure installation conditions]

- ETC gate passing support information
  ➡ Install for both intracity and intercity expressways
  ➡ Toll booths with numerous entrances and toll booths with a large amount of traffic inflow should be prioritized when installing equipment

- Merging support information
  ➡ Calculated arrival times are calculated with the assumption that vehicles will travel at constant speeds,
  so having highly accurate information is important
  ➡ Merging areas with a large amount of traffic, merging areas with short merging lanes, and merging areas with poor cruising line visibility should be prioritized when installing equipment

2-3. Automated bus

(1) Issues, verification items, and targets

Issues

- **Clarify environmental conditions required for practical implementation of level 4 ART in mixed transportation environments**

Verification items

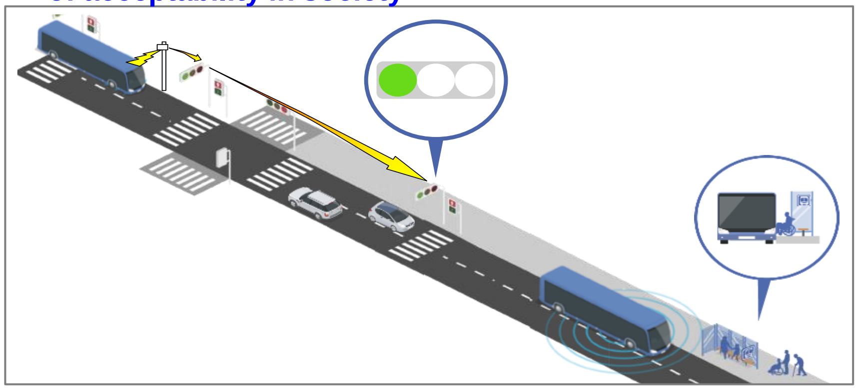
(1) Analysis of factors necessitating driver involvement in mixed transportation environments
  (a) Confirm implementation of automated driving in mixed transportation environments
  (b) Assess factors that can cause manual intervention
(2) Effectiveness of cooperative infrastructure in regularly scheduled transport
  (a) Confirm effectiveness of PTPS in improving arrival speed and punctuality
  (b) Confirm impact on driving in situations involving signal recognition difficulty
  (c)GNSS measurement deviation during automated driving
(3) Comfort when boarding/exiting
  (a) Assess acceleration when stopping and accelerating from a standstill
  (b)Evaluation of reproducibility of precision docking control
(4) Assessment of impact of automated vehicle driving on traffic flow, and factors causing this impact
  (a) Changes in traffic jam conditions resulting from the installation of a bus lane
  (b) Automated bus and ordinary bus processing times
  (c) Conflict occurrence related to automated buses

Benefits of cooperative infrastructure technologies

- Implement automated driving which does not require driver involvement
- Implement regularly scheduled transport
- Improve comfort (bus stop curb docking, gradual acceleration and braking)

Targets

- **Clarify which infrastructure is required for the expansion of ODD**
- **Identify what infrastructure conditions are required for the improvement of ART service**
- **Clarify issues to be addressed in order to cultivate a sense of acceptability in society**



ODD: Operational Design Domain
ART: Advanced Rapid Transit

2-3. Automated bus

(2) Summary

- We verified that magnetic markers, dedicated bus lanes, traffic signal information provided via DSRC, and PTPS vehicle-infrastructure cooperation made it possible for buses with automated driving technologies to provide punctual service on bus routes without manual intervention by the driver.
- We verified that precision bus docking control using magnetic marker and automated driving technologies produced a higher level of accuracy than driving by a professional driver, and that it could be used to produce buses that are more people-friendly for everyone

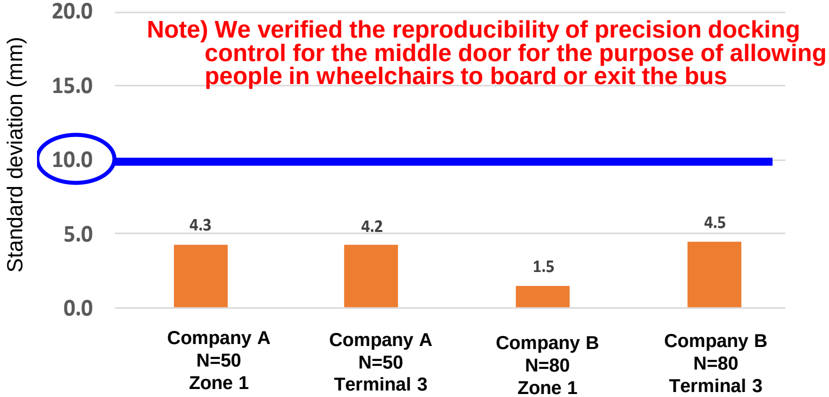
  However, we observed various situations on dedicated bus lanes that necessitate disengaging automated driving, such as routes being impeded by vehicles parked on the street or driver involvement due to unexpected cutting, and we identified issues related to societal acceptability and operation.

Zone 1 bus stop

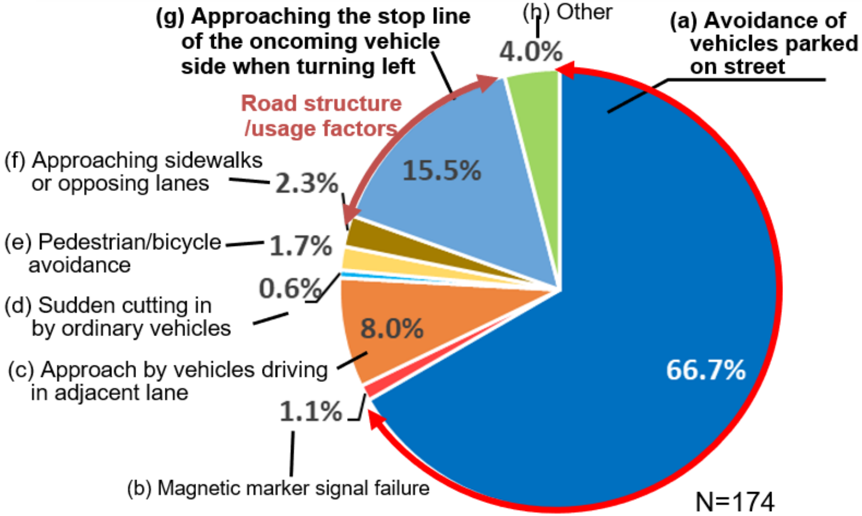
Terminal 3 bus stop

Standard deviation was calculated from the results of precision docking control at Zone 1 and Terminal 3 bus stops

(Own vehicle location estimation: magnetic markers)



Composition rates of the causes of manual interventions during magnetic marker driving (applies to manual intervention by companies A and B)



Driving environment factors (potential for reductions through improvement of driving environment)

Road structure and usage factors (potential for reductions through improvement of road structures and their usage)

2-3. Automated bus

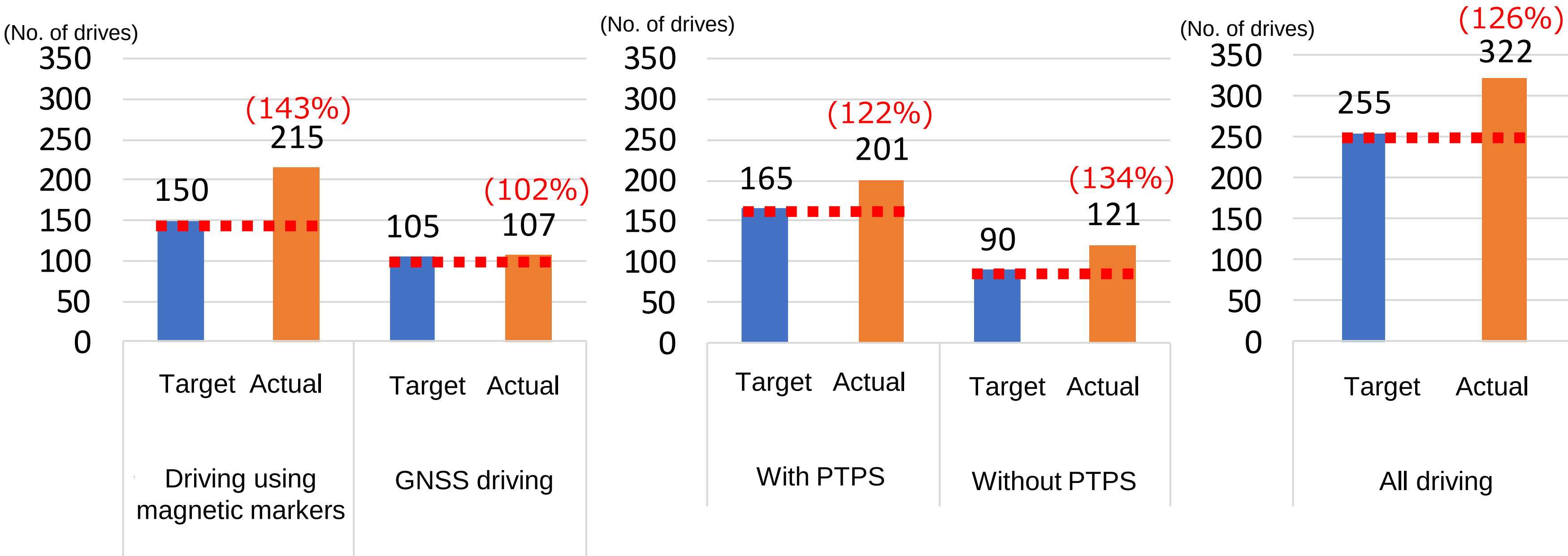
(3) Analysis of factors necessitating driver involvement in mixed transportation environments

- Confirm implementation of automated driving in mixed transportation environments
  - Confirmation of the number of route drives using automated driving in comparison to the target number of route drives

[Analysis results]

* The number of route drives using automated driving* exceeded the target number of route drives (the number of driving samples deemed necessary for performing statistically significant evaluation).
  * Drives were counted as being performed using automated driving even if there was momentary manual intervention as long as manual driving was not sustained or continuous.

Target number of route drives and driving results to date(total for three companies: No. of drives from June to November)



Figures in parentheses in red indicate achievement rates compared to targets

2-3. Automated bus

(3) Analysis of factors necessitating driver involvement in mixed transportation environments

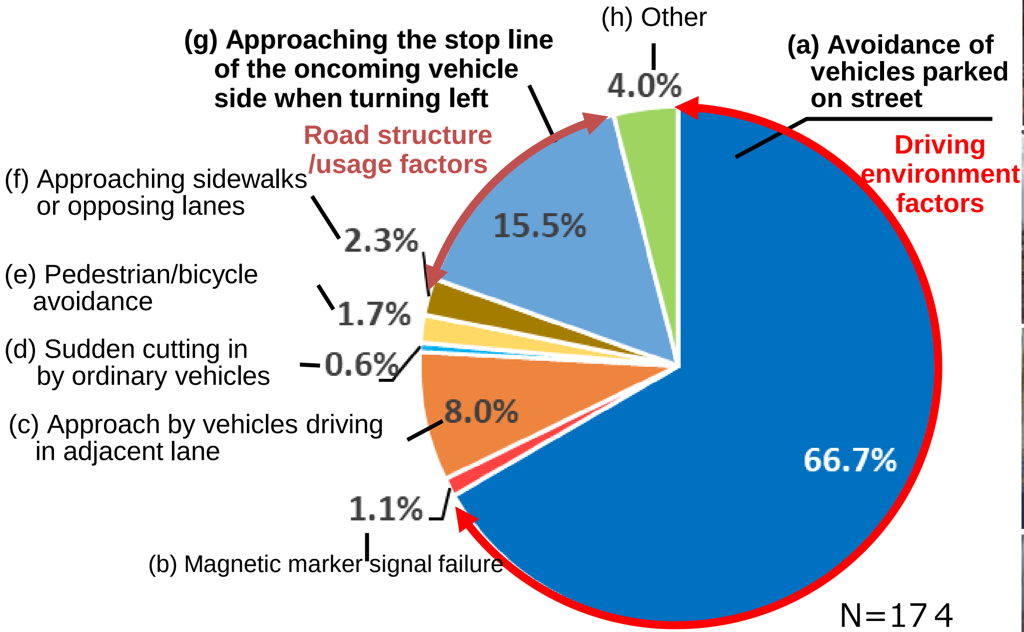
- Assess factors that can cause manual intervention (magnetic marker driving)
  - We confirmed situations in which manual intervention occurred while automated driving was being performed and assessed the contributing factors

【 [Analysis results]

* Approximately 80% of manual intervention was due to "(a) avoidance of vehicles parked on streets" or "(g) approaching the stop line of the oncoming vehicle side when turning left"

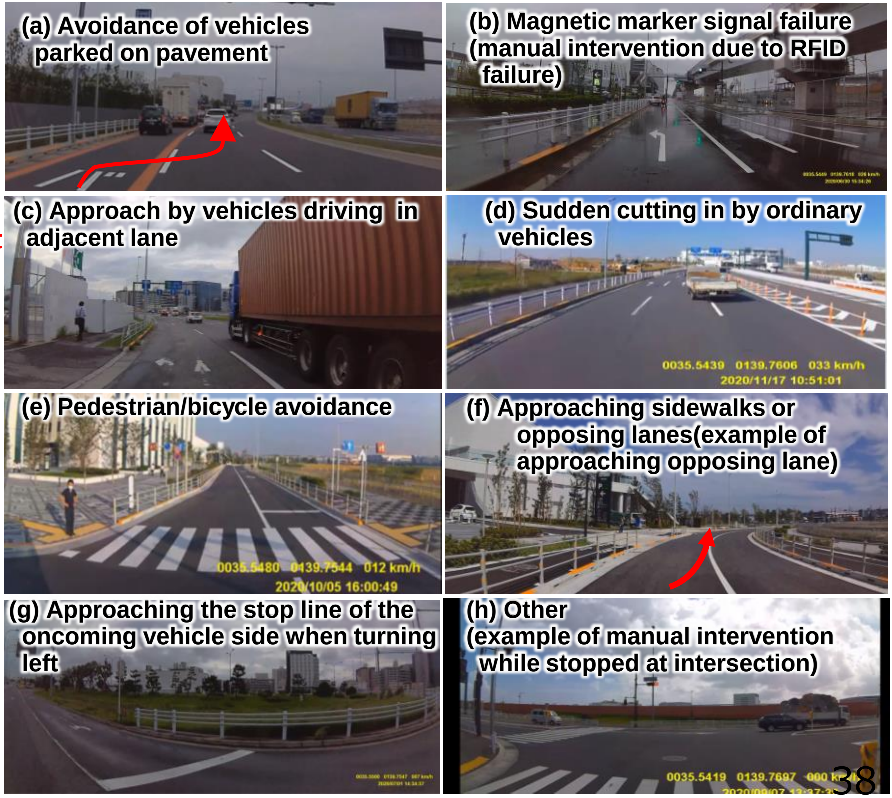
→ Automated driving function continuity is expected to increase as the result of driving environment improvement measures to address (a) and road structure and usage improvements (stop line position adjustment, etc.) to address (g)

Composition rates of the causes of manual interventions during magnetic marker driving (applies to manual intervention by companies A and B)



↔ Driving environment factors (potential for reductions through improvement of driving environment)

↔ Road structure and usage factors (potential for reductions through improvement of road structures and their usage)



2-3. Automated bus

(3) Analysis of factors necessitating driver involvement in mixed transportation environments

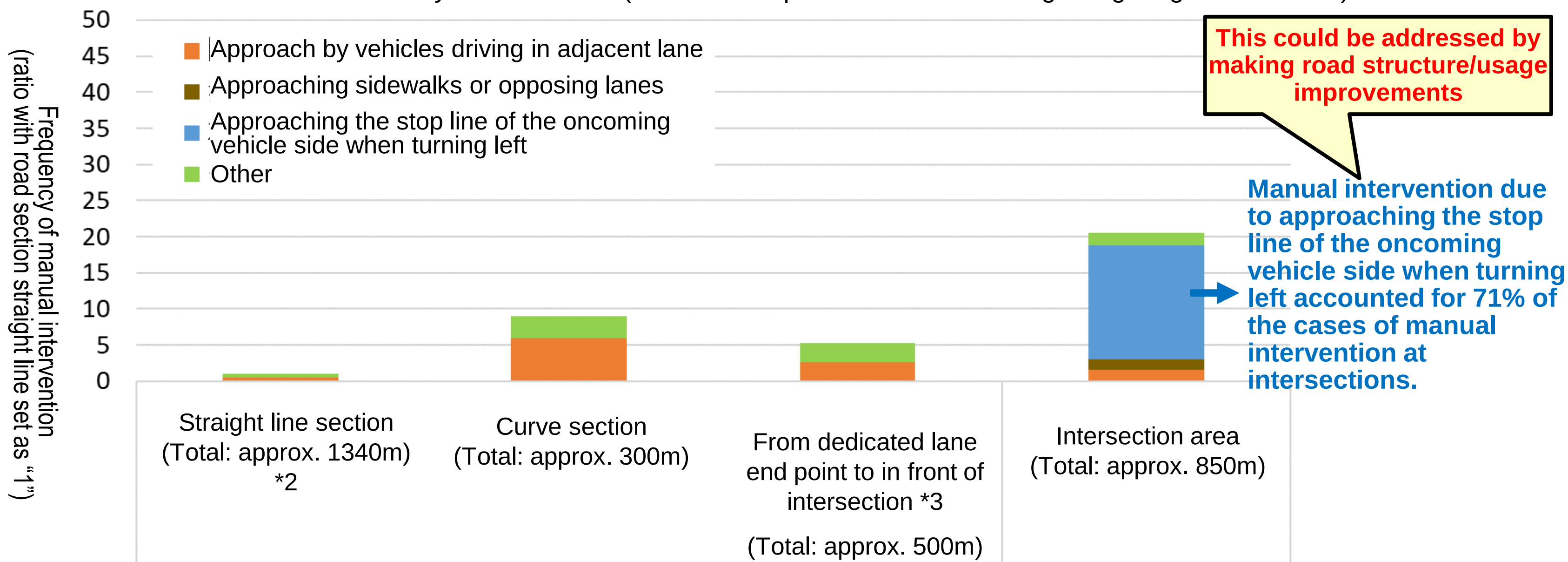
- Assess factors that can cause manual intervention (magnetic marker driving)
  - Data for locations where manual intervention took place was organized by road structure and factor

[Analysis results]

・The incidence of manual intervention was high for intersections, but the majority of these consisted of manual intervention due to approaching the stop line of the oncoming vehicle side when turning left.

→ The continuity of automated driving functions could be improved by making improvements to road structures and usage at intersections (adjusting stop line positions, etc.).

Ratio of manual intervention factors by road structure (Total for companies A and B: Driving using magnetic markers)*1



*1:Excluding manual intervention in special exception locations (areas with large amounts of on-street parking, area near Terminal 3, etc.) and due to on-street parking

*2:The figure in "(Total: approx. ○m)" refers to the total distance per route drive

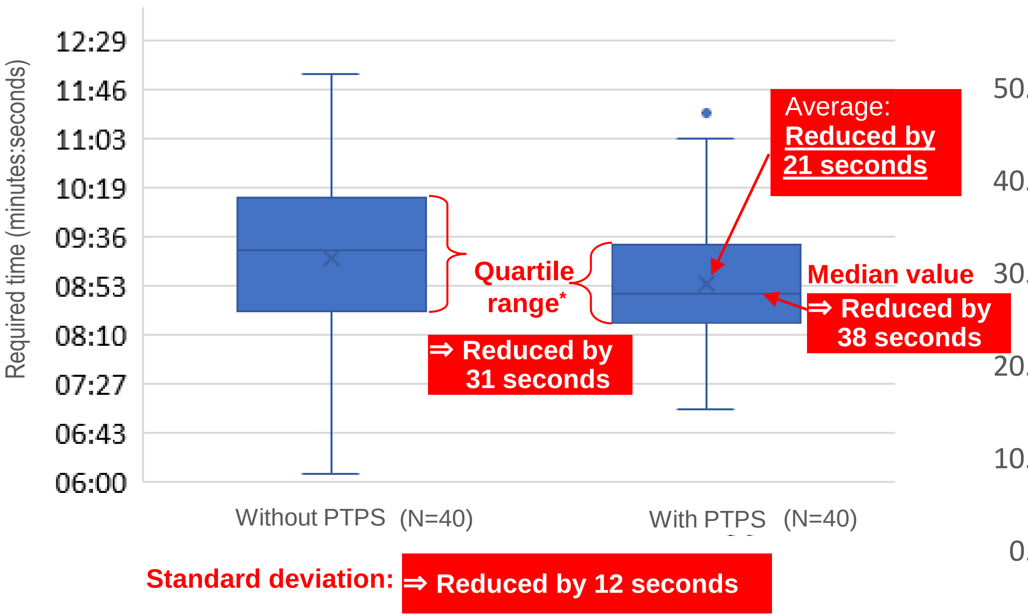
*3:Refers to the section between where a dedicated lane ends and 30 meters in front of the intersection

(4) Effectiveness of cooperative infrastructure in regularly scheduled transport

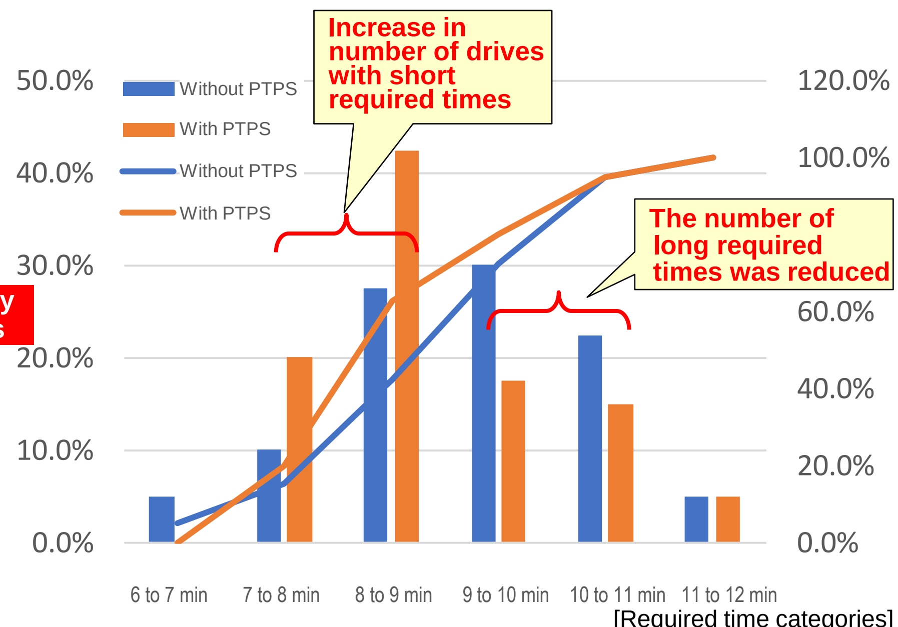
- Confirm effectiveness of PTPS in improving arrival speed and punctuality
  - Confirm effectiveness of PTPS in reducing required time and improving punctuality based on required time, standard deviation information, etc.

[Analysis results]
* The average required time per route when using PTPS was reduced by 21 seconds (approx. 4%), and the amount of disparity in required times was greatly reduced
→ We quantitatively confirmed that PTPS contributed to speediness and punctuality

Comparison of statistics related to required times with/without PTPS (for drives by Company C)



Comparison of distribution of required times with/without PTPS (for drives by Company C)



*Quartile range: One indicator of amount of disparity. Calculated by subtracting the 25 percentile required time from the 75 percentile required time.

2-3. Automated bus

(5) Comfort when boarding/exiting

- Assess acceleration when stopping and accelerating from a standstill
  - Assess incidence frequency for each maximum longitudinal acceleration category when stopping at or starting from a standstill at intersections and bus stops

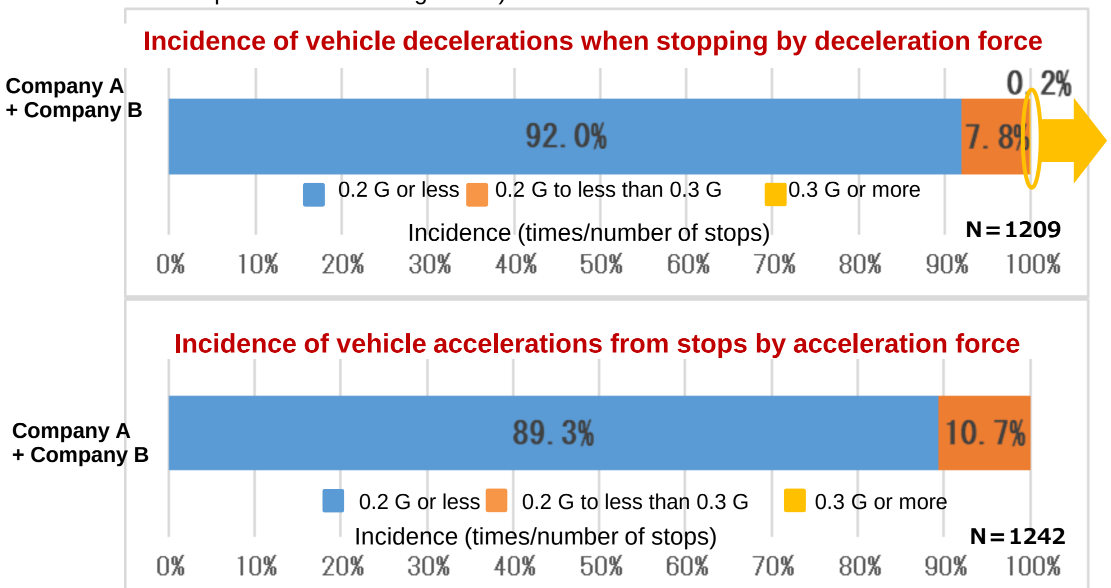
[Analysis results]

* Approximately 90% of stops and starts from standstills were done at acceleration or deceleration rates that do not cause passenger discomfort (0.2 G* or less), and the acceleration and deceleration were smooth enough that they did not present problems for standing passengers.

  * In drivers' education for heavy vehicle class 2 drivers licenses, the rule of thumb is that acceleration and deceleration rates must be 0.2 G or below to avoid subjecting passengers to discomfort.

* The sudden deceleration of 0.3G or greater occurred because the traffic light turned yellow just before the vehicle entered the intersection
  → In the future, the use of traffic signal remaining seconds information is expected to eliminate the problem of sudden deceleration

◆ Incidence of vehicle acceleration/deceleration by acceleration/deceleration force (Company A + Company B, driving using magnetic markers)
(Data regarding maximum acceleration and deceleration rates for the 20 seconds before and after each vehicle stop and start were organized)



[Example of situation involving a deceleration of 0.3 G or more]

2-3. Automated bus

(5) Comfort when boarding/exiting

- Evaluate reproducibility of precision docking control
  - Confirm degree of automated bus precision docking control reproducibility based on standard deviation between bus stop and bus when using precision docking control.

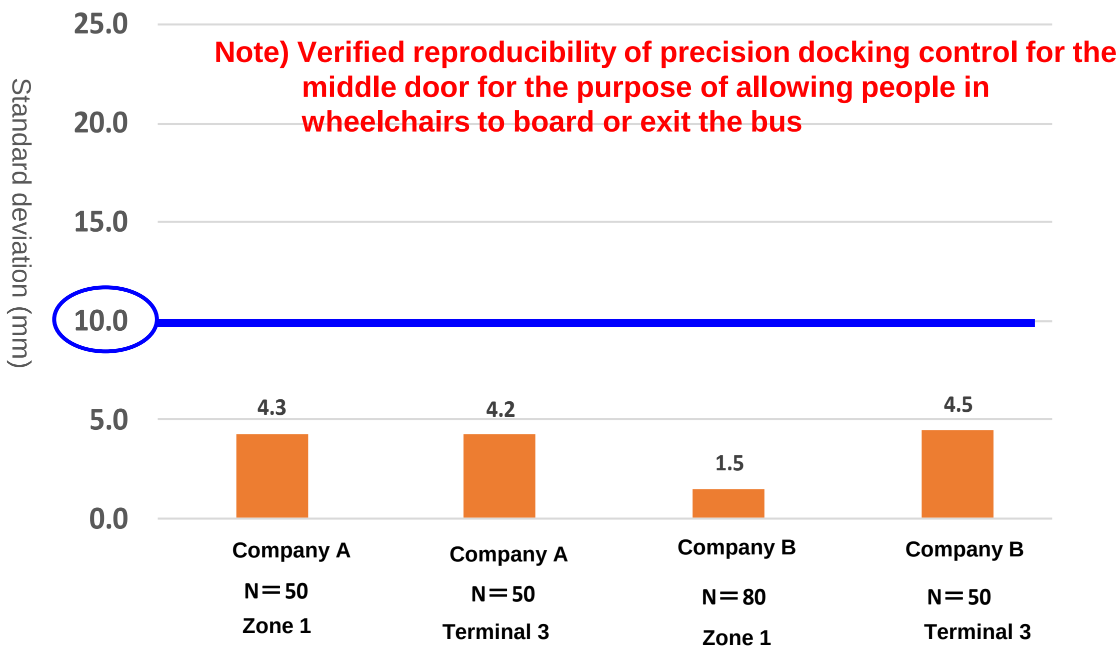
[Analysis results]

* Magnetic markers made it possible to perform precision docking control with a high degree of reproducibility (standard deviation of less than 10 mm) in Zone 1 and Terminal 3

Zone 1 bus stop

Terminal 3 bus stop

Calculate standard deviation from precision docking control results at Zone 1 and Terminal 3 bus stops
(Own vehicle location estimation: magnetic marker)



2-3. Automated bus

(6) Recommendations:

[Infrastructure effectiveness and proposed required infrastructure conditions]

- Magnetic markers
  - If prioritizing infrastructure preparation, highest priority should be given to locations where GNSS vehicle location accuracy is low and bus stops where precision docking control is used.
  - When preparing this infrastructure, improvements should be made to the roadway traffic environments, road structures, and road operation methods which can lead to manual intervention (such as by adjusting stop line locations).
  - Markers should be placed close together for locations with narrow turn radiuses, such as intersections.
- Traffic signal information/PTPS
  - Traffic signal information should be provided for smooth automated driving in situations where traffic signal identification is difficult, such as when traffic signal colors are obstructed by large vehicles.
  - It would be best to provide confirmed remaining seconds information after PTPS operation, etc., has been performed so that this traffic signal information could be used more effectively.
- Bus-only lanes
  - Bus-only lanes could help increase the continuity of automated driving at the current automated driving level, in which on-street parking makes continuous automated driving difficult.
  - For bus-only lanes to function effectively, it is important to implement additional publicity and awareness-raising regarding the behavior of automated vehicles, thoroughly inform drivers by using bus-only lane signs, and emphasize the need for compliance with bus-only lane rules.

[Impact of automated vehicle driving on traffic flow]

- The amount of traffic volume that was processed may decrease slightly when automated buses are present, so in future societal deployment, the impact on traffic where these routes are in use must be confirmed in advance.
- No crossing road traffic jams were caused by using PTPS to extend green lights and shorten red lights.

Test result findings were arrived at and agreed upon based on the following

- ✓ Data provided by test participants (322 route drive tests and 416 precision docking control tests)
- ✓ Test participant evaluation questionnaire

3. V2N delivery of traffic environmental information

3-1. Results of rainfall information testing

(1) Overview of delivered information

- Below is an overview of the information

Information source: Japan Meteorological Business Support Center

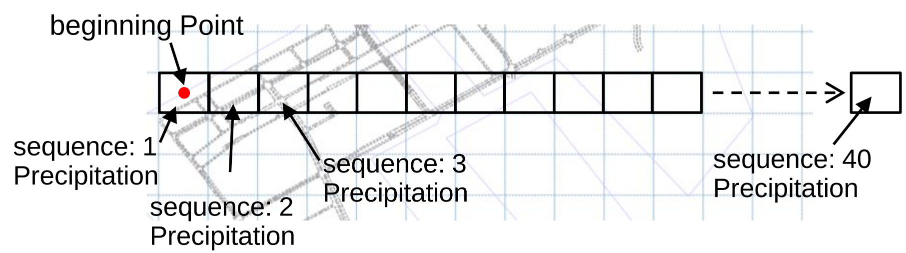
Provided information: High-resolution Precipitation Nowcasts or High-resolution Precipitation Nowcasts (5 minute precipitation amount) (cumulative rainfall over a 5-minute period in a grid square measuring 250 m x 250 m, current condition analysis and 30 minute forecasts issued every 5 minutes, binary data)

Provision scope: SIP Phase 1 and Phase 2 high-accuracy 3D map range (Waterfront City + Metropolitan Expressway, Joban Expressway, Tomei, Shin-Tomei)

Rainfall information received from data aggregation server (JasPar standard)

<table>
<tr><th colspan="5">Item</th><th>Contents</th></tr>
<tr><td rowspan="13">container</td><td rowspan="5">basic</td><td rowspan="2">time</td><td colspan="2">start</td><td>Data time</td></tr>
<tr><td colspan="2">expire</td><td>Expiration time (start + 5 min)</td></tr>
<tr><td rowspan="3">section</td><td rowspan="3">beginning Point</td><td>latitude</td><td>Latitude of center of first 250 m grid square</td></tr>
<tr><td>longitude</td><td>Longitude of center of first 250 m grid square</td></tr>
<tr><td>accuracy</td><td>Location accuracy</td></tr>
<tr><td rowspan="5">contents</td><td rowspan="3">environment</td><td colspan="2">sequence</td><td>250 m grid square number</td></tr>
<tr><td colspan="2">rain</td><td>Amount of precipitation predicted over 30 minute period starting now</td></tr>
<tr><td colspan="2">accuracy</td><td>Precipitation amount accuracy</td></tr>
<tr><td colspan="4">:</td></tr>
<tr><td colspan="3">environment</td><td>10 km row</td></tr>
<tr><td colspan="5">:</td></tr>
<tr><td colspan="4">basic</td><td></td></tr>
<tr><td colspan="4">contents</td><td></td></tr>
</table>

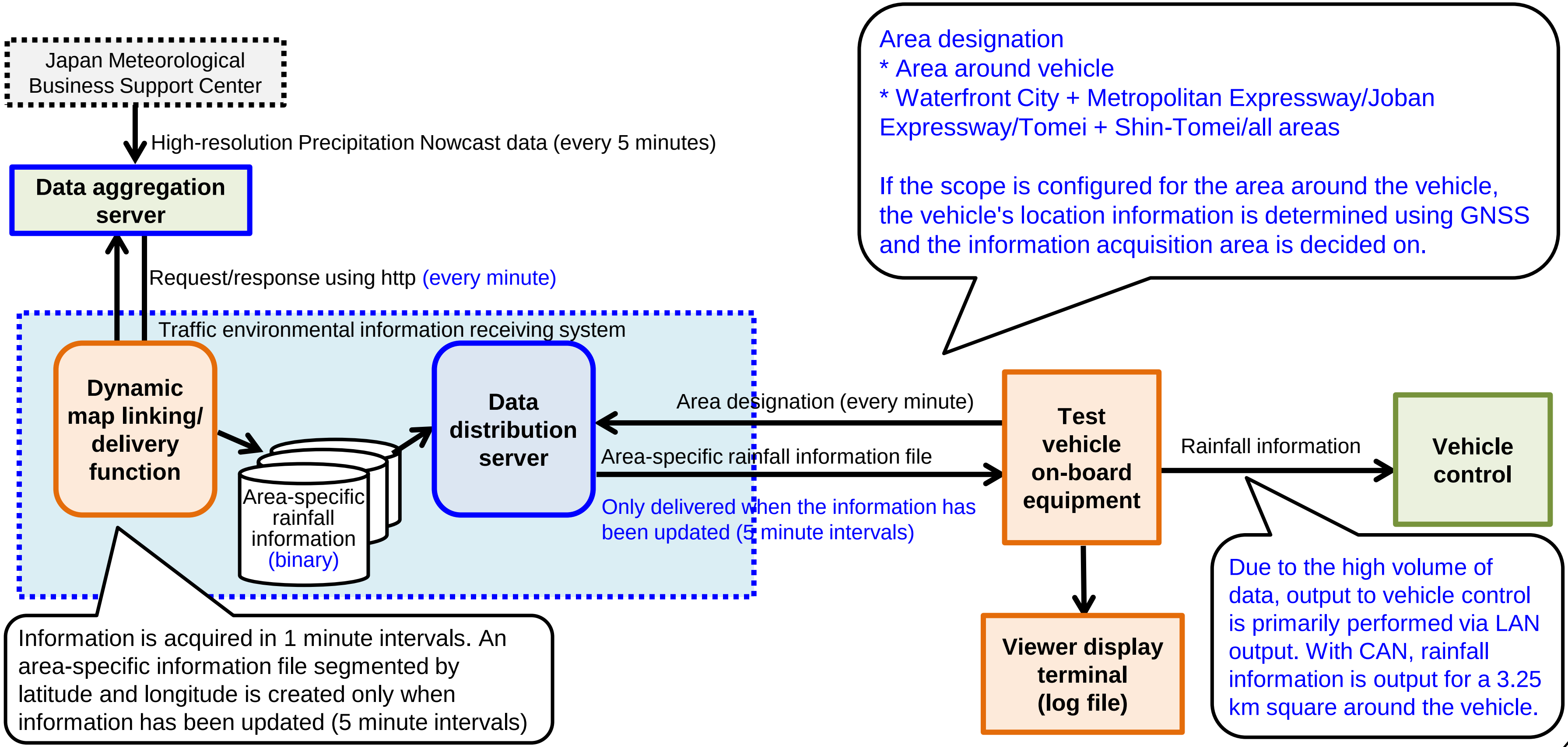
Precipitation amounts for 40 grid squares each measuring 250 m x 250 m, extending 10 km in the longitudinal direction, are packed a single item of content. Multiple pairs of basic and content information are used to provide precipitation information for an entire area.



3-1. Results of rainfall information testing

(2) Information delivery process (flow of data)

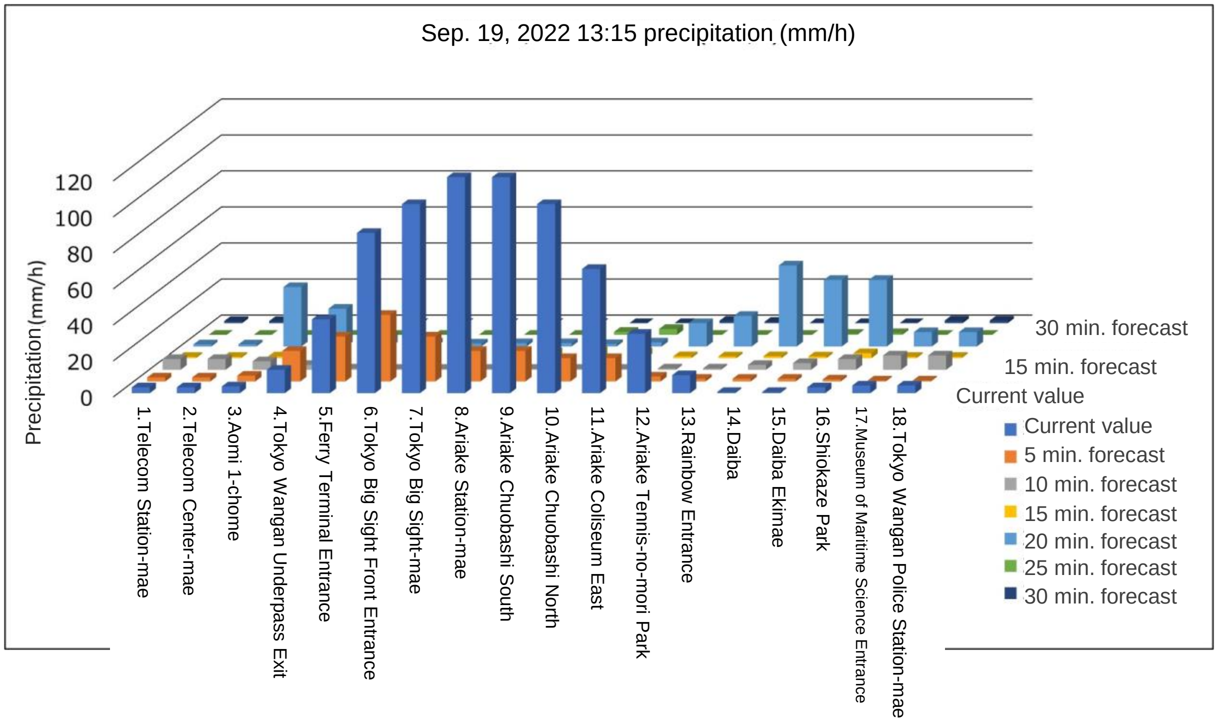
- A 30 km square around the current location of the vehicle or for the designated area (Waterfront City + Metropolitan Expressway/Joban Expressway/Tomei + Shin-Tomei /all areas) is specified to deliver rainfall information using PULL delivery and output it to vehicle control
- The CAN output area is only a 3 km square (due to data volume and delivery time considerations)



3-1. Results of rainfall information testing

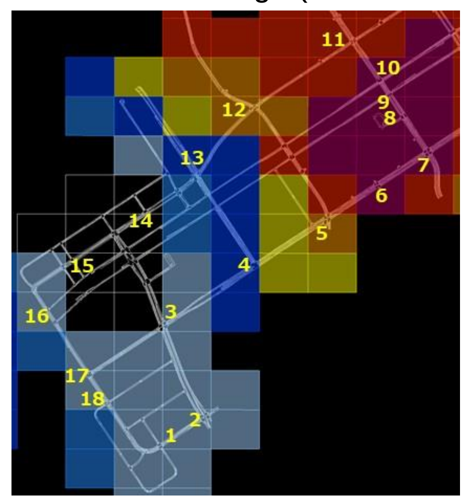
(3) Test results

- During the approach of a typhoon: The viewer was used to confirmation rainfall information for a small area around vehicles that were being driven, and it was confirmed that the information could be used to make decisions regarding handing over control to the driver during automated driving
- In particular, the amount of rainfall in the immediate vicinity of the vehicle could be confirmed on the viewer, so the information was highly effective.



Graph of precipitation by intersection location


Drive recorder image (for reference)



Viewer

3-2. Results of lane-specific road traffic information testing

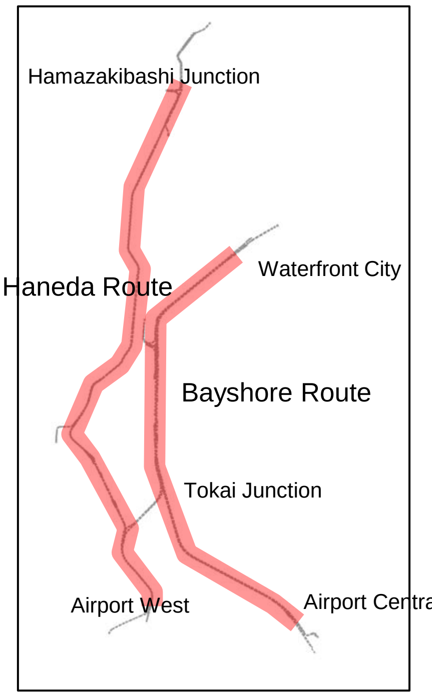
(1) Overview of delivered information

- Below is an overview of the information

Information source: Probe information (OEM), road traffic information (car navigation equipment manufacturer)
Provided information: Traffic congestion tail end location information for forking and merging areas, location information for locations of driving impediments, such as accidents or start of traffic congestion
Provision scope: Metropolitan Expressway Haneda Route and Bayshore Route
Envisioned traffic congestion start point: Near Haneda Route Hamazakibashi Junction, near Bayshore Route Tokai Junction

Lane-specific road traffic information (caution information) includes the following items and is updated once per minute.

(1) Start time
(2) End time
(3) Location
(4) Route name
(5) Lane number
(6) Accuracy of location
(7) Accuracy of traffic congestion inference



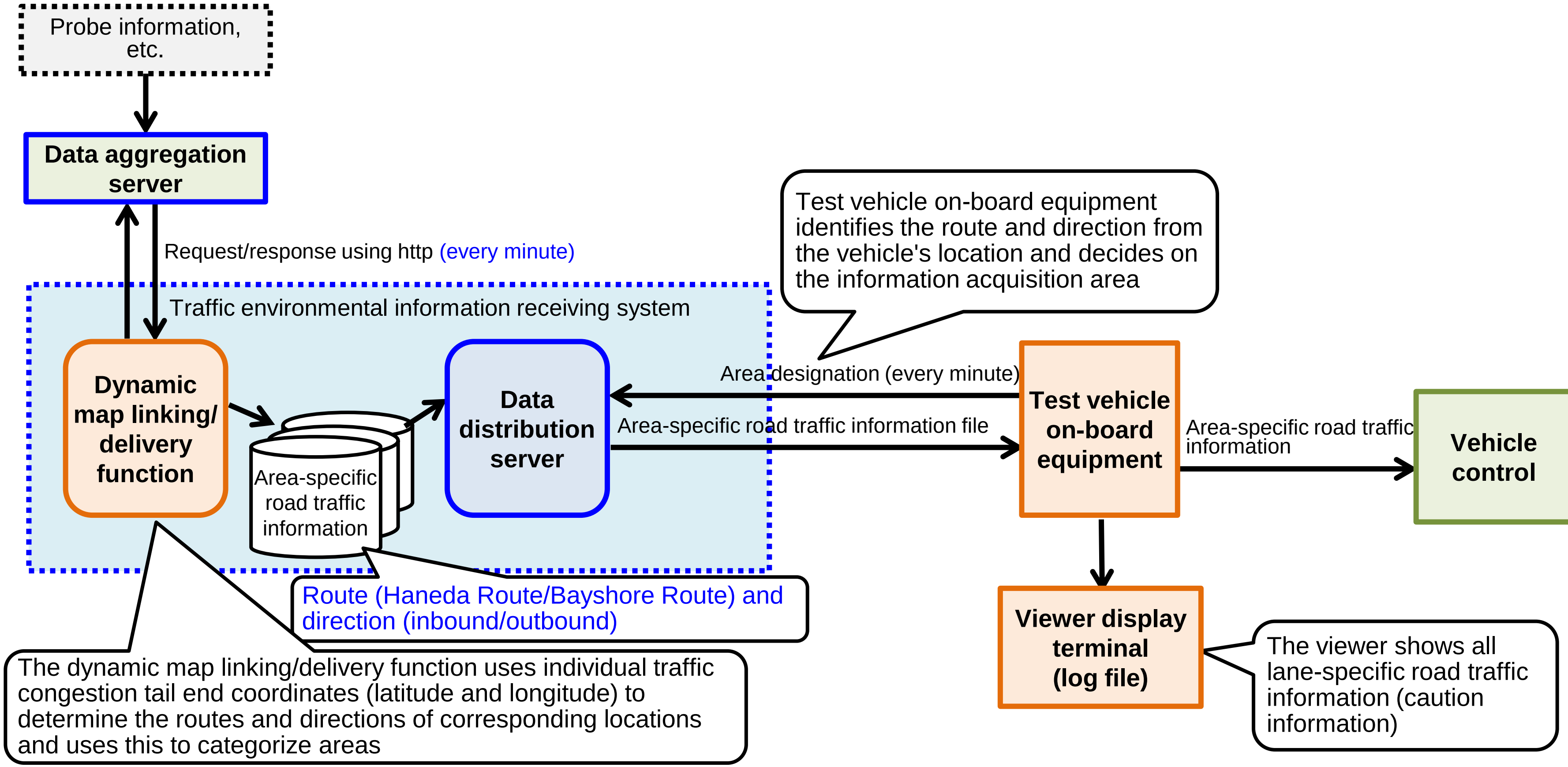
Source:Processed from electronic topographic map 25000(Geospatial Information Authority of Japan map)

Delivery range

3-2. Results of lane-specific road traffic information testing

(2) Information delivery process (flow of data)

- The GNSS information received by the test vehicle on-board equipment is used to determine the route the vehicle is driving and its direction (inbound/outbound) and to obtain a lane-specific road traffic information (caution information) file specific to the expressway route and direction using the PULL method.

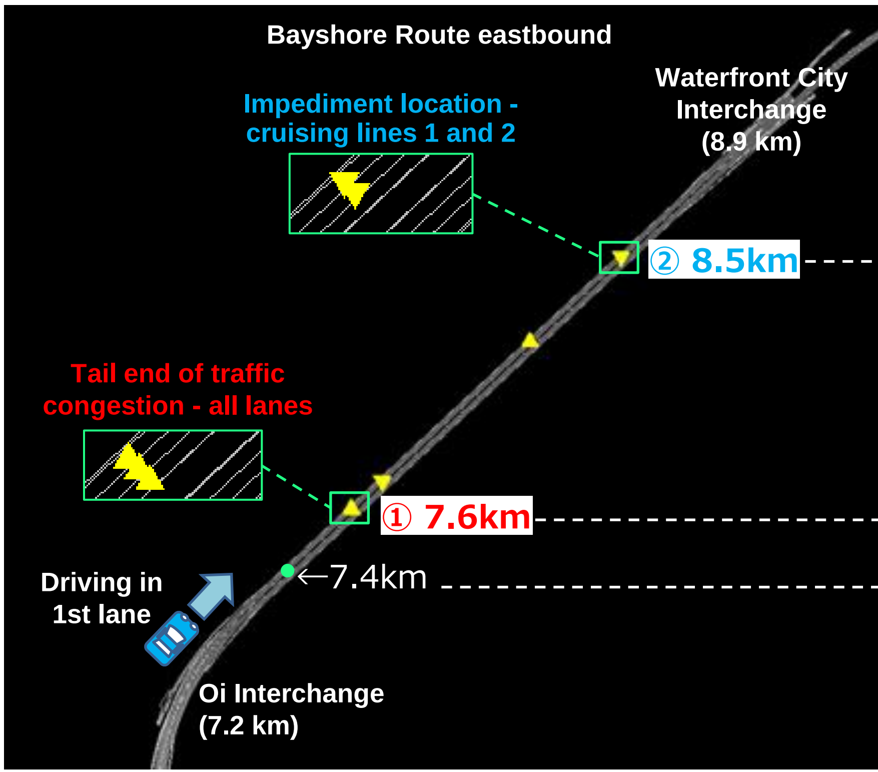


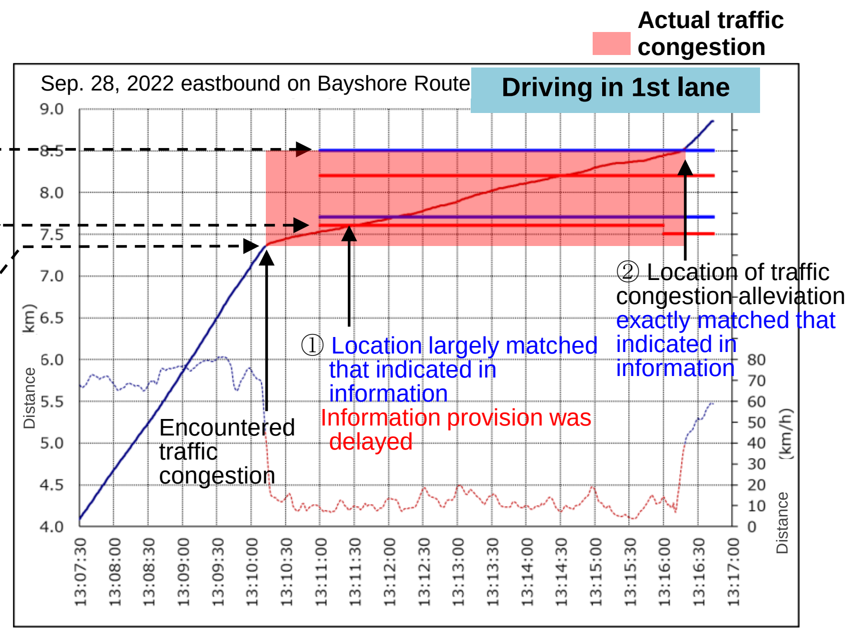
3-2. Results of lane-specific road traffic information testing

(3) Test results

- ① Entered traffic congestion area roughly 100 to 200 meters before the tail end of traffic congestion, the 7.6 km point
  ⇒ The location was largely as indicated in the information, but the updating of provided information was too slow
- ② The traffic congestion alleviated at the location of the impediment, at the 8.5 km point
  ⇒ The location matched that indicated in the information exactly

Drive recorder image





3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(1) Overview of delivered information

- Below is an overview of the information.

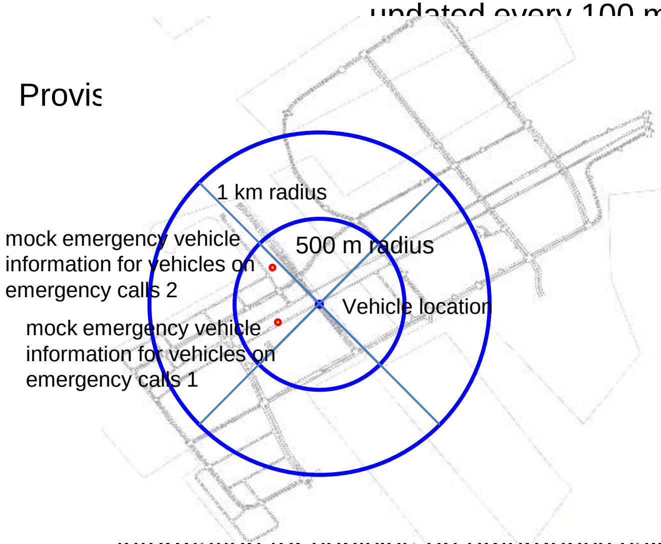
Information source: R&D regarding the provision of traffic signal information leveraging the cloud, etc. (UTMS Society, Koito Electric Industries)
Mock emergency vehicle information for vehicles on emergency calls

Provided information: Location information for mock emergency vehicle information for vehicles on emergency calls was updated every 100 ms and distributed every

Provis ront City area

ains up to 10 items of GNSS nation mock emergency vehicle nation for vehicles on emergency for a one second period, ordered iologically from oldest to newest ock emergency vehicle information ehicles on emergency calls is ied for one second or longer, its tion of travel cannot be inferred)

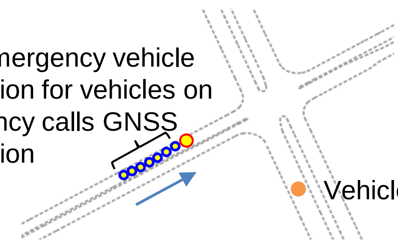
emergency vehicle information for vehicles on emergency calls



In preparation for societal deployment, it will be essential to consider and standardize data formats, taking into consideration the ability to distinguish between multiple vehicles

Mock emergency vehicle information for mock emergency vehicle information for vehicles on emergency calls information provided by data aggregation server

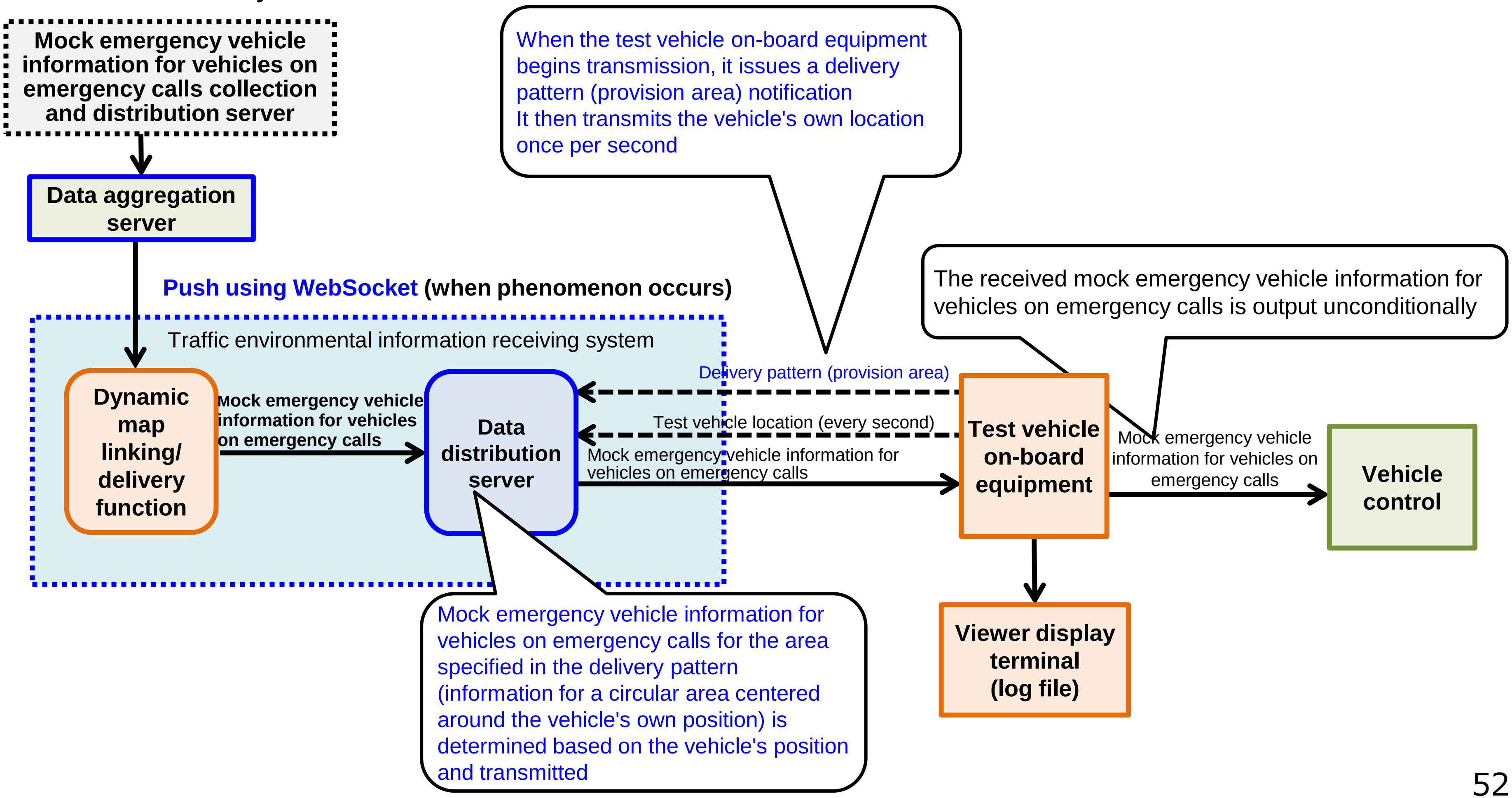
Item			Byte	Remarks
On-board equipment time	Year		1	BCD (last 2 digits)
	Month		1	BCD
	Day		1	BCD
	Hour		1	BCD
	Minute		1	BCD
	Second		1	BCD
	Millisecond		2	BCD (left-aligned, 3 digits)
Vehicle ID			5	
Reserved			1	
Driving state			1	1: Driving
No. of items of GNSS continuous information			1	0 to 20
Latest location	Latitude [10-7 deg]		4	JGD2011 (semi-dynamic correction unnecessary)
	Longitude [10-7 deg]		4	JGD2011 (semi-dynamic correction unnecessary)
GNSS continuous information 1	GNSS measurement time	Hour	1	BCD
		Minute	1	BCD
		Second	1	BCD
		Millisecond	2	BCD (left-aligned, 3 digits)
	Reserved		1	
	Latitude [10-7]		4	Dynamic map must be aligned with datum (present period → original period)
	Longitude [10-7]		4	Dynamic map must be aligned with datum (present period → original period)
	Movement speed [km/h]		1	
	Reserved		1	
	Sea level altitude [0.1 m]		2	Dynamic map must be aligned with datum (present period → original period)
	Geoid altitude [0.1 m]		2	Dynamic map must be aligned with datum (present period → original period)
	HDOP value		2	
	No. of satellite positioning measurements		1	
	Positioning state		1	0: No positioning, 1: Independent, 2: DGPS, 4. RTK Fix, 5: RTK Float
:				
GNSS continuous information n			24	The last location information is the latest information



Conceptual image mock emergency vehicle information for mock emergency vehicle information for vehicles on emergency calls

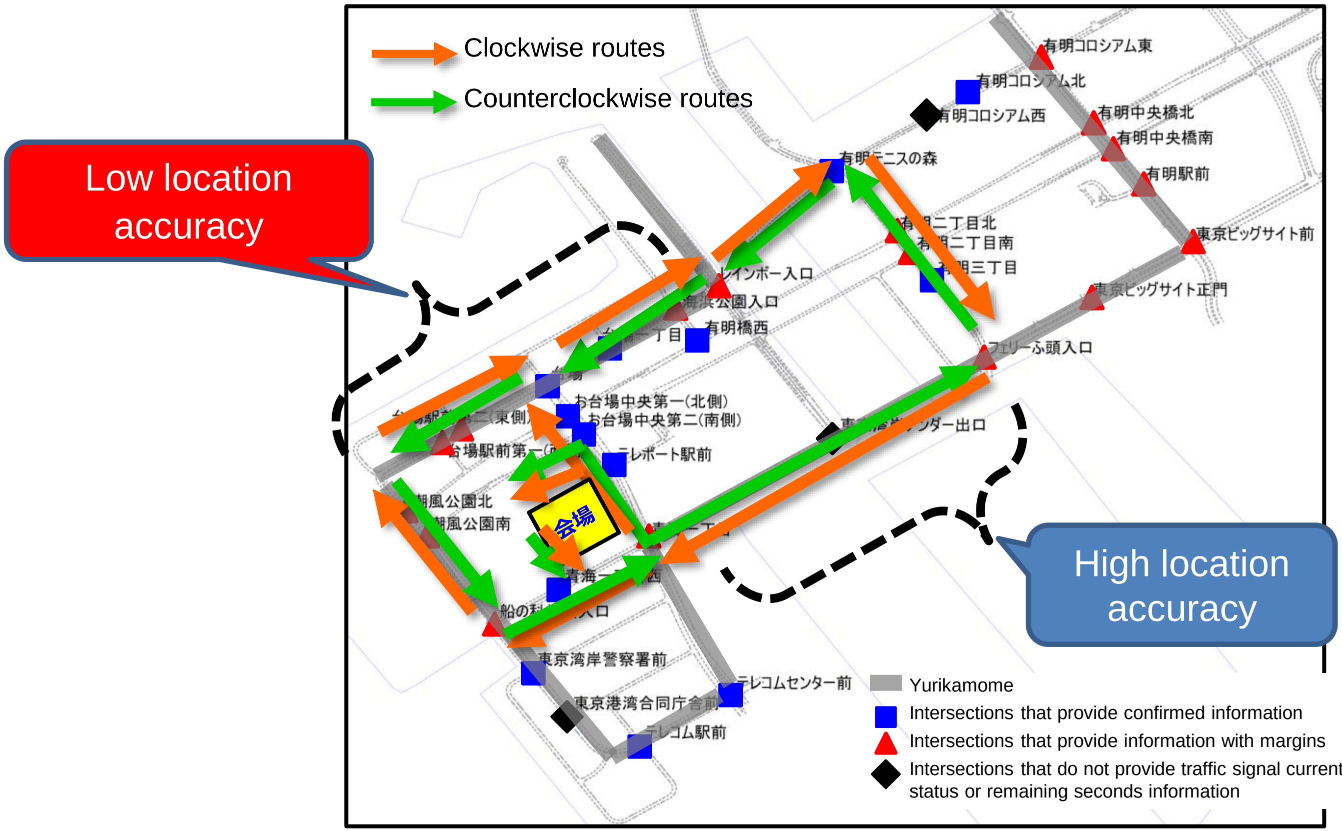
(2) Information delivery process (flow of data)

- The vehicle issues notice of the area for which it requires information (a circle around the vehicle), and mock emergency vehicle information for vehicles on emergency calls is delivered to the vehicle using PUSH delivery



(3) Test results [1/9]

- The following clockwise and counterclockwise routes were defined and testing was performed.
- <u>Location information accuracy was confirmed to decline in multipath environments (under the Yurikamome overpass and nearby buildings). The amount of deviation was particularly large in the vertical direction</u>
  (measures must be taken to improve location accuracy using map matching technologies, IMU, etc.)



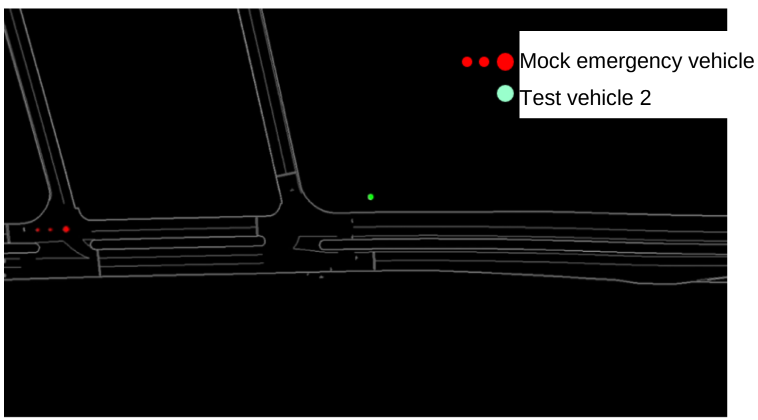
Mock emergency vehicle driving routes

3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

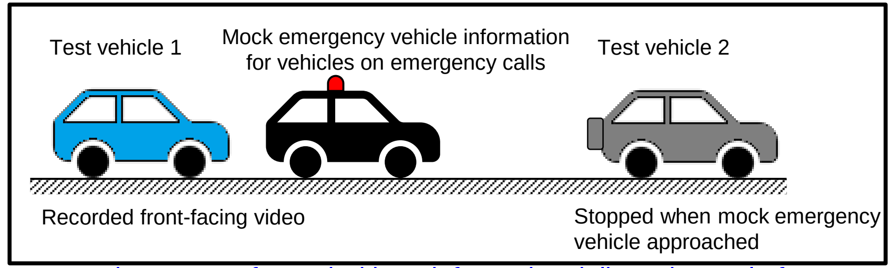
(3) Test results [2/9]

- Test vehicle 2 drove in front of the mock emergency vehicle on an emergency call, detected that the mock emergency vehicle information for vehicles on emergency calls was approaching, and pulled over to stop on the road shoulder.
- Test vehicle 1 drove behind the mock emergency vehicle information for vehicles on emergency calls and confirmed that test vehicle 2 had stopped on the shoulder.

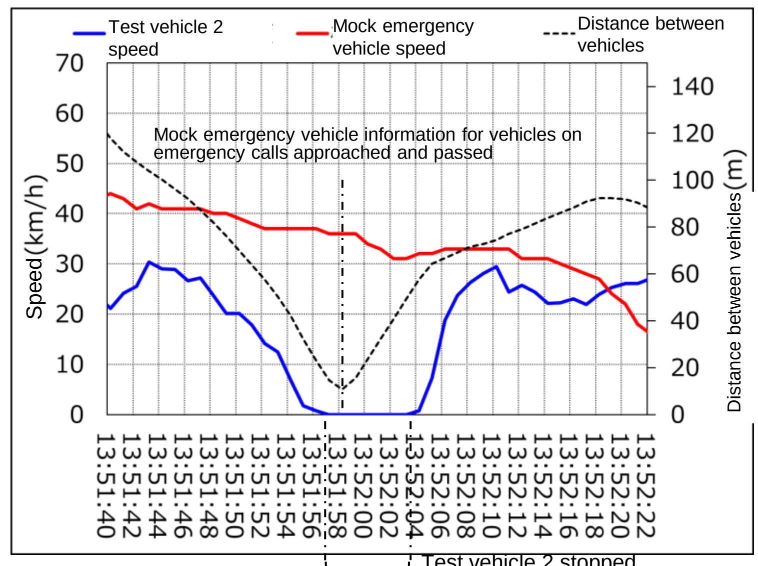
Test vehicle 1 drive recorder video



Test vehicle 2 SIP viewer screen



Testing was performed with an information delivery interval of 2 seconds → 1 second

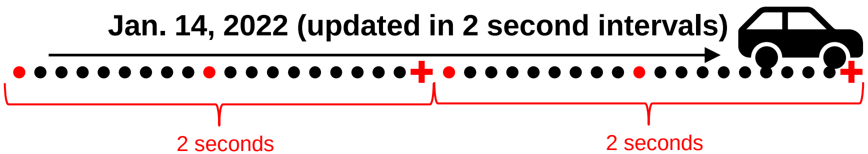


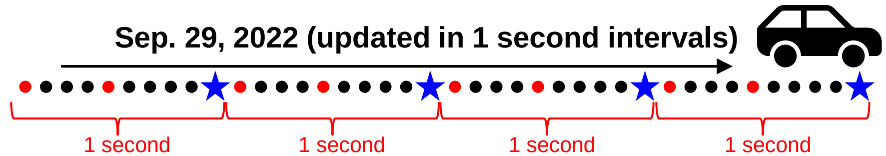
Driving graph of test vehicle 2 and the mock emergency vehicle information for vehicles on emergency calls

3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(3) Test results [3/9]: Differences between 2 second and 1 second intervals

- Updating information in 1 second intervals allowed vehicles to predict the driving trajectories and routes of emergency vehicles well in advance



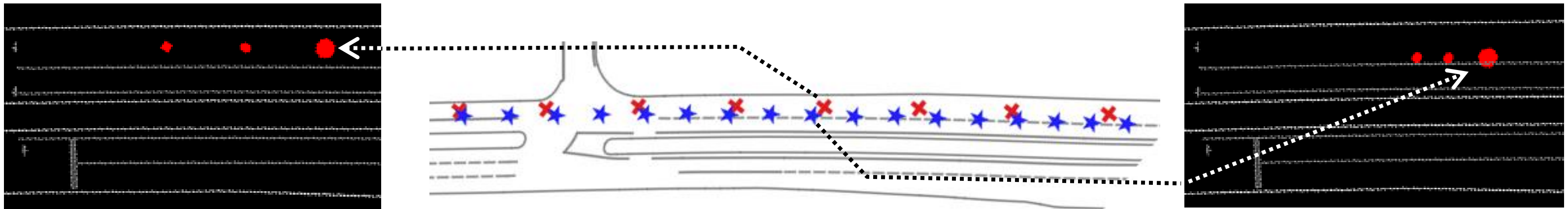


Received data (2 second intervals)

On-board equipment time	No. of items of GNSS information	GNSS information								
		GNSS measurement time	Latitude	Longitude	Speed (km/h)	Elevation (m)	Geoid m	HDOP	No. of satellites	Positioning state
2022/01/14 13:13:52.093	20	13:13:51.964	35.6227593	139.7721391	41	5.8	39.4	0.9	12	2:DGPS
		13:13:51.864	35.6227683	139.7721324	42	5.8	39.4	0.9	12	2:DGPS
		13:13:51.764	35.6227775	139.7721256	42	5.7	39.4	0.9	12	2:DGPS
		13:13:51.664	35.6227865	139.7721188	41	5.7	39.4	0.9	12	2:DGPS
		13:13:51.564	35.6227953	139.7721121	42	5.7	39.4	0.9	12	2:DGPS
		13:13:51.464	35.6228045	139.7721053	42	5.7	39.4	0.9	12	2:DGPS
		13:13:51.364	35.6228135	139.7720986	41	5.6	39.4	0.9	12	2:DGPS
		13:13:51.264	35.6228225	139.7720918	42	5.6	39.4	0.9	12	2:DGPS
		13:13:51.164	35.6228315	139.7720849	41	5.5	39.4	0.7	12	2:DGPS
		13:13:51.074	35.6228403	139.7720783	42	5.5	39.4	0.7	12	2:DGPS
		13:13:50.964	35.6228493	139.7720714	42	5.5	39.4	0.9	12	2:DGPS
		13:13:50.864	35.6228583	139.7720646	41	5.4	39.4	0.9	12	2:DGPS
		13:13:50.764	35.6228673	139.7720578	41	5.4	39.4	0.9	12	2:DGPS
		13:13:50.664	35.6228763	139.7720511	41	5.4	39.4	0.9	12	2:DGPS
		13:13:50.564	35.6228853	139.7720443	41	5.4	39.4	0.9	12	2:DGPS
		13:13:50.464	35.6228942	139.7720374	41	5.3	39.4	0.9	12	2:DGPS
		13:13:50.364	35.6229032	139.7720306	41	5.3	39.4	0.9	12	2:DGPS
		13:13:50.264	35.6229122	139.7720239	41	5.3	39.4	0.9	12	2:DGPS
		13:13:50.164	35.6229212	139.7720171	41	5.3	39.4	0.9	12	2:DGPS
		13:13:50.074	35.6229302	139.7720103	41	5.2	39.4	0.7	12	2:DGPS

Received data (1 second intervals)

On-board equipment time	No. of items of GNSS information	GNSS information								
		GNSS measurement time	Latitude	Longitude	Speed (km/h)	Elevation (m)	Geoid m	HDOP	No. of satellites	Positioning state
2022/09/29 13:51:53.308	10	13:51:53.269	35.6230293	139.7719113	37	3.1	39.4	0.6	12	2:DGPS
		13:51:53.169	35.6230373	139.7719053	37	3.1	39.4	0.6	12	2:DGPS
		13:51:53.079	35.6230453	139.7718993	37	3.1	39.4	0.6	12	2:DGPS
		13:51:52.969	35.6230532	139.7718933	36	3.1	39.4	0.6	12	2:DGPS
		13:51:52.869	35.6230610	139.7718873	36	3.1	39.4	0.6	12	2:DGPS
		13:51:52.769	35.6230690	139.7718813	37	3.0	39.4	0.6	12	2:DGPS
		13:51:52.669	35.6230768	139.7718753	37	3.0	39.4	0.6	12	2:DGPS
		13:51:52.569	35.6230847	139.7718693	37	3.0	39.4	0.6	12	2:DGPS
		13:51:52.469	35.6230927	139.7718633	37	3.0	39.4	0.6	12	2:DGPS
		13:51:52.369	35.6231005	139.7718573	36	3.0	39.4	0.6	12	2:DGPS
2022/09/29 13:51:54.308	10	13:51:54.269	35.6229498	139.7719714	37	3.4	39.4	0.6	12	2:DGPS
		13:51:54.169	35.6229578	139.7719654	37	3.3	39.4	0.6	12	2:DGPS
		13:51:54.079	35.6229658	139.7719593	37	3.3	39.4	0.6	12	2:DGPS
		13:51:53.969	35.6229737	139.7719533	37	3.3	39.4	0.6	12	2:DGPS
		13:51:53.869	35.6229817	139.7719474	37	3.3	39.4	0.6	12	2:DGPS
		13:51:53.769	35.6229897	139.7719413	37	3.2	39.4	0.6	12	2:DGPS
		13:51:53.669	35.6229977	139.7719353	37	3.2	39.4	0.6	12	2:DGPS
		13:51:53.569	35.6230055	139.7719294	37	3.2	39.4	0.6	12	2:DGPS
		13:51:53.469	35.6230135	139.7719233	37	3.2	39.4	0.6	12	2:DGPS
		13:51:53.369	35.6230215	139.7719173	37	3.1	39.4	0.6	12	2:DGPS



Viewer screen (2 second intervals)

Plotting of latest location information in received data

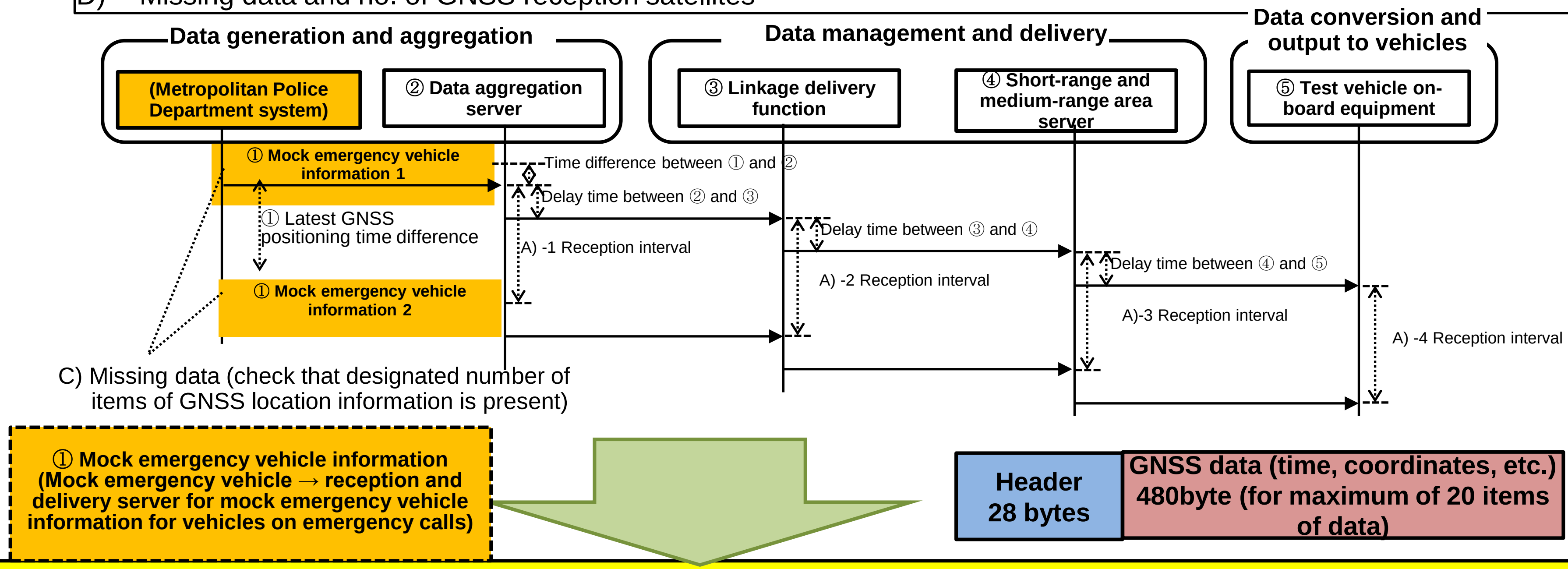
Viewer screen (1 second intervals)

3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(3) Test results [4/9]: Differences between 2 second and 1 second intervals

- To compare the differences between delivery cycles of mock emergency vehicle information for vehicles on emergency calls (once every two seconds/once every second), received data was analyzed from the following perspectives.

A) Checking for deviation in reception intervals
Ideally, the reception intervals should be identical, as follows: [A)-1]=[A)-2]=[A)-3]=[A)-4]
B) How much delay time and deviation is there from the GNSS positioning time within the data ① to the test vehicle on-board equipment ⑤?
C) Whether or not there is data missing = confirm if there is missing data
D) Missing data and no. of GNSS reception satellites



As a result, although we found some deviation, **from these perspectives, differing delivery cycles did not produce any major differences.**

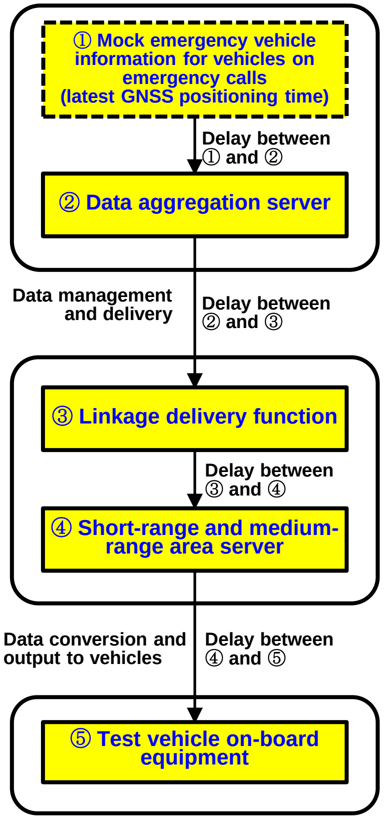
3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(3) Test results [5/9]: Differences between 2 second and 1 second intervals

A) Comparison of deviation in reception intervals

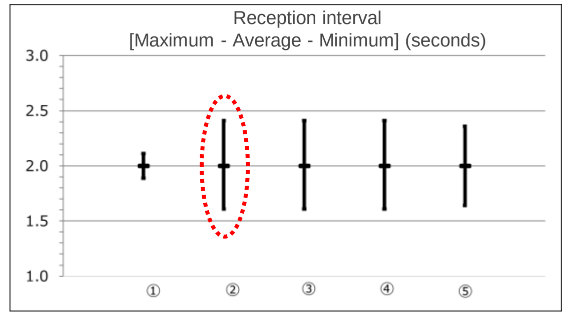
Comparison of **deviation in reception intervals between devices**

- The trends were identical for 2-second and 1-second intervals, with no significant differences
- Overall, there was a great deal of deviation in data aggregation server reception intervals (standard deviation), and differences in delivery cycles were slightly larger for 2-second cycles than for 1-second cycles. The linkage delivery functions and short-range and medium-range area servers carried on the reception intervals of the data aggregation server as-is
- The maximum and minimum test vehicle on-board equipment reception intervals were roughly equivalent to the data aggregation server, and the standard deviation was small



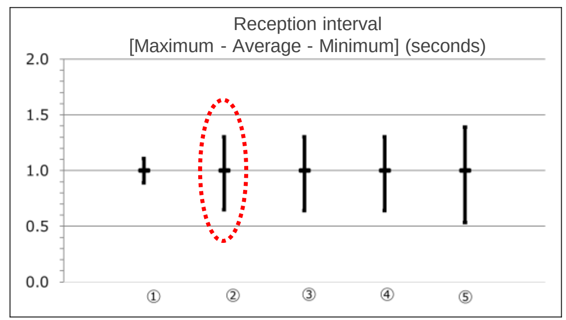
2 second delivery interval

	Min. (s)	Avg. (s)	Max. (s)	Standard deviation
① Mock emergency vehicle information for vehicles on emergency calls	1.890	2.000	2.110	0.008
② Data aggregation server	1.610	2.000	2.409	**0.073**
③ Linkage delivery function	1.610	2.000	2.409	0.073
④ Short-range and medium-range area server	1.610	2.000	2.409	0.073
⑤ Test vehicle on-board equipment	1.641	2.000	2.360	0.017



1 second delivery interval

	Min. (s)	Avg. (s)	Max. (s)	Standard deviation
① Mock emergency vehicle information for vehicles on emergency calls	0.890	1.000	1.110	0.009
② Data aggregation server	0.647	1.000	1.302	**0.065**
③ Linkage delivery function	0.642	1.000	1.301	0.066
④ Short-range and medium-range area server	0.642	1.000	1.301	0.066
⑤ Test vehicle on-board equipment	0.532	1.000	1.391	0.018



Values for ① mock emergency vehicle information for vehicles on emergency calls are the deviation in GNSS positioning times in the data (the time difference between the first block of latest data and the second block of latest data)
Values for ② to ⑤ are the receiving intervals

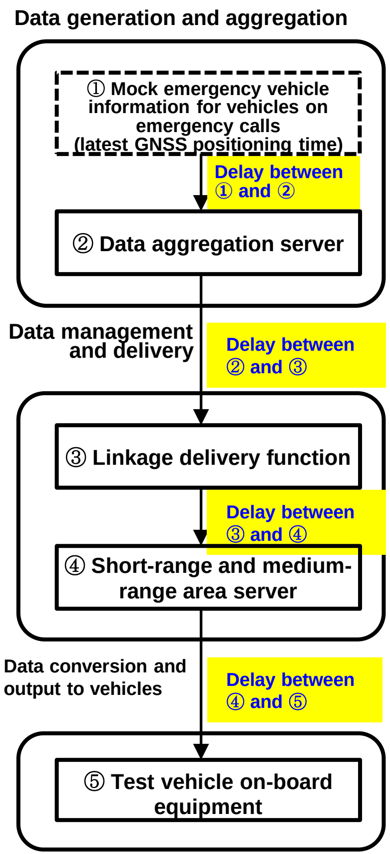
3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(3) Test results [6/9]: Differences between 2 second and 1 second intervals B) Comparison of delay times

Comparison of **delay times between devices**

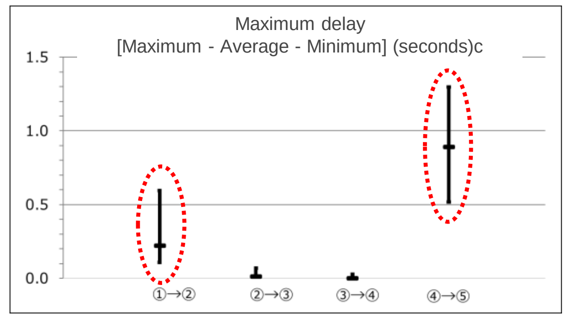
- The trends were identical for 2-second and 1-second intervals, with no significant differences
- There was a large amount of deviation (standard deviation) between ① and ② and between ④ and ⑤
- Deviation between ① and ② was dependent on the sender of the mock emergency vehicle information for vehicles on emergency calls
- Deviation between ④ and ⑤ was dependent on the short-range and medium-range area server
- Both the average value and the amount of deviation were small between ② and ③ and between ③ and ④.

If adjustments could be made to sender of the mock emergency vehicle information and the short-range and medium-range area server, the amount of deviation in delay times could be kept to a matter of several milliseconds



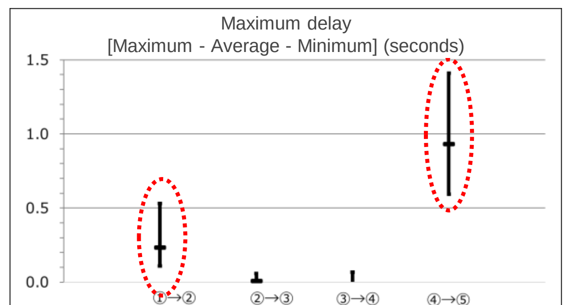
2 second delivery interval

	Min. (s)	Avg. (s)	Max. (s)	Standard deviation
①→②	0.109	0.220	0.596	**0.051**
②→③	0.008	0.012	0.068	0.003
③→④	-0.003	0.001	0.027	0.002
④→⑤	0.516	0.890	1.298	**0.051**
Total	–	1.123	1.989	–



1 second delivery interval

	Min. (s)	Avg. (s)	Max. (s)	Standard deviation
①→②	0.110	0.232	0.530	**0.055**
②→③	0.001	0.008	0.057	0.004
③→④	-0.010	-0.001	0.067	0.003
④→⑤	0.594	0.933	1.411	**0.051**
Total	–	1.172	2.065	–



The negative values between ③ and ④ are believed to be due to deviations in the time synchronization of individual servers.

(3) Test results [7/9]: Differences between 2 second and 1 second intervals C) Data loss comparison

- The trends were identical for 2-second and 1-second intervals, with no significant differences
- Within the mock emergency vehicle information for vehicles on emergency calls, there are normally up to 20 items of GNSS location information when the cycle is 2 seconds, or up to 10 items when the cycle is 1 second. For either cycle length, there is a possibility of GNSS location information being lost.
- For 1 second cycles, sometimes the amount of GNSS location information could be 11 items of data, including data that was missing from the previous data delivery, or it could be 10 items of data. (depending on whether the data is delivered during the next cycle or if it is simply lost)

⇒ Due to the data format size limitation, the maximum number of items of GNSS location information is 20 items, so when using 1 second cycles, missing data is believed to be delivered during the next delivery cycle.

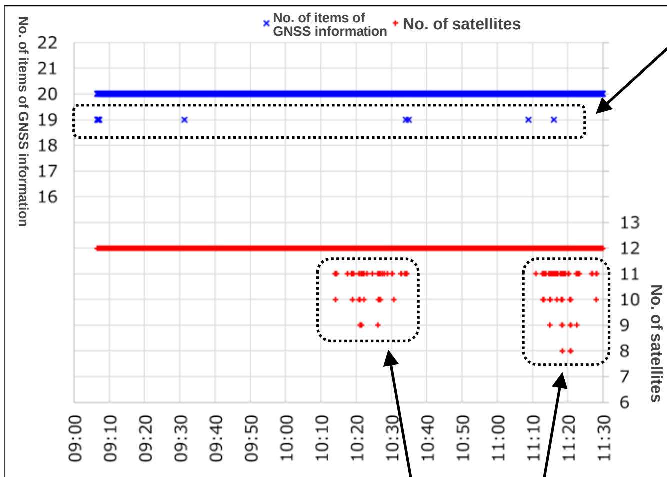
- Data loss happened irrespective of the number of positioning satellites.

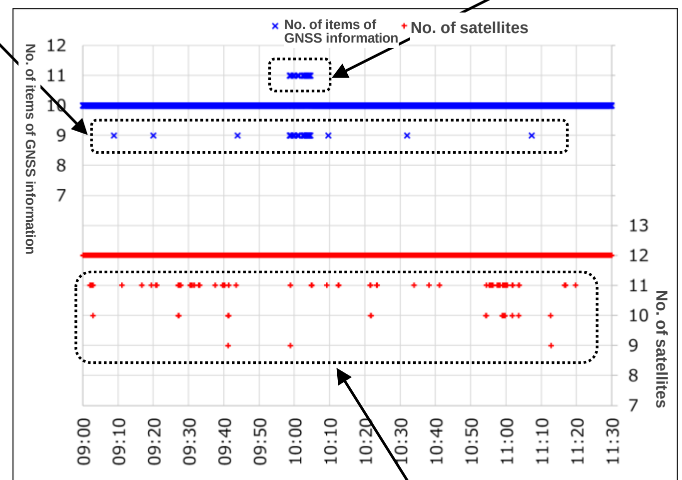
2 second delivery interval

GNSS location information loss

1 second delivery interval

11 items of GNSS location information





The number of positioning satellites differed between the two time periods

The number of positioning satellites differed between all of the time periods

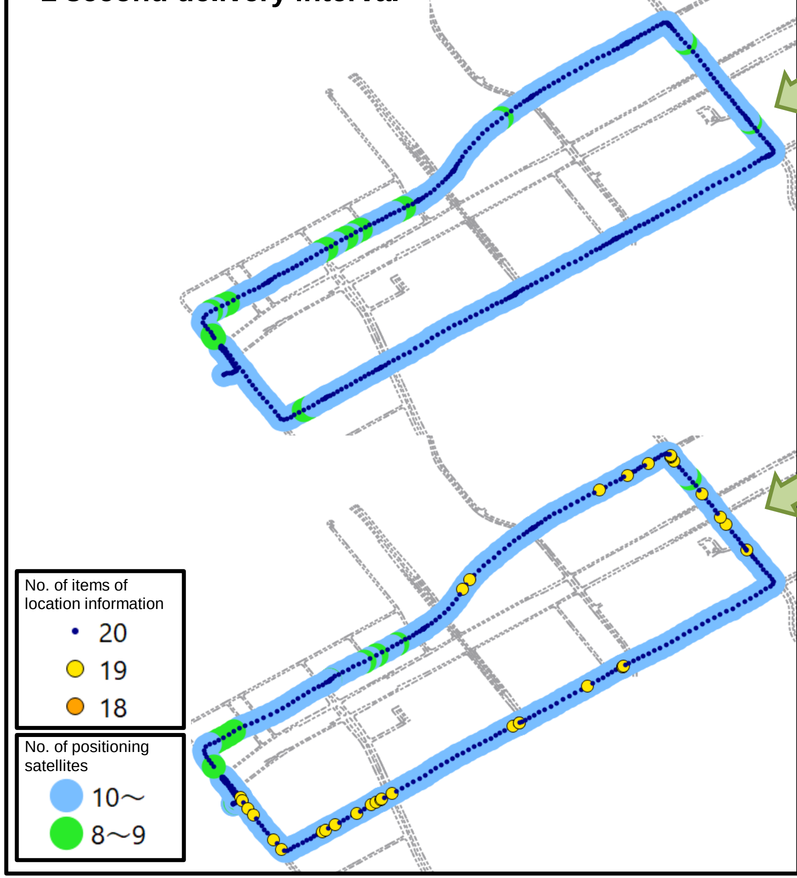
3-3. Results of testing of mock emergency vehicle information for vehicles on emergency calls

(3) Test results [8/9]: Differences between 2 second and 1 second intervals

D) Missing data and no. of GNSS reception satellites

- For both 2 and 1 second cycles, there were times when route driving was performed with no data loss and times when there was intermittent data loss.
- Data loss happened irrespective of the location or the positioning status (number of positioning satellites: 8 or more).
- This appears to be dependent on the device used to send the mock emergency vehicle information for vehicles on emergency calls

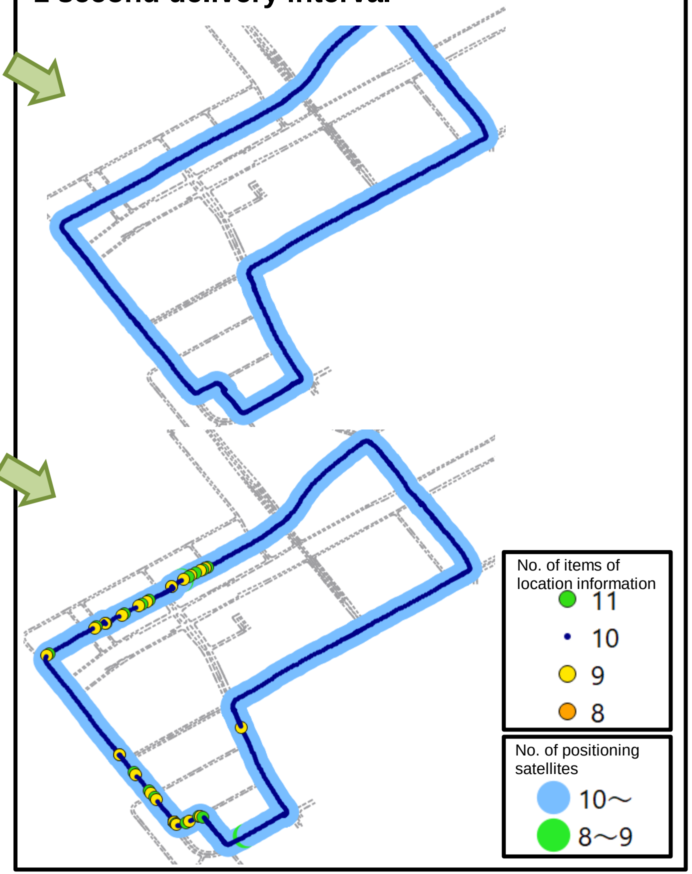
2 second delivery interval



Examples of no data loss occurring in either situation

Examples of data loss occurring in both situations

1 second delivery interval



(3) Test results [9/9]: Discussion of the differences between 2 second and 1 second update intervals

- We believe that changing the frequency with which mock emergency vehicle information for vehicles on emergency calls information is provided from 2 seconds to 1 second would have only a minimal impact from a transmission and processing perspective, and, from an information usage perspective, it would enable the use of the information in a wider range of close proximity use cases.

Legend: ○: Good, X: Poor, △: Mixed

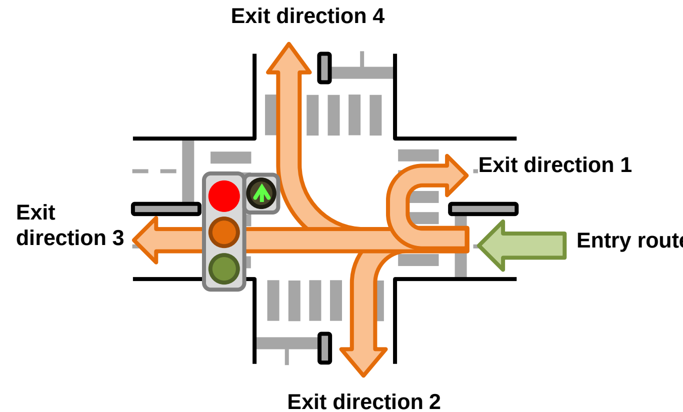
		2 second update interval 20 items of information indicating the location of the vehicle each 100 ms, sent in 2 second intervals	**1 second update interval** 10 items of information indicating the location of the vehicle each 100 ms, sent in 1 second intervals
Transmission and processing perspectives (infrastructure-side)	Uplink from mock emergency vehicle information for vehicles on emergency calls	No difference (For details, see the test results [4/9] to [8/9])	
	Inter-server processing		
	Downlink to test vehicle		
Information usage perspective (vehicle-side)	Determining approach of distant vehicle at a relatively early stage	○ No problem when using 2 second update interval	○ No problem when using 1 second update interval
	Close proximity vehicle control	× Due to large spacing between reception times, the information is hard to use as predictive information (the vehicle's own sensors might detect the mock emergency vehicle faster)	△ The information is relatively easier to use than when using the 2 second interval
Overall evaluation		△ • There were no transmission or processing problems • The information was effective in determining the approach of the distant emergency vehicle at a relatively early stage	○ • There were no transmission or processing problems • When an emergency vehicle is approaching from far away, this information could be used to predict its driving • When an emergency vehicle is in close proximity, this information would be effective in identifying the approach of the emergency vehicle at a somewhat earlier stage than when the information is provided in 2 second intervals (However, if vehicles learn in advance that an emergency vehicle is approaching, this delivery delay is not expected to have an impact)

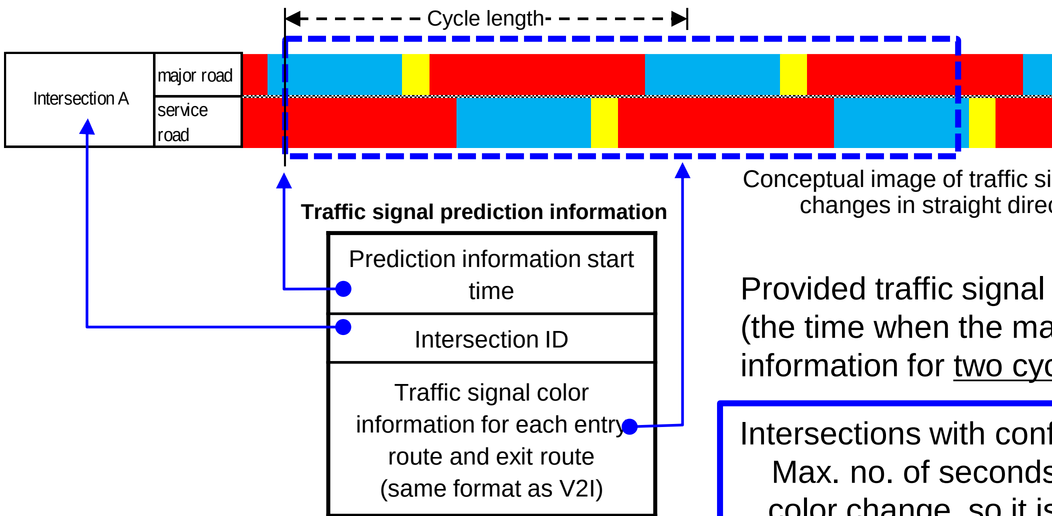
3-4. Results of traffic signal prediction information testing

(1) Overview of delivered information

- Below is an overview of the information

Information source: Metropolitan Police Department
Provided information: Traffic signal color prediction information when traffic signal cycle is confirmed
Provision scope: Traffic signals in Waterfront City area





Conceptual image of traffic signal color changes in straight direction

Provided traffic signal prediction information contains the cycle start time (the time when the major road's traffic signal turns green) and light color information for <u>two cycles for each exit direction of each entry route.</u>

Traffic signal prediction information is generated and provided three seconds before start of prediction information

Intersections with confirmed traffic signal prediction information :
Max. no. of seconds remaining = min. no. of seconds remaining before color change, so it is possible to predict the timing of the traffic signal color change

Intersections with traffic signal prediction information with margins :
Max. no. of seconds remaining > min. no. of seconds remaining before color change, so it is not possible to predict the timing of the traffic signal color change

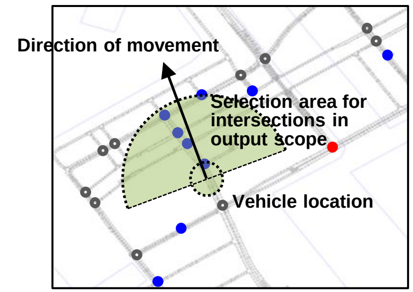
For traffic signals with no traffic signal aspect/remaining seconds, no traffic signal prediction information is provided

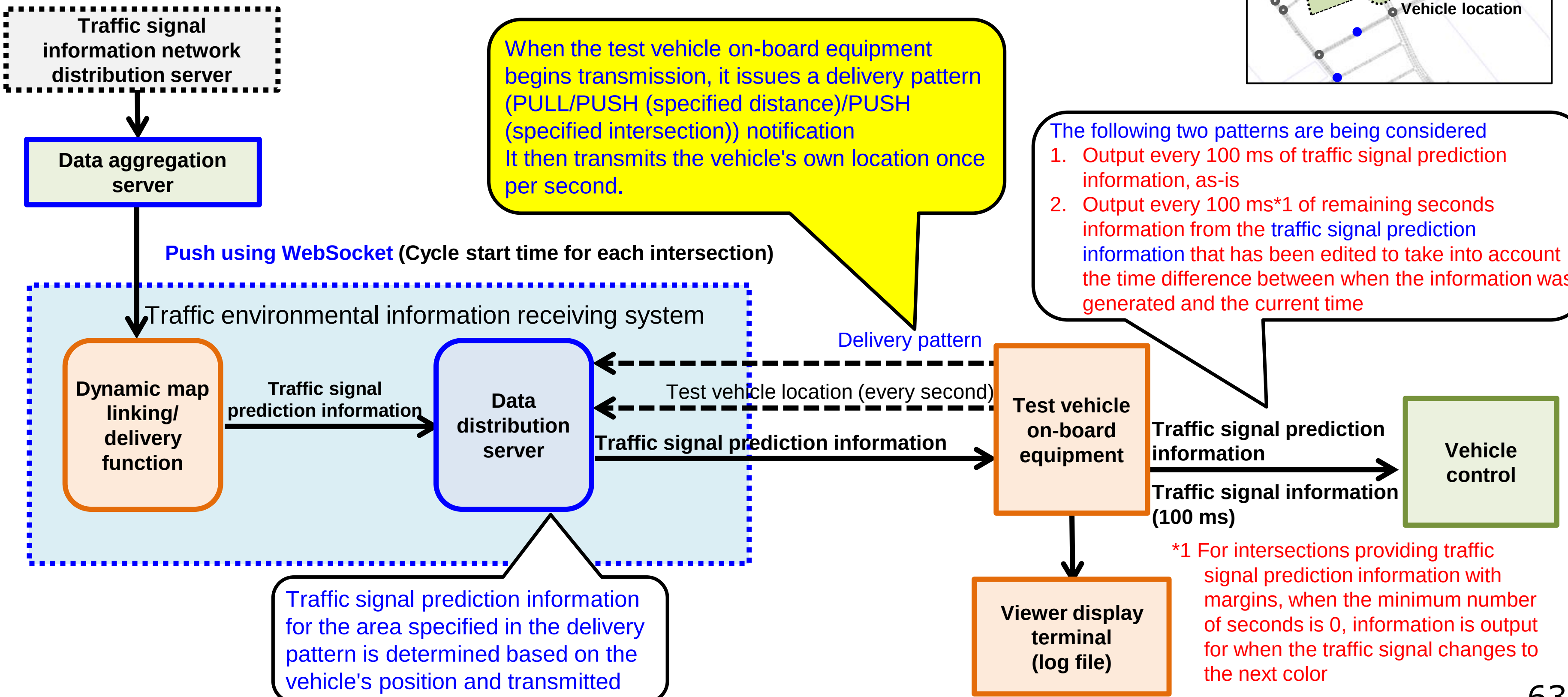
3-4. Results of traffic signal prediction information test

(2) Information delivery process (flow of data)

- Traffic signal prediction information sent from Metropolitan Police Department servers when the traffic signal cycle is confirmed is delivered using the PULL/PUSH (specified distance) or PUSH (specified intersection) method. The test vehicle on-board equipment then outputs the prediction information the modified remaining seconds information (choose one) (CAN output filtering will also be performed)

The test vehicle on-board equipment's traffic signal prediction information output scope consists of intersections within a 30 m radius of the vehicle's position and a half-circle with a 330 m radius facing the direction in which the vehicle is travelling (the same as V2I traffic signal information)





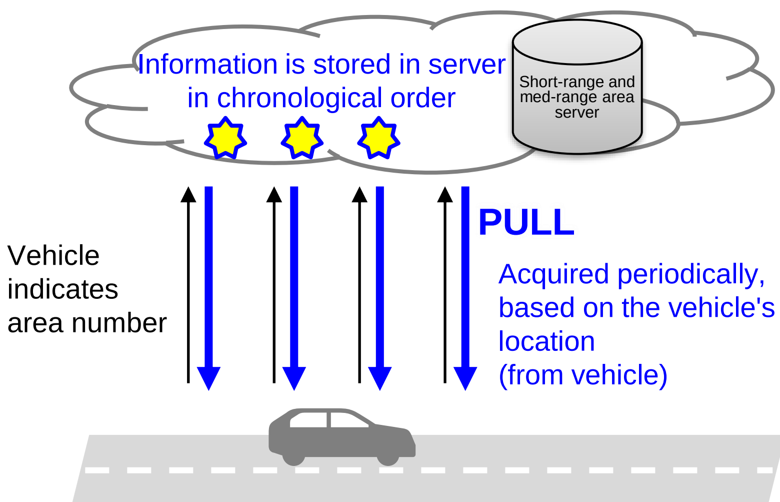
3-4. Results of traffic signal prediction information test

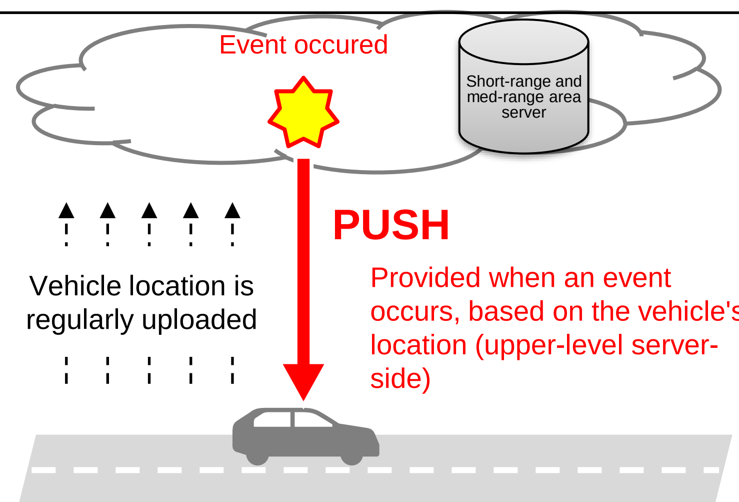
(2) Information delivery process (delivery method)

- Traffic environmental information was delivered using PUSH and PULL methods
- Information delivery methods for efficiently extracting information from the cloud
  ⇒ We considered how to reduce transmission delays related to transmitted traffic and network transmission

PULL: High volume, low frequency information updates
✓ Rainfall information
✓ Lane-specific road traffic information

PUSH: Low volume, high frequency information updates
✓ Mock emergency vehicle information for vehicles on emergency calls
✓ Traffic signal prediction information





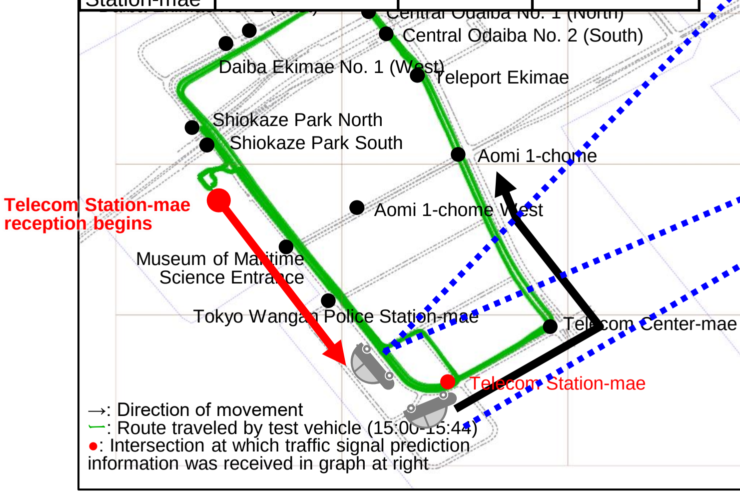
3-4. Results of traffic signal prediction information test

(3) Test results [1/2]

- Traffic signal aspect information was received via V2N for intersections that were in front of the vehicle but were not visible. The information could be used to support driving assistance and automated driving when entering intersections so, as with V2I, recognition can be improved by use of dual information systems.
- With regard to the potential for using this information for traffic signal color recognition when using driving assistance or automated driving, the FOTs found that, due to the following issues, there are problems with using the information for dilemma avoidance and with recognizing traffic signal colors at or near the times when traffic signal colors changed. Measures must therefore be considered for addressing these issues.

① There were discrepancies between the times when traffic signals actually changed and the contents of traffic signal prediction information (time difference of approx. 2 seconds)
② For intersections with remaining seconds margins, it is not possible to notify vehicles (or make predictions) of when traffic signals will change

Name of intersection	Time traffic signal color was recognized in drive recorder video	Traffic signal prediction information reception time	Use of green traffic signal information for first cycle of traffic signal prediction information
Telecom Station-mae	15:26:36	15:25:56	



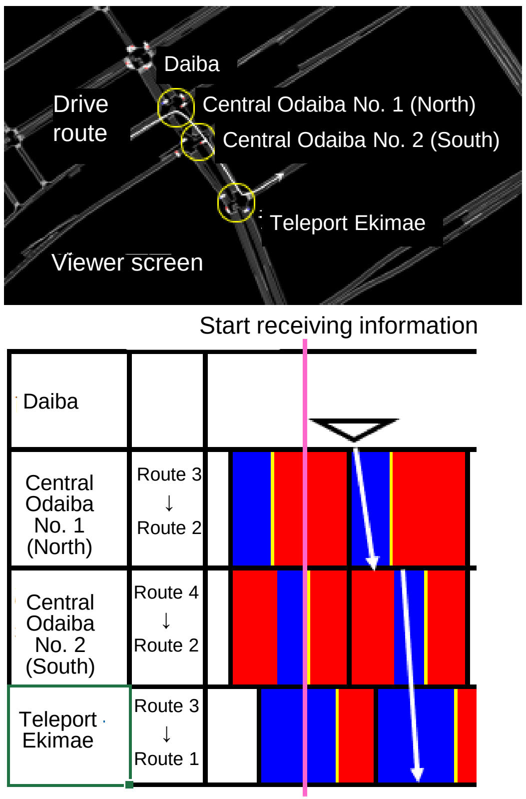
3-4. Results of traffic signal prediction information test

(3) Test results [2/2]

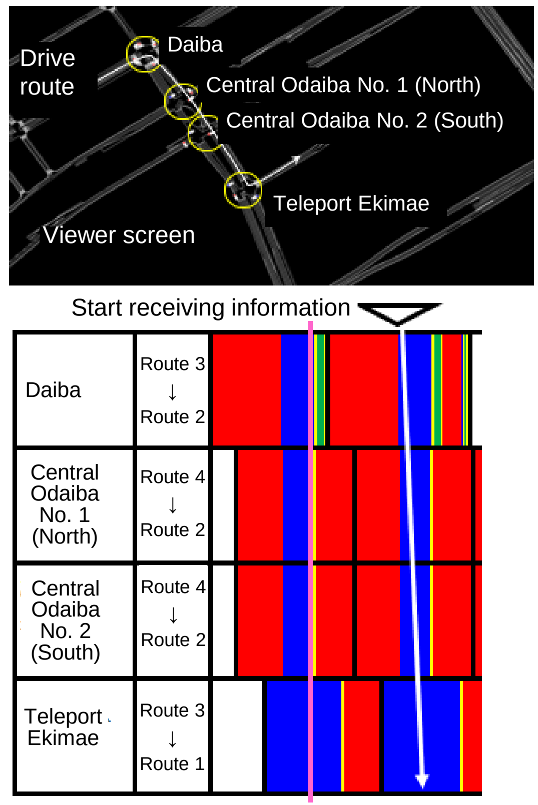
- We confirmed the status of the delivery of traffic signal prediction information using PUSH delivery (specified intersection)
- For route 1 (figure at left), where traffic signal prediction information was requested for the three intersections in front of the Central Odaiba No. 1 (North) intersection, and route 2 (figure at right), where traffic signal prediction information was requested for the four intersections in front of the Daiba intersection, traffic signal information for multiple intersections along the driving routes could be received at the same time

  ⇒ This showed that the information would make it possible to avoid stopping at intersections and would be effective for selecting the optimal driving route

Route 1



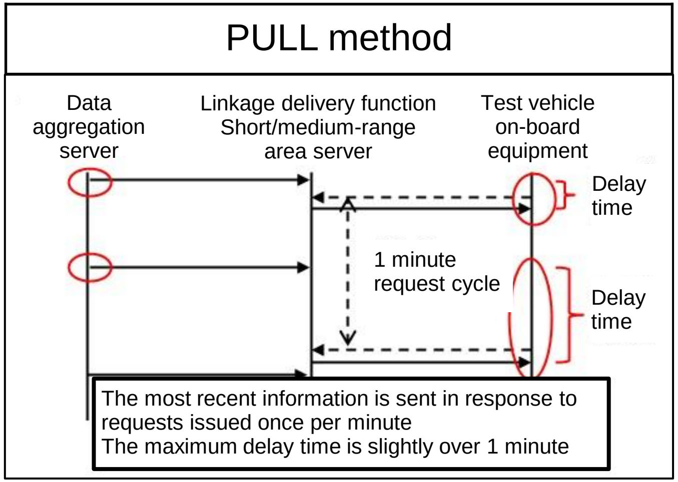
Route 2

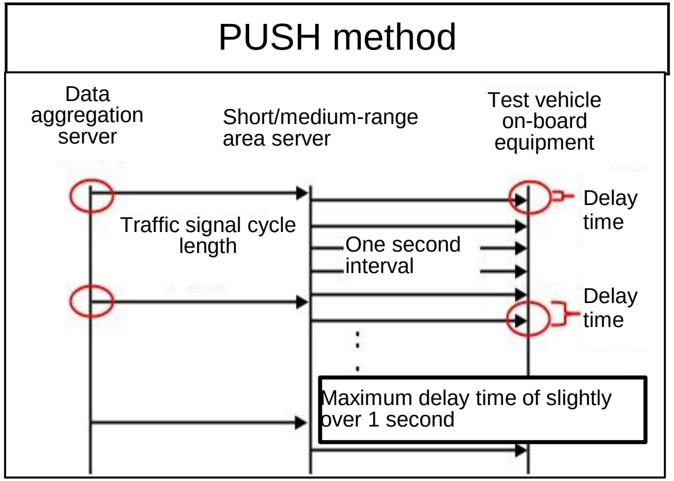


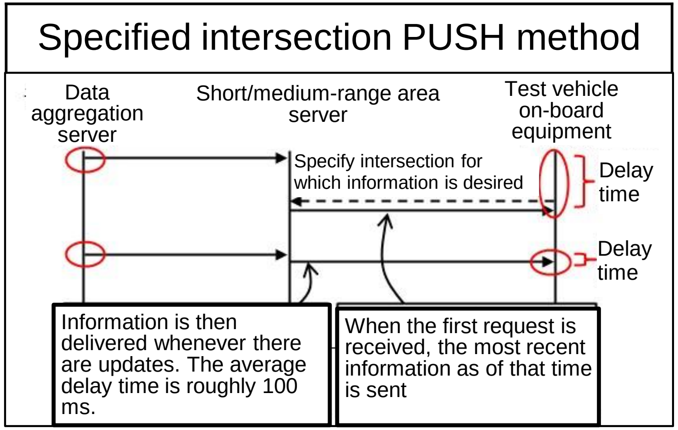
3-5. Results of testing of data transmission volume

(1) Features of the V2N information delivery system

- In the testing involving delivering information via V2N, traffic environmental information was delivered using both PUSH and PULL methods
- Information delivery methods vary depending on the traffic environmental information, so these figures show the transmission transactions and delay times for each method



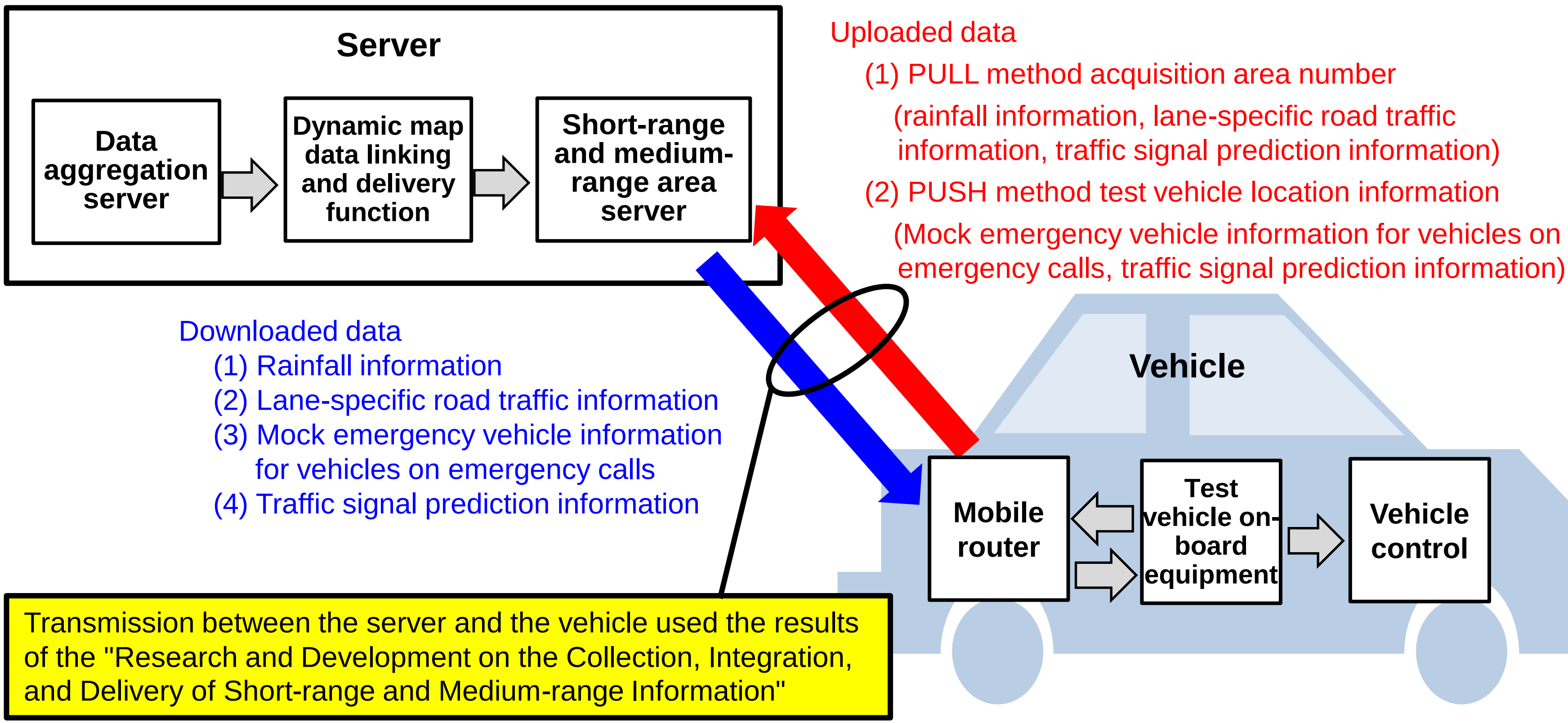




3-5. Results of testing of data transmission volume

(2) Conditions assumed when calculating V2N data size (amount of transmitted data)

- This document presents a summary of the amount of transmitted data via V2N (the size of the V2N data received by the vehicle)
- For operational purposes, the V2N data size (amount of transmitted data) was determined based on the amount of data downloaded to the vehicle from the upper layer server and the amount of data uploaded upon request from the vehicle to the upper layer server
- The following conditions were assumed when calculating the V2N data size in the FOTs



3-5. Results of testing of data transmission volume

(3) Test results

- The table below shows the amounts of data transmitted per hour via V2N during the FOTs

Table Amounts of data transmitted per hour (KB/hr)

		PULL method	PUSH method (specified distance)	PUSH method (specified intersection)
Upload		602.4	543.6	24.3 *5
Download	Rainfall information *1	175.9	–	–
	Lane-specific road traffic information *2	611.3	–	–
	Mock emergency vehicle information for vehicles on emergency calls *3 *(2-second interval/cycle)*	–	4,262.4 (355.2/5min)	–
	Traffic signal prediction information *4	708.6	6,678.0	50.6 *6
Total	Rainfall information *1	778.3	–	–
	Lane-specific road traffic information *2	1,211.7	–	–
	Mock emergency vehicle information for vehicles on emergency calls *3 *(2-second interval/cycle)*	–	4,806.0 (400.5/5min)	–
	Traffic signal prediction information *4	1,311.0	7,222.6	74.9 *6

*1 Assuming an acquisition area measuring 10 km x 10 km
*2 Assuming an average of 1.4 data transmissions (lanes) per minute (calculated using data from Dec. 2021 to Jan. 2022 and Mar. 2022 data)
*3 Amount of mock emergency vehicle information for vehicles on emergency calls received when encountering emergency vehicles and receiving information for two emergency vehicles continuously for one hour (top) and for five minutes (bottom)
*4 Assuming that intersection traffic signal prediction information is received for five intersections at a time
*5 Assuming that an intersection is traversed every two minutes (intersection switching)
*6 Assuming an average cycle length of 132 seconds (receiving 27.2 items of data per hour)

3.6 Recommendations based on V2N FOTs (1) Rainfall information

Vehicle-end needs

Rainfall information (amount of rainfall in a grid square measuring 250 m x 250 m, current condition analysis and 30 minute forecasts) would be effective for driving assistance and vehicle control. It is expected to be used in the following ways in particular. ※1

- Handover requests from automated driving to the driver
- Starting automated driving from manual driving
- Caution information for drivers
- Travel time forecasting that takes rainfall into account
- Route modification
- Withdrawing for safety purposes
- Vehicle speed adjustment
- Following distance adjustment
- Vehicle stability control

In addition to rainfall information, the following weather information is expected to be useful for driving assistance and vehicle control. ※2、3

- Wind speed/ tornadoes
- Fog/dust
- Lightning
- Snowfall accumulation on roads/road icing
- Flooding
- Earthquakes/tsunamis
- Snowfall/hail
- Storm waves

※ **1. The usage methods above are the use cases envisioned for these FOTs. Use cases will continue to be deliberated on in the future, with an eye towards actual implementation.**
※ **2. The weather information that is effective for driving assistance and vehicle control, indicated above, includes weather information for which use cases will be deliberated on in the future.**
※ **3. In the future, weather information that is effective for driving assistance and vehicle control will not be limited to the above information.**

FOTs results

The tests confirmed the following potential for refining information delivery methods.

- It would be preferable to shorten the time between when information is generated and when it is delivered
(In the FOTs system, data aggregation server processing takes approximately 10 seconds, data is shared between the data aggregation server and the linkage distribution server in one minute intervals, and data is shared between the data distribution server and the test vehicle on-board equipment in one minute intervals, so a delay of up to 2 minutes and 10 seconds may occur (the Japan Meteorological Business Support Center segment is not included within the verification scope))
- The processing burden placed on the vehicle must be reduced, and there may be cases in which the vehicle would request information for areas such as the areas around distant destinations.
- There is room for improvement in how rainfall levels are divided up, such as breaking the 0 to 5 mm/h category into multiple, more detailed categories, while combining the categories for rainfall levels of 30 mm/h and above.

※ **The rainfall information used in the FOTs was High-resolution Precipitation Nowcast information created and delivered by the Japan Meteorological Business Support Center. The accuracy of the information was not included within the scope of the FOTs (there were no requests from test participants to improve the accuracy of the information)**

- ◆ Recommendations for test (infrastructure) equipment
- ◆ Clarify issues to be addressed in order to cultivate a sense of acceptability in society

Recommendations and challenges involved in fostering public acceptability (Results of use cases used in the FOTs) :

- Socially acceptable use cases must be clarified and fleshed out in preparation for practical implementation
- It would be best to continue deliberating data items based on use cases

3.6 Recommendations based on V2N FOTs (2) Lane-specific Road Traffic Information

Vehicle-end needs

Situations in which lane-specific road traffic information is necessary

- When there is traffic congestion (including traffic congestion that extends to road side strips such as traffic congestion at exits) and making vehicle control decisions (following, lane changes)
- When there is no traffic congestion, but there are driving obstacles (traffic accidents, fallen objects, etc.)

How lane-specific road traffic information can be used

- Handover requests to the driver
- Lane changes (path planning)
- Route changes (route planning)
- Preliminary deceleration (deceleration in advance)

This may also be effective on general roads (left or right turn traffic congestion at intersections, traffic congestion at the entrances and exits of facilities, etc.)

FOTs results

The technical issues involved in utilizing information have become clear, and ongoing efforts must now be made towards achieving real-world deployment

Information accuracy improvement required	If more accurate information regarding the locations of the tail ends of traffic congestion (in the direction of travel) were available, it could be used to slow down well in advance ● Detection accuracy (solving problems such as traffic congestion information being received but there being no actual traffic congestion, etc.) ● Time accuracy (reducing the amount of delay due to processing and delivering information when traffic congestion is detected) ● Location accuracy (improving the accuracy of location information in the direction of travel and lane direction when traffic congestion is detected)
Requested message contents (Additional items)	● Information reliability (time accuracy, location accuracy) ● Traffic congestion probability based on statistical information ● Whether traffic congestion areas are growing or shrinking ● Average vehicle speed at the tail end of the traffic congestion ● Linking of tail end information and start point information

Recommendations to the contractor for the "Examination and Evaluation of Automated Driving Control Technologies that Use Lane-specific Probes, etc." project (Pacific Consultants)

- ◆ Recommendations for test (infrastructure) equipment
- ◆ Clarify issues to be addressed in order to cultivate a sense of acceptability in society

Recommendations and challenges involved in fostering public acceptability (Results of use cases used in the FOTs) **:**

- It would be best to improve the precision of delivered information and add messages

Vehicle-end needs

Mock emergency information for vehicles on emergency calls would be effective for driving assistance and vehicle control because <u>it would enable vehicles to learn in advance about approaching emergency vehicles</u>.

- This would provide sufficient advance notice to take necessary action.
  - Deceleration, stopping, pulling off onto the shoulder, waiting before entering an intersection, requesting handover to the driver, issuing a warning to the driver, etc.
- It could also be combined with a map to make it possible to determine if the approach of the emergency vehicle would have no impact on one's own vehicle.
  - This would be the case, for example, when the emergency vehicle is in the opposing lane of a road with a central divider
- Emergency vehicle identification support
  - Determination if a vehicle detected with an on-board camera, etc., is on an emergency call or not

FOTs results

The information delivered in the FOTs would be effective in driving assistance and when providing information to the driver, etc. When using it for automated driving, vehicle control, or similar use cases or applications, the effectiveness of the information could be further improved by refining the information from the following perspectives.
(In preparation for real-world deployment, additional discussion should be carried out within the industry regarding how automated vehicles are to behave when an emergency vehicle is approaching)

Location accuracy	● Horizontal: Being able to identify which lane the vehicle is in would make the information even more effective (some participants indicated the on-board sensors could be used when emergency vehicles are approaching) ● Vertical: The location must be identified for emergency vehicles in grade-separated intersections and overpasses (this could be handled through map linkage)
Delivery interval	● The information could be made even more effective by shortening the delivery interval to one second or less, which would consequently reduce the amount of location deviation.
Delivery method	● It would be best to avoid placing a burden on vehicles, but there is also a need for vehicles to specify areas * Delivery methods fall within the competitive area scope, so participants' opinions were divided
Delivery range	● Preferably, information should be delivered for ranges of up to 1 km for some use cases and applications
Information types	● In addition to location information, if possible, providing information such as direction of travel, turn signal status, possible routes, stop intent, vehicle type, vehicle size, speed, acceleration, yaw rate, etc. would make the information even more effective

*** The collection of emergency vehicle location information is currently being debated in another SIP project. The results of these FOTs should be shared with the other SIP project.**

- ◆ Recommendations for test (infrastructure) equipment (Recommendations to the automobile industry)
- ◆ Clarify issues to be addressed in order to cultivate a sense of acceptability in society

Recommendations and challenges involved in fostering public acceptability (Results of use cases used in the FOTs) **:**
- Socially acceptable use cases must be clarified and fleshed out in preparation for practical implementation
- It would be best to continue deliberating data items based on use cases

3.6 Recommendations based on V2N FOTs (4) traffic signal prediction information

Vehicle-end needs

The FY2019-2020 FOTs in the Tokyo Waterfront area (V2I) confirmed that traffic signal information is effective in situations involving impediments to traffic color identification or deviations in traversal decision-making.

- Factors impeding color recognition: Traffic signal color information
  - Backlighting
  - Direct lighting
  - Concealment/obstruction
  - Blending into background
  - Nighttime
  - Raindrops
- Differences in intersection traversal decision-making: Traffic signal remaining seconds information
  - Intersections located short distances from adjacent traffic signals
  - Intersections on routes with high speed limits
  - Intersections with short yellow signal durations

⇒ Participants would like for traffic signal information to be provided over an even larger area (all intersections in sections in which automated driving is performed).

FOTs results

The FY2021 FOTs confirmed the effectiveness of traffic signal prediction information provided via V2N over a large area.

- V2N traffic signal prediction information was also effective in situations involving impediments to traffic color identification or deviations in traversal decision-making, where V2I was effective*1*2
- The information applies to large areas, so it could be used to reduce the number of vehicle stops and shorten the amount of time required. It could therefore contribute to achieving carbon neutrality.
  (Even in suburban and rural areas where traffic signals are far apart, the information could assist in setting cruising speeds and providing driving assistance.)

*1: Issues such as the time gaps between actual traffic signal colors and the contents of V2N information, which occurred in the FOT environment, need to be addressed.

*2: Traffic signal prediction information needs to be delivered after finalizing remaining seconds at intersections with margins

*** The generation of traffic signal prediction information is currently being debated in another SIP project. The results of these FOTs should be shared with the other SIP project.**

- ◆ Recommendations for test (infrastructure) equipment
- ◆ Clarify issues to be addressed in order to cultivate a sense of acceptability in society

Recommendations and challenges involved in fostering public acceptability (Results of use cases used in the FOTs) **:**

- Expanding V2N traffic signal information distribution areas is hoped to contribute to the expansion of drivable areas
- In preparation for practical implementation, the technical issues that were discovered through the FOTs should be addressed

4. Findings regarding the public acceptability of automated driving based on the impact assessment

4. Findings regarding the public acceptability of automated driving

(1) Issues, verification items, and targets

Issues

- **Ensure reliability of signal recognition by vehicle**
- **Presence of dilemma zones* interfering with smooth traffic flow**

Verification items

(1) Traffic signal information
  (a) Effectiveness of traffic signal color information
  (b) Effectiveness of traffic signal remaining seconds information
(2) Assessment of impact of automated vehicle driving on traffic flow and factors causing this impact

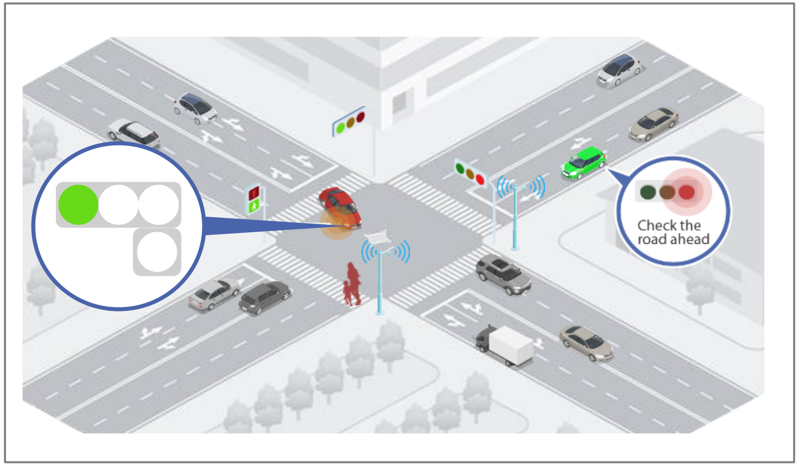
*Dilemma zone definition
Region in which, when the traffic light turns yellow, the vehicle would not be capable of stopping before the stop line when decelerating at the normal deceleration rate but the vehicle would not be able to traverse the intersection (stop line) while the traffic light was still yellow if maintaining the same pace

Benefits of cooperative infrastructure technologies

- Recognition improved by use of dual information systems
- Avoidance of dilemma zones* through use of predictive traffic signal information (number of remaining seconds)

Target

- Verify effectiveness of distributing traffic signal information
- Confirm specifications aimed at standardization and consensus by test participants
- Identify environmental conditions required for traffic signal information distribution
- **Clarify issues to be addressed in order to cultivate a sense of acceptability in society**



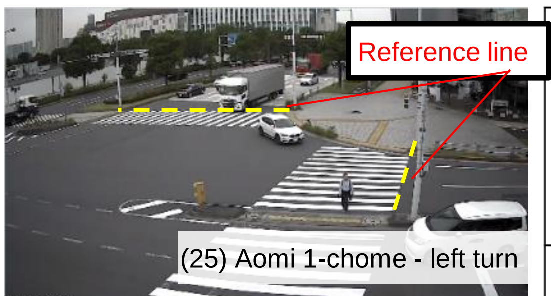
4. Findings regarding the public acceptability of automated driving

(2) Summary

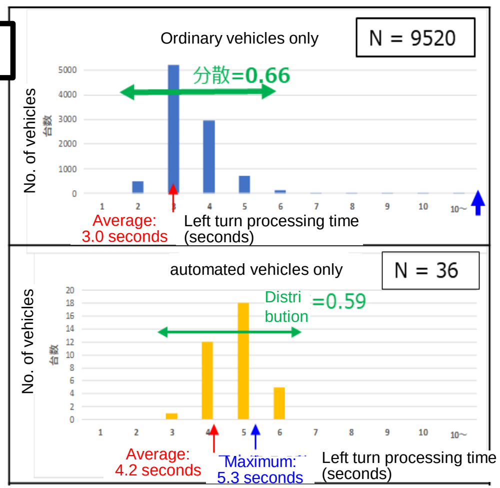
- The intersection left and right turn processing volumes were not observed to fall significantly when automated vehicles were present, and were observed to be more consistent than the processing volumes when only ordinary vehicles were present.
- We observed that when look-ahead information was used, sudden deceleration did not occur when stopping at traffic lights.
- automated vehicles were observed to consistently stop at designated locations when pedestrians were detected at pedestrian crossings at intersections or on non-intersection sections.
- With regard to dilemma zone behavior, sudden braking was observed in following vehicles as the result of sudden braking by test vehicles resulting from differences in driver decisions, the timing of detection of other vehicles by vehicle sensors, etc.

It would be best to widely share gathered situation information, not only with other test participants but with a wide range of parties, to assist with future automated driving development.

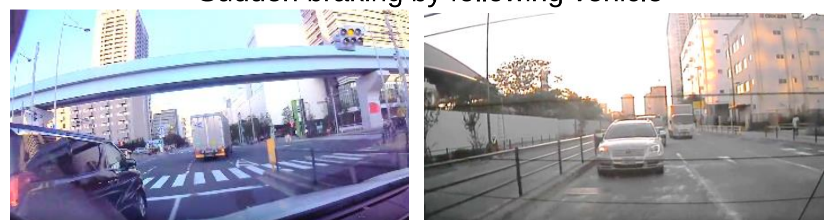
Evaluation of processing when turning left



Evaluation method:
Measure reference line traversal times based on fixed-point camera video data and calculate processing times based on differences in these times



Sudden braking by following vehicle



The traffic signal arrow turned yellow, so the test vehicle rapidly braked. The following vehicle intended to turn right, so it accelerated.

Because the test vehicle stopped, the following vehicle suddenly stopped with a small amount of knocking. It was a close call.

4. Findings regarding the public acceptability of automated driving

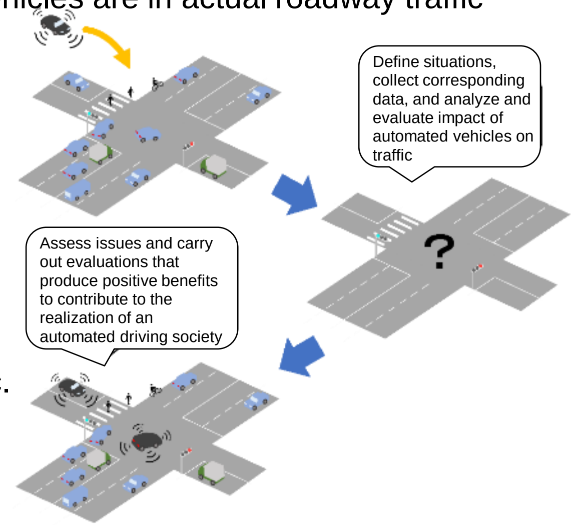
(3) Evaluation approach

[Impact assessment]

Assessment of impact of automated vehicles on surrounding environment when driving safely in actual traffic environments. This includes their impact on nearby ordinary vehicles, crosswalk pedestrians, etc.

- **Evaluation approach**
  - Define situations in which automated vehicles driving in actual roadway traffic environments influence traffic, collect information about these situations, and analyze situations when automated vehicles are in actual roadway traffic environments and when they are not

- **Areas of focus in evaluations**
  - When automated vehicle are in traffic
    - ✓ Whether traffic flows as normal
    - ✓ Whether the environment is safer than normal
    - ✓ Whether the flow of traffic gets better/worse
    - ✓ Whether there are changes in the behavior of vehicles near the automated vehicle
  - When automated vehicles encounter pedestrians/bicycles at intersections, etc.
    - ✓ Whether traffic flows as normal, etc.

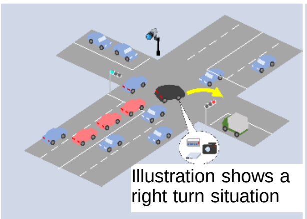
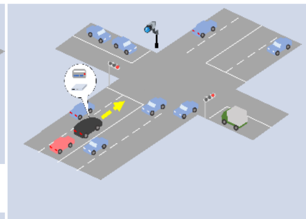
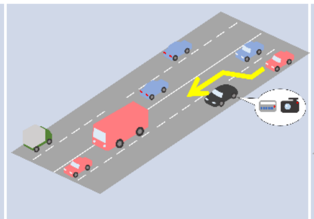
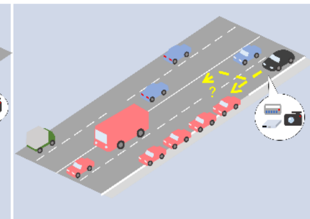
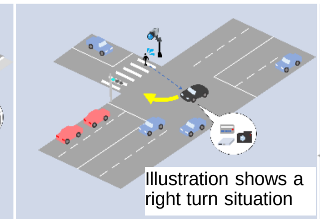
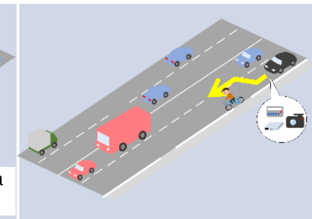


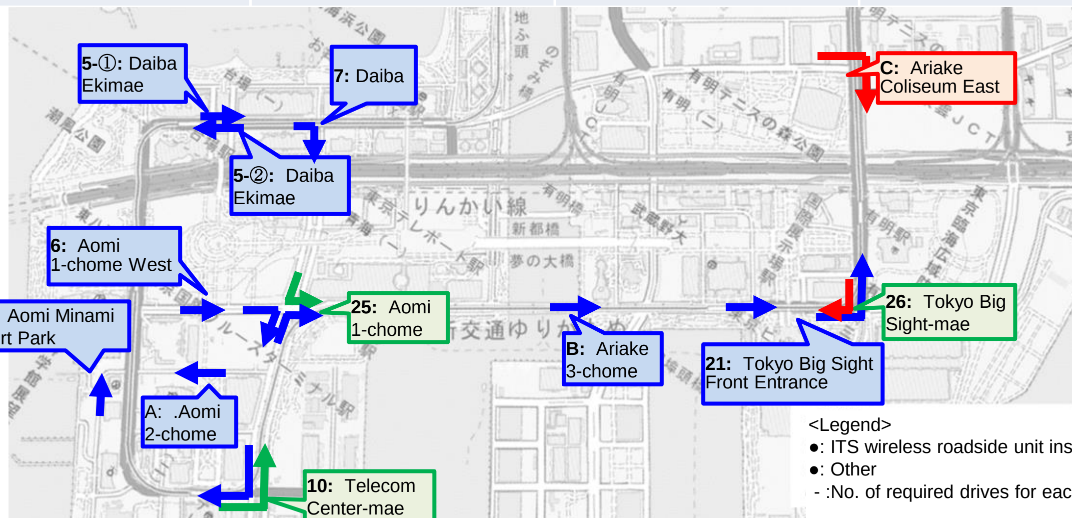
Assess evaluations and points to note as automated driving gradually becomes more prevalent in society

4. Findings regarding the public acceptability of automated driving

(4) Evaluation items

- Collect data for traffic consisting only of ordinary vehicles and traffic which includes automated vehicles
- Perform analysis and evaluation of the following items

①Impact and issues related to driving environments				② Impact and issues related to pedestrians, etc.	
					
Evaluation of processing when turning left/right	Stopping at red lights when driving straight	Behavior of nearby vehicles when driving straight (sudden braking, cutting in, etc.)	Handling of on-street parking (avoidance, left turns)	Crossing pedestrians when going straight, turning right, or turning left	Handling of bicycles



<Legend>
●: ITS wireless roadside unit installation location
●: Other
-: No. of required drives for each participant

Source: Processed from electronic topographic map 25000 (Geospatial Information Authority of Japan map)

4. Findings regarding the public acceptability of automated driving

(4) Evaluation items

- The following impacts on the surrounding environment were looked at when performing impact assessment
- The following pages provide some representative test results (underlined)

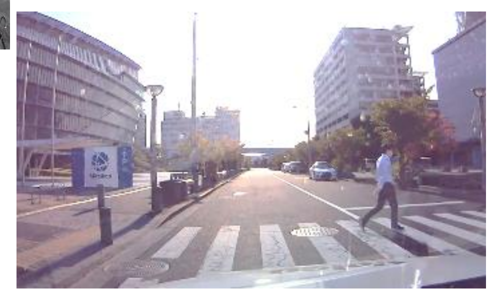
A) Impact on surrounding environment (driving space)
(i) Evaluation of processing when turning left
(ii) Evaluation of processing when turning right
(iii) Behavior of nearby vehicles when driving straight
(iv) Evaluation of handling of on-street parking
(v) Behavior when stopping at a red light when driving straight
(vi) Speed deviation when driving straight
(vii) Evaluation of impact on encounters between test vehicles turning right and oncoming cars driving straight

B. Impact on the surrounding environment (pedestrians, etc.)
(i) Crossing pedestrians when going straight
(ii) Crossing pedestrians when turning left or right
(iii) Impact on bicycles and motorcycles

Evaluation of behavior when turning left

Evaluation of behavior at red lights when driving straight

Evaluation of behavior when encountering a crosswalk pedestrian when driving straight



4. Findings regarding the public acceptability of automated driving

(5)Test results

A) Impact on surrounding environment (driving space) (ii) Evaluation of processing when turning right

1) Evaluation items: Changes in right turn processing time resulting from the presence of automated vehicles
(no crosswalk pedestrians or oncoming vehicles driving straight forward)

- Areas of focus: (a) Does the processing time change for the automated vehicle?
(b) Does the processing time change for nearby vehicles (following vehicles)?
- Evaluation method: Measure reference line traversal times(*1) based on fixed-point camera video data and calculate processing times based on differences in these times

*1: Only for standard-sized cars

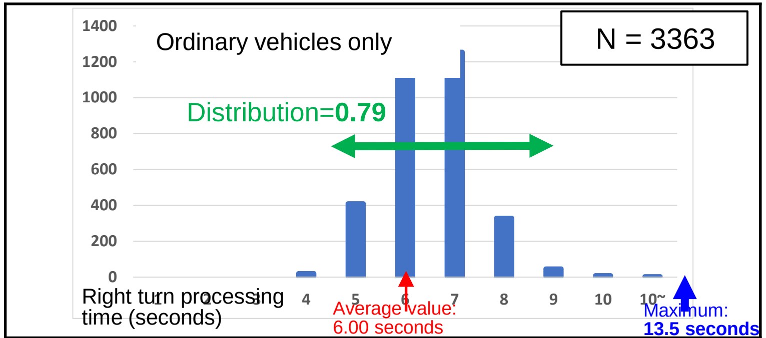
2)Results: Target intersection: (c) Ariake Coliseum East - right turn(*2)

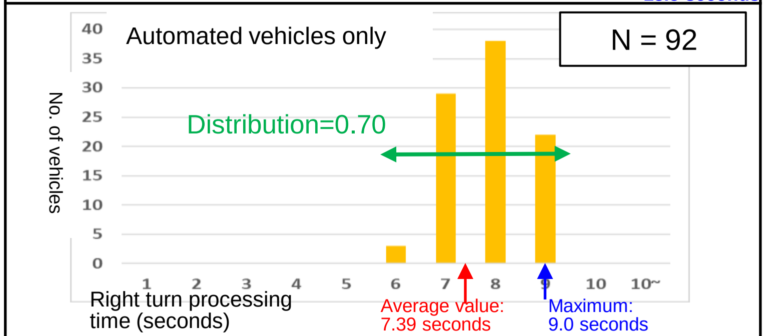
*2: All of the vehicles following the automated vehicle at this intersection were ordinary vehicles (not involved in the testing)

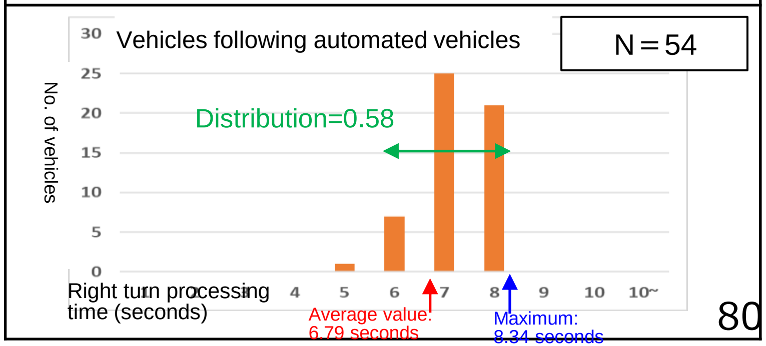
- The average processing times for ordinary vehicles was low, but the maximum values were high.
- Average processing times were high for automated vehicles and nearby vehicles (following vehicle), but maximum values were low. There was also little variation for nearby vehicles.

3)Observations and future prospects

- Nearby vehicles (following vehicles) tend to behave more like automated vehicles, influenced by their safe driving.
- The FOTs suggest that the presence of automated vehicles could produce more stable driving environments (roadway traffic environments which are not influenced by differences in driver characteristics or proficiency).







Reference line

(c) Ariake Coliseum East - right turn

4. Findings regarding the public acceptability of automated driving

(5)Test results

A) Impact on surrounding environment (driving space) (iii) Behavior of nearby vehicles when driving straight

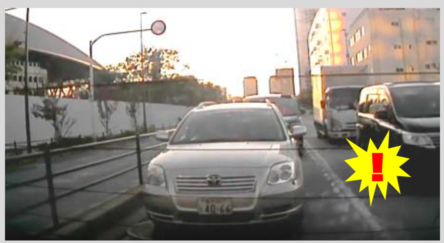
■ **Behavior of automated driving when the traffic signal changes when driving straight forward, etc. (right turn)** ID:16161

* Case of an automated vehicle entering a queue of vehicles waiting to turn right and the traffic signal changing from yellow to red. The following vehicle intended to pass through the intersection, but the automated vehicle in front of it stopped, resulting in the risk of a rear-end collision

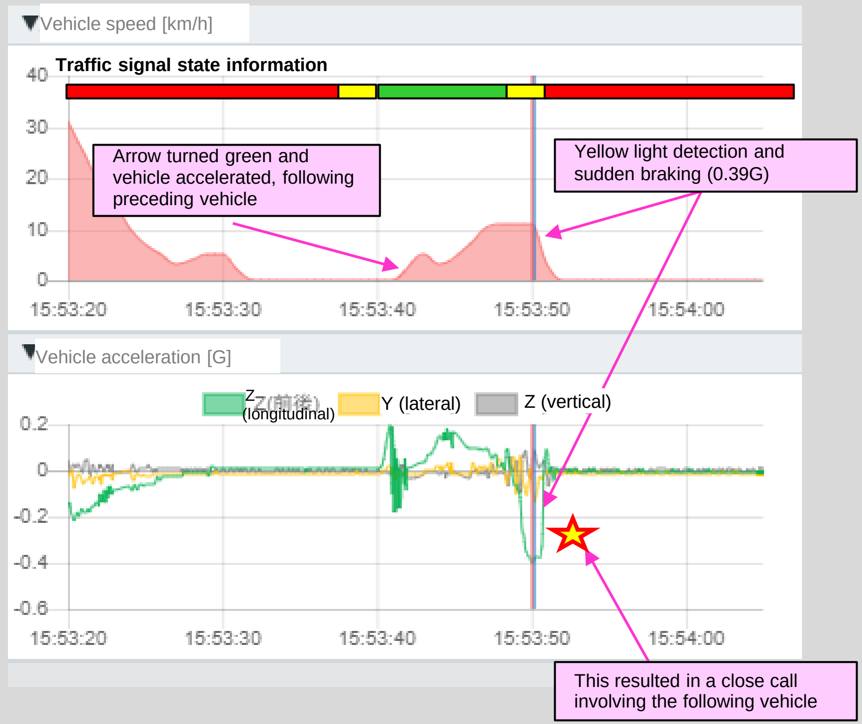
automated vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing


A group of cars was waiting to turn right. The right turn traffic signal turned green and vehicles accelerated (following timing was somewhat slow). Following vehicles also lined up.


The traffic signal arrow turned yellow, so the test vehicle rapidly braked. The following vehicle intended to turn right, so it accelerated.

Because the test vehicle stopped, the following vehicle suddenly stopped with a small amount of knocking. It was a close call.



Analysis: Behaving more safely when turning right affects following vehicles

* The way the vehicle was behaving, it appeared that it would normally begin and carry through with turning right, but it stopped when the yellow signal was detected.
* Earlier stop/right turn decision-making could be performed if traffic signal information were available, so this case is an example of one where cooperative infrastructure could assist with risk avoidance.

4. Findings regarding the public acceptability of automated driving

(5)Test results

A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

■ **Behavior of automated vehicle when stopping at a red light while driving straight**

*[automated]Situations involving sudden deceleration near an intersection and the possibility of a close call involving the preceding vehicle

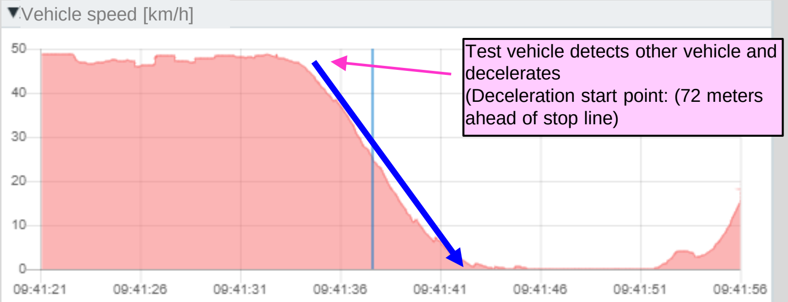
ID:4226

automated vehicle attributes	Passenger vehicle	No cooperative infrastructure	Image processing

The test vehicle detected a traffic light and a preceding vehicle (motorcycle) and began decelerating (72 meters before the stop line)

The test vehicle was close to the intersection, so it decelerated rapidly (-0.3G)

The test vehicle stopped after decelerating suddenly, and there was the potential for congestion involving the preceding vehicle



Analysis: Stopping based on spatial monitoring appears to be insufficient for carrying out safe driving

- Stopping was based on spatial monitoring alone, so stopping was performed near the intersection
- There was the potential for a close call involving the preceding vehicle

4. Findings regarding the public acceptability of automated driving

(5)Test results

B . Impact on the surrounding environment (pedestrians, etc.)

(i) Crossing pedestrians when going straight

1) Evaluation items: Evaluation of the impact of automated vehicles on crosswalk pedestrians

- Areas of focus:
  - ➢ When encountering crosswalk pedestrians, did automated vehicles wait for the pedestrians to cross before traverse the intersection?
  - ➢ Did automated vehicles that encountered crosswalk pedestrians stop before the stop line?

Manual driving (example of vehicle traversing intersection)

2) Results Target intersection:(A) Aomi 2-chome - driving straight

- When encountering crosswalk pedestrians, there were ordinary vehicles which did not wait for the pedestrians to pass, instead crossing the crosswalk first. However, automated vehicles always waited for the pedestrians to pass first.

3) Analysis and future prospects

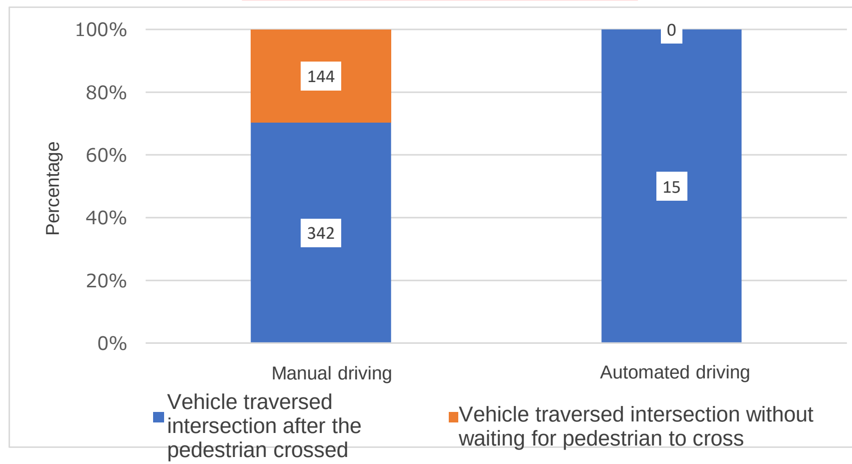
- automated vehicle always engaged in safe driving when detecting a crosswalk pedestrian.
- Confirmation has not yet been carried out of what risks might be created for nearby vehicles by the safe driving behavior of automated vehicles when encountering a pedestrian

Automated driving (example of vehicle stopping)

■ Percentage of cases involving encountering pedestrians in which pedestrians were given right of way
(Evaluation of all vehicles that encountered crosswalk pedestrians during the intensive driving period)

- Lower percentages below indicate a greater likelihood of a vehicle crossing the crosswalk first, without waiting for the pedestrian to cross

	Ordinary vehicle	automated vehicle
Percentage of cases in which pedestrians were given right of way	70.4%(N= 486)	100%(N=15)



However, in addition to safe stopping cases, a case was also confirmed of approaching a pedestrian.

4. Findings regarding the public acceptability of automated driving

(5)Test results

B . Impact on the surrounding environment (pedestrians, etc.) (i) Crossing pedestrians when going straight

■ **Behavior of automated vehicles when driving straight and encountering crosswalk pedestrians**

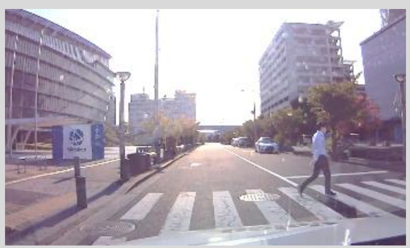
* Case of an encounter with a crosswalk pedestrian on a basic road section (with no traffic signal). The vehicle was slow to detect the crosswalk pedestrian, so it crossed the stop line by a large amount and drew near the pedestrian.

ID:16057

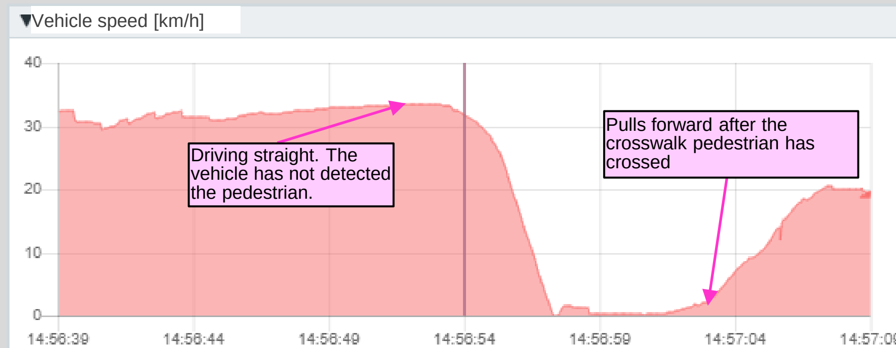
automated vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing

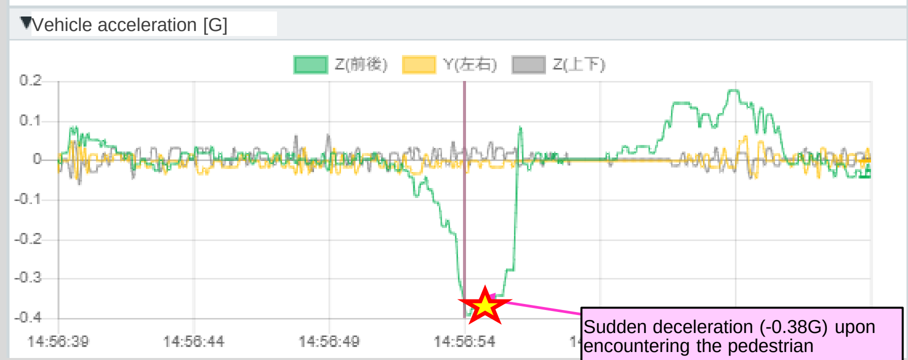

The vehicle approaches the pedestrian crossing. It has not yet detected the presence of the crosswalk pedestrian.


The vehicle detects the crosswalk pedestrian and suddenly decelerates (0.38G). The vehicle crosses the stop line by a large amount and draws near the pedestrian.

After confirming that the pedestrian has crossed, the vehicle pulls forward.





Analysis: The vehicle did not detect the crosswalk pedestrian until the last minute, so it suddenly decelerated.

* Trees, light poles, etc., could have acted as obstacles, delaying the detection of the crosswalk pedestrian.
* The vehicle suddenly decelerated, but then waited until the pedestrian had crossed before pulling forward.

4. Findings regarding the public acceptability of automated driving

(6) Summary based on the test evaluations of impact assessment in FY2019-2020

[Findings based on test results]

1. **Impact on traffic flow**
   A) The presence of automated vehicles causes right turn and left turn processing times to increase slightly, but we assessed driving stability for following vehicles and confirmed that roadway traffic environments in which there were automated vehicles present became safer driving environments
   B) The actual speeds of automated vehicles are equal to or below legal speeds, while ordinary vehicles tend to drive at somewhat high speeds, so consideration must be given to the possibility of reduced traffic flow smoothness when automated vehicles become more widespread, but automated vehicles have high promise for increasing safety
2. **Impact on traffic flow (encounters with crosswalk pedestrians)**
   A) We confirmed that when encountering pedestrians, the extremely safety oriented behavior of vehicles resulted in situations in which vehicles could not turn right or left. Instead of simply making safety the first priority, there is a need to balance safety and smooth traffic flow, including the use of cooperation between vehicles and their surrounding environments
3. **Impact on pedestrians**
   A) No cases were observed in automated driving of insufficient eye contact between drivers and pedestrians having an impact (such as hesitation to cross or a reduction in attention paid to other vehicles)
   We believe that this is because automated vehicles look like ordinary vehicles and there are drivers in the driver's seat even when automated driving is being performed
   B) The impact and risks that may exist in the future, when driverless operation is used, were not confirmed (this falls outside the scope of this test)
4. **Impact on safety (accidents)**
   A) We confirmed that cooperation with infrastructure, primarily within intersections, contributes to cooperation with the behavior of nearby vehicles, pedestrians, bicycles, etc.
   B) However, we also observed cases of close calls due to sudden deceleration on non-intersection sections and in front of intersections, etc., and confirmed the possibility of impact on the surrounding environment
   We confirmed that one of the improvement requirements during the development of automated driving systems is the ability to handle a greater diversity of surrounding environments (approaching ordinary vehicles, obstruction by large vehicles, etc.)

4. Findings regarding the public acceptability of automated driving

(7) Results of test participant questionnaires regarding public acceptability

- Based on the findings on the previous page, we collected and confirmed the opinions of test participants regarding the public acceptability of automated vehicles through the four years of FY2019 to FY2022. We confirmed the following.

Table - Test participant questionnaire items (public acceptability)

	① Experience sharing	② Matters to be given consideration when developing/selling automated driving systems in the future	③ Issues involved in real-world deployment of automated driving systems
1. Impact on traffic flow	• Cases of driving tending to be safer when turning right or left • Cases of driving at a slower speed than other vehicles on straight road segments	• Matters to be considered other than those indicated below (negative impact on traffic smoothness, road rage, sudden braking or the like causing close calls with following vehicles)	1. Issues related to content of column ①
2. Impact on traffic flow (encounters with crosswalk pedestrians)	• Situations in which excessive prioritization of pedestrian traffic and excessively safety-oriented behavior resulted in situations in which vehicles could not turn right or left	• Matters to be taken into consideration regarding encountering crosswalk pedestrians while turning left or right	2. Issues related to content of column ①
3. Impact on pedestrians	• Situations in which automated driving resulted in insufficient eye contact between drivers and pedestrians, causing pedestrians to hesitate to cross the road or otherwise causing diminished vehicle attentiveness	• Measures for reducing risk when automated vehicles perform level 4 driverless operation on general roads	3. Issues related to content of column ①
4. Impact on safety	• Situations in which sudden deceleration on non-intersection sections, in front of intersections, and the like could cause close calls	• Things taken into consideration regarding sensor performance, control, and prediction	4. Issues related to content of column ①

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "1. Impact on traffic flow"

① Issues experienced by test participants

[Case of driving tending to be safer when turning right or left]

- The vehicle was able to **stop at the intersection stop line without entering a dilemma zone by using remaining seconds information** when turning left.

[Case of driving at a slower speed than other vehicles on straight road segments]

- **There was a case of dangerous passing**, and the participant's vehicle could not be described as having made driving safer.
- When the participant received cycle information from the wireless ITM system **and began decelerating, the vehicle behind the participant's vehicle did not know what to do**. This is believed to be because the following vehicle was unaware of that cycle information.

② Measures taken during FOTs and matters to be given consideration when developing/selling automated driving systems in the future

[**Technology-related**]

- **Indicate that the vehicle is an automated vehicle, and the current status of the automated vehicle to the following vehicle through an HMI**
- **Detect in advance when there is a possibility that an automated vehicle will impede the driving of an ordinary vehicle and prevent this problem by having the automated vehicle pull over to the shoulder temporarily when the road is wide to allow the following vehicle to pass.**

[**Driving environment-related or system-related**]

- **Test participants recognized there as being a need to redefine speed limits in individual areas, taking into consideration actual traffic flow**.

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "1. Impact on traffic flow"

③ Issues involved in real-world deployment of automated driving systems

[**Technology-related**]

- **Communicating intent with others in the traffic environment, such as the drivers of oncoming vehicles, presents a problem**.
- **Converting the mutual sharing of vehicle location information into a cooperative area activity.**
- **The collection of data from automated vehicles and data showing how automated vehicles and other road users interact**.
- **There is an extremely high amount of parking on the side of the street in the Waterfront City area**.
- **Responsibility for sharing information regarding the general behavior and characteristics of automated vehicles with the general public and ensuring the awareness of the general public should lie with the government and industry, not with individual companies**.

[**Driving environment-related or system-related**]

- Some test participants indicated that they felt that actual vehicle speeds and safety margins, and how they intersect, should be reviewed and revised, and **speed limits need to be changed**.
- Driving by ordinary drivers already regularly exceeds the speed limits set by the Road Traffic Act, and automated vehicles which obey the law will be subject to tailgating or road rage. For public acceptability to be achieved, **day-to-day enforcement will need to be stepped up and safe driving education activities** will need to be carried out.
- **The amount of time that arrow signals are lit for will need to be adjusted**.

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "2. Impact on traffic flow (encounters with crosswalk pedestrians)"

① Issues experienced by test participants

[Cases in which the prioritization of pedestrians resulted in **vehicles being unable to complete left or right turns]**

- **The vehicle is designed to stop while there is a pedestrian in the pedestrian crossing, which made it difficult to complete a left turn. Ultimately, the oncoming vehicle lost patience and turned right**.

[Cases in which the prioritization of pedestrians **did not result in vehicles being unable to complete left or right turns]**

- When traffic lights for vehicles turn green, automated vehicles, like manually driven vehicles, **pull up to just before pedestrian crossings, check that there are no pedestrians in the pedestrian crossing, and then resume driving**. Because of this, the automated vehicle was able to complete left and right turns just as a manually driven vehicle would.

② Measures taken during FOTs and matters to be given consideration when developing/selling automated driving systems in the future

[**Technology-related**]

- **Infrastructure sensors (such as LiDAR sensors) that monitor objects in intersections must be installed and information must be provided to automated vehicles that traverse intersections.**
- **Pedestrian information must be provided via V2N transmission.**
- **Vehicle-to-vehicle communication, HMIs, or the like could be used.**
- **One test participant indicated that it was focusing its efforts on developing a system for making an emergency stop if anything was wrong with the driver.**

[**Driving environment-related or system-related**]

- **Having separate signals for pedestrians and for vehicles would be better for automated driving**.

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "2. Impact on traffic flow (encounters with crosswalk pedestrians)"

③ Issues involved in real-world deployment of automated driving systems

[**Technology-related**]

- **Methods for sharing sensor data between vehicles** or **sharing information with vehicles regarding pedestrians walking within the environment**.
- The pedestrian information provided by the infrastructure needs to be more detailed than just "there is/is not a pedestrian," like the data in these FOTs. It also need to include information such as **the locations and numbers of pedestrians, which way they are walking, their walking speed, etc.**
- **Automated vehicles must become better at recognizing traffic participants and at predicting their behavior.**

[**Driving environment-related or system-related**]

- **Distribution of information regarding pedestrian traffic signals**
- **Traffic signal cycles need to be revised and traffic signals such as separate pedestrian and vehicle traffic signals need to be installed.** **The timing and duration of accelerating from a stop and of coming to a stop need to be adjusted.**

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "3. Impact on pedestrians"

① Issues experienced by test participants

[Implementation of measures to deal with the situation of **"pedestrians hesitating to cross the road/diminished vehicle attentiveness"]**

- **A test participant used HMI to communicate with crosswalk pedestrians and display the automated vehicle's status ("This car waits for pedestrians").** Vehicle lighting was used to indicate which pedestrians this information was being displayed for, and **information was provided based on the positions of pedestrians as identified by the vehicles' cameras**.

[When the situation of "pedestrians hesitating to cross the road/diminished vehicle attentiveness" **did not occur**]

- **This situation did not occur.** This is believed to be because there was someone in both the driver's seat and in the passenger's seat, so from a pedestrian's perspective the vehicles appeared to be, and were recognized as, ordinary vehicles.

② Measures taken during FOTs and matters to be given consideration when developing/selling automated driving systems in the future

[**Technology-related**]

- Test participants are considering **using external HMI to alert nearby pedestrians, etc.**
- It would be best to **define test and verification level 4 systems and scenarios and to develop, implement, and supply simulations (DIVP, etc.) based on driving environments.**

③ Issues involved in real-world deployment of automated driving systems

[**Technology-related**]

- **There is a need for further deliberation and evaluation of appropriate methods of communication between automated vehicles and pedestrians.**

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "4. Impact on safety (in intersections)"

① Issues experienced by test participants

[There was an impact on safety]

- **There were cases of sudden braking within intersections.** Test vehicles were driven with an abundance of caution to avoid rear-end collisions by ordinary vehicles. (A guard vehicle always followed the automated vehicle)
- For low-speed automated vehicles (vehicles with maximum speeds under 20 km/h), even if the vehicle enters an intersection while the light is green, **if the intersection is a large one, the light for the intersecting road could turn green before the vehicle has fully traversed the intersection**.

② Measures taken during FOTs and matters to be given consideration when developing/selling automated driving systems in the future

[**Technology-related**]

- Perform testing equivalent to the impact assessment with the aim of **combining multiple sensors to achieve robust levels of detection**.

③ Issues involved in real-world deployment of automated driving systems

[**Technology-related**]

- **It seems likely that there would be challenges in creating an infrastructure coordination system that would enable the detection of vehicles and pedestrians in locations where visibility is poor for on-board sensors.**
- **Another challenge is communication with pedestrians and ordinary vehicles driving behind automated vehicles.**

4. Findings regarding the public acceptability of automated driving

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "4. Impact on safety (in non-intersection sections and in front of intersections)"

① Issues experienced by test participants

[There was an impact on safety]

- **There were cases in which there were no pedestrians or bicycles on the road but the vehicle mistakenly identified them as being present and applied the brakes.** In each case, the driver swiftly overrode the vehicle and accelerated or decelerated, always taking care not to impede other traffic during the testing.
- **One challenge is setting left turn routes when there are illegally parked vehicles in the left turn lane.**
- **There were cases of large trucks blocking the way in front of the test vehicle in front of intersections, so the test vehicles' on-board sensors could not determine the situation in the intersection or detect the traffic signal color until immediately before entering the intersection.**
- **At intersections that provide margin information**, test participants observed that the number of remaining seconds sometimes changed suddenly, which creates a **risk of sudden braking**.

② Measures taken during FOTs and matters to be given consideration when developing/selling automated driving systems in the future

[**Technology-related**]

- Perform testing equivalent to the impact assessment with the aim of **combining multiple sensors to achieve robust levels of detection**.
- **Test participants indicated concerns about the range at which detection was possible for fast-moving bicycles (road bicycles and hybrid bicycles) or e-scooters approaching rapidly from the rear if the view of them was blocked by a following vehicle (such as a large truck, a cargo truck, or an automobile that was extremely close to the automated vehicle).**

(7) Summary of results of test participant questionnaires regarding public acceptability

Summary of questionnaire results regarding "4. Impact on traffic flow (in non-intersection sections and in front of intersections)"

③ Issues involved in real-world deployment of automated driving systems

[**Technology-related**]

- **It seems likely that there would be challenges in creating an infrastructure coordination system that would enable the detection of vehicles and pedestrians in locations where visibility is poor for on-board sensors.**
- **Another challenge is communication with pedestrians and human-driven vehicles driving behind automated vehicles.**
- **The accuracy of traffic signal remaining seconds information is an issue.** For traffic signals with margins, especially, the inability to accurately determine the timing of the color change prevents the information from being used effectively.
- **Functions must be developed to identify/predict risky situations and decelerate accordingly** as soon as possible to prevent automated vehicles from engaging in sudden deceleration.

[**Driving environment-related or system-related**]

- Other traffic participants must be **made to understand the limits and risks of automated driving** to prevent them from unreasonably passing or cutting in front of automated vehicles that are engaged in safe driving.
- **The accuracy of traffic signal remaining seconds information is an issue.** For traffic signals with margins, especially, the inability to accurately determine the timing of the color change prevents the information from being used effectively.

4. Findings regarding the public acceptability of automated driving

(8) public acceptability (impact assessment): Summary of test contents and questionnaire responses

Through the impact assessment testing, participants did the following:

- Clarified issues and problems that could occur when automated driving is performed in mixed transportation environments
- Analyzed and considered future measures and future developments, together with data, based on the expertise and data from the tests
- Evaluated the public acceptability of automated driving in preparation for widespread use in society

Impact on traffic flow (carriageway driving)

A) Left/right turn processing time: Accommodations must be made for non-autonomous vehicles

- ✓ The presence of autonomous vehicles also **causes right turn and left turn processing times to increase slightly, but following vehicles were confirmed to be driving safely.**
- ✓ We confirmed that the inclusion of autonomous vehicles in roadway traffic environments may become safer driving environments.
- ✓ There may be a need to deal with issues such as rear-end collisions or tailgating/road rage by following vehicles.

B) Driving speed: There are differences in driving speeds between autonomous vehicles and non-autonomous vehicles

- ✓ The actual speeds of autonomous vehicles are equal to or below legal speeds, while ordinary vehicles tend to drive at somewhat high speeds, so **consideration must be given to the possibility of the flow of traffic becoming less smooth when autonomous vehicles become more widespread, but autonomous vehicles have high promise for increasing safety.**
- ✓ Issues to be addressed include communicating intent to others in the traffic environment/other road users and identifying and dealing with situations which could impede test vehicle traffic flow.

C) Vehicles parked on the street: Vehicle detection capabilities must be improved

- ✓ Handling of on-street parking is an issue to be addressed.
- ✓ Both technical and systemic measures must be used with respect to detecting parked vehicles and passing/avoiding them.

4. Findings regarding the public acceptability of automated driving

(8) public acceptability (impact assessment): Summary of test contents and questionnaire responses

2. Impact on traffic flow (encounters with crosswalk pedestrians)

A) Impact on nearby vehicles: There is a need for harmonization with the surrounding environment and nearby vehicles

- ✓ Testing confirmed situations in which excessively safe driving left vehicles unable to turn left or right.
- ✓ There were situations in which oncoming vehicles wishing to turn right lost patience and turned right and cases of tailgating/road rage by following vehicles.
- ✓ **There is a need to balance safety and smooth traffic flow, including harmonization with the surrounding environment and nearby vehicles, instead of simply making safety the highest priority.**
- ✓ Many participants indicated that using HMIs to promote greater awareness by following vehicles would be effective in the future expansion of automated driving.

3. Impact on pedestrians

A) Communication with pedestrians: There were no major impediments

- ✓ **No cases were observed** in automated driving **of insufficient eye contact between drivers and pedestrians having an impact (such as hesitation to cross or a reduction in attention paid to other vehicles).**
- ✓ Test participants also indicated that they did not experience any issues involving a lack of communication through the tests.

B) Handling of pedestrians: Organizations involved in automated driving were confirmed to be highly attentive and conscientious

- ✓ With respect to future road environments with driverless vehicles, participants were implementing or considering implementing measures in which **externally-mounted HMIs were used by vehicles to communicate and display the status of the autonomous vehicle**. Organizations must always give thorough consideration to the impact of autonomous vehicles on pedestrians.

4. Findings regarding the public acceptability of automated driving

(8) public acceptability (impact assessment): Summary of test contents and questionnaire responses

4. **Impact on safety (accidents)**
   A) **The need for harmonization with the surrounding environment: There needs to be communication with pedestrians and non-autonomous vehicles**
      - ✓ **It was confirmed that cooperation with infrastructure,** primarily within intersections, **contributes to cooperation with the behavior of nearby vehicles, pedestrians, bicycles, etc.**
      - ✓ During test driving, when test participants prioritized pedestrian safety, they experienced scattered cases of tailgating/road rage by following vehicles and of right turns by oncoming vehicles. We confirmed **that there is a need for greater understanding and cooperation by other parties in the surrounding environment**.
      - ✓ It is important to define use cases and ODDs and to perform ongoing verification and evaluation of actual scenarios.
      - ✓ We confirmed that, even for low-speed autonomous vehicles, in the case of large intersections, there were cases of the traffic signal turning red and the traffic signal of the intersecting road turning green before the test vehicle had turn fully traversed the intersection.
      - ✓ **Communication is vital not only for pedestrians but also for non-autonomous vehicles driving behind autonomous vehicles and for vehicles on crossing roads.**

4. Findings regarding the public acceptability of automated driving

(8) public acceptability (impact assessment): Summary of test contents and questionnaire responses

4. Impact on safety (accidents)

B) Eliminating situations which can lead to close calls: Development work must be performed to deal with the issue of sudden deceleration in non-intersection sections and in front of intersections

- ✓ Test participants observed cases of close calls due to sudden deceleration on non-intersection sections and in front of intersections, etc., and confirmed the possibility of impact on the surrounding environment.
- ✓ Test participants reported **cases of this occurring** throughout the test period.
  For example:
  - In situations in which sudden braking was performed within an intersection, there were occasional close calls of rear-end collisions from following vehicles. Measures were taken to prevent this, such as having guard vehicles drive behind autonomous vehicles, and test driving was performed taking care to avoid the danger of rear-end collisions by ordinary vehicles.
  - Measures will need to be taken to address these issues in order for this technology to be used in society at large.
  - At intersections that provide margin information, test participants observed that the number of remaining seconds sometimes changed suddenly, which creates a risk of sudden braking.
  - **In locations where poor visibility prevented detection by on-board sensors, , there were close calls involving failure to detect vehicles or pedestrians.**
  - **The creation of an infrastructure coordination system was confirmed to be an important implementation requirement.**
  - **As indicated in (A), communication with pedestrians and non-autonomous vehicles driving behind autonomous vehicles** was also confirmed to be important to eliminating close calls.

Summary

For autonomous driving to gain public acceptability, it will be important to reflect the findings of these FOTs in safety-related aspects of driving assistance and autonomous vehicles

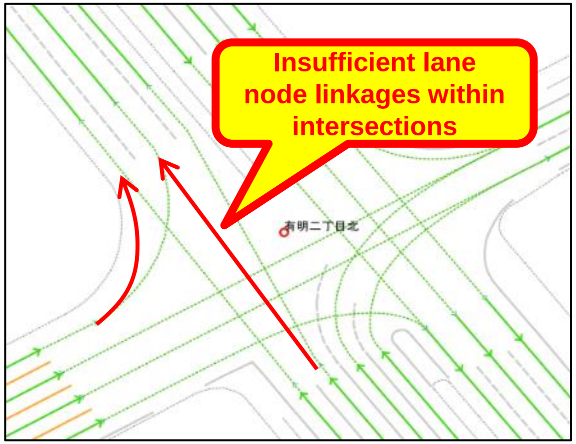
5. International cooperation

5-1. High-accuracy 3D maps

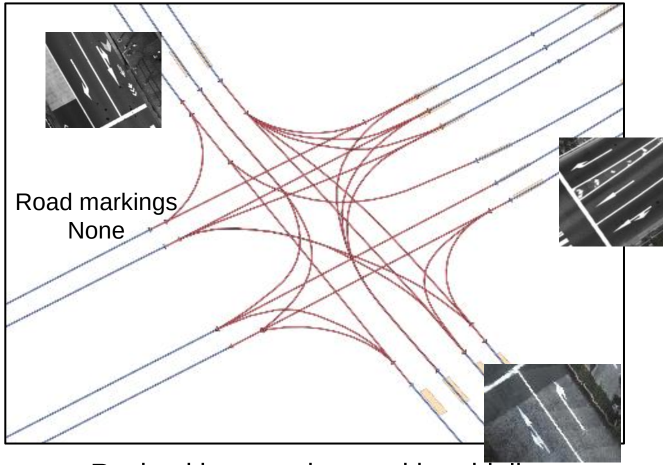
(1) Lane node linkage within intersections

- There were inconsistencies in the connections of lane node linkages within intersections in the map data distributed in June 2020.
  - This was the result of a misinterpretation by the data creator of the contents of the SIP map specifications and standards, and was not a problem with the specifications or standards themselves.
  - It was decided that this problem would be addressed by creating guidelines regarding the connections of lane node linkages within intersections.
- Lane node linkages within intersections were revised for a sample set of five intersections in the map data distributed in January 2021.
  - Participant opinions were sought regarding how to handle link connections.
- Based on their feedback, "Automated Driving System Map Data Specification Proposal Ver.1.1 [Map Data Creation Guidelines]" was revised in March 2021.
- In the map data that was distributed in October 2021, the lane node linkages within intersections were fixed for all intersections requiring updates, in accordance with the guidelines.

Acquisition standards for lane node linkages within intersections



Intersections with insufficient lane node linkages within intersection



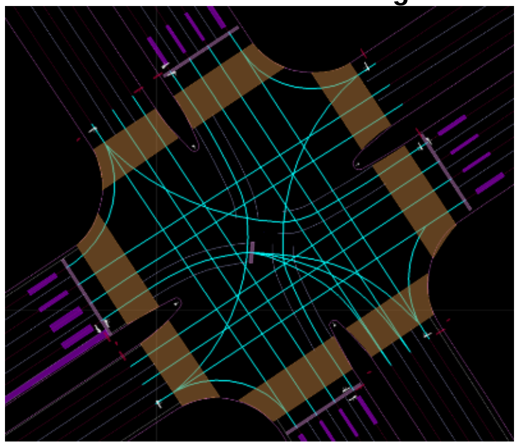
Revised in accordance with guidelines

5-1. High-accuracy 3D maps

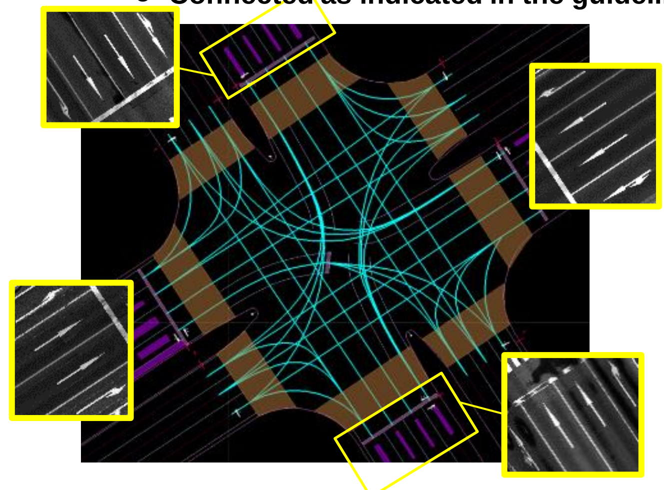
(2) Examples of revisions to lane node linkages within intersections

- **In the previous version, as a general rule, each inflow was connected with a single outflow**

Tokyo Big Sight-mae

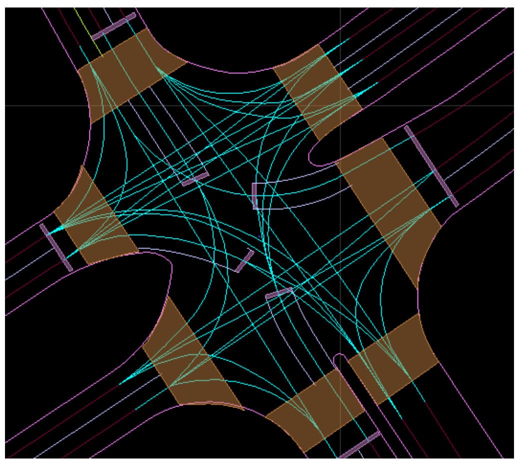


- **Connected as indicated in the guidelines**

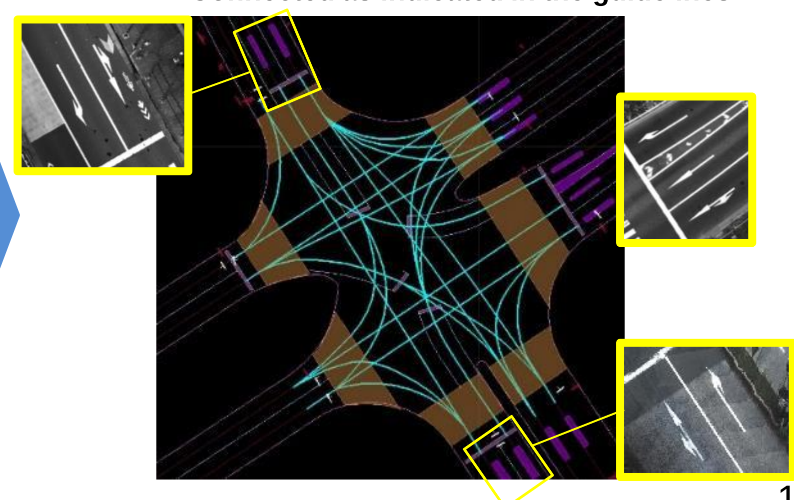


- **In the January 2021 version, all traversable lane node linkages within intersections were connected.**

Kaihin Park Entrance



- **Connected as indicated in the guidelines**



Five intersections revised in the January 2021 data

- ✓ Kaihin Park Entrance
- ✓ Ariake 2-chome North
- ✓ Ariake 3-chome
- ✓ Ferry Terminal Entrance West
- ✓ Ferry Terminal Entrance (no traffic signal)

5-1. High-accuracy 3D maps

(3) Map Data Creation Guidelines

- Map Data Creation Guidelines were created, as shown at right.

自動走行システム向け地図データ仕様への提案

Ver.1.1

【地図データ作成時におけるガイドライン】

本ガイドラインは、「戦略的イノベーション創造プログラム（SIP）第2期／自動運転（システムとサービスの拡張）／東京臨海部実証実験の実施」を通じて明らかとなった、「自動走行システム向け地図データ仕様への提案 Ver.1.1」（以下、「SIP 地図データ仕様」とする）における地図データ作成者の解釈によって地図データ作成基準にばらつきが生じる可能性のある曖昧な記述に対する留意事項を取りまとめたものである。なお、本ガイドラインは、「SIP 地図データ仕様」の記述を変更することなく、補足説明を追記したものとなっているため、本ガイドライン1冊で SIP 地図データ仕様に則った地図データの作成が行える構成となっている。また、本ガイドラインは協調領域の地図データを作成するための一助となることを目的にまとめたものであり、「SIP 地図データ仕様」及びその翻案元である「高度 DRM-DB 資料」の修正や変更を求めるものではない。

※「自動走行システム向け地図データ仕様への提案 Ver.1.1」：
内閣府が実施する『「戦略的イノベーション創造プログラム（SIP）・自動走行システム」（内1①）自動走行システムの実現に向けた諸課題とその解決の方向性に関する調査・検討におけるダイナミックマップ構築に向けた試作・評価に係る調査検討』の受託者であるダイナミックマップ構築検討コンソーシアムが、平成29年に一般財団法人日本デジタル道路地図協会が設置した高度デジタル道路情報対応検討会において検討した先進運転支援のための新しい高度デジタル道路情報に関する資料（「高度 DRM-DB 資料」）を翻案した二次著作物。

令和3年3月

東京臨海部実証実験コンソーシアム

1

5-2. Global benchmark survey

(1) Global benchmark evaluation criteria [1/2]

[Public interest] Openly recruiting participants, including foreign - affiliated companies, and stimulating private sector investment by matching funds

1) No. of participating organizations
2) Types of participating organizations(industry/government/academia)
3) Business categories of participating organizations
4) Whether or not the project involved any foreign-affiliated companies
5) Inducement of private sector investment

[Practical implementation] Using existing systems in order to promote practical implementation and addressing safe driving support and automated driving from the perspective of promoting widespread adoption

Not being limited to the motor vehicle industry, but instead including deliberations regarding the amount of data traffic transmitted when the system is actually implemented

1) Type of vehicle(s) used in study(manually driven vehicles/vehicles with safe driving assistance functions/automated vehicles/public mobility)
2) Communications technologies(V2V/V2I/V2N)
3) Method of using infrastructure information(Provision of information to drivers/use of information in vehicle control)
4) Whether or not transmission delays or data traffic load were evaluated
5) Whether or not the architecture was examined with respect to practical implementation
6) Actual usability of usage information(whether usage information was provided by existing system/whether usage information was created for testing purposes)

[Scale]

1) No. of vehicles
2) Total driving distance
3) Size of FOT area(total road length of test area/area of test area)
4) Road category ①(general road/expressway)
5) Road category ②(public road/test course)

[Standardization] Use of existing standards in the test system in order to promote practical implementation and coordination with ADASIS with an eye toward international cooperation

1) Status of usage of existing standards in the test system (whether or not existing standards were used, [name of standard])
2) Whether or not existing standards were verified or coordinated with (whether or not this was done, [name of standard])
   * Whether or not studies, simulations, or other deliberations were carried out for test systems that were not conformant with standards with an eye towards coordinating with said standards in the future
3) Active participation in international standardization activities

: Key points

5-2. Global benchmark survey

(1) Global benchmark evaluation criteria [2/2]

[Functions] Performing verification of delivery methods (PUSH/PULL) in order to promote practical implementation

1) Dynamic and semi-dynamic information delivered via V2N for the purposes of vehicle control
2) Static and semi-static information delivered via V2N for the purposes of vehicle control
3) Use cases of delivering information via V2N for vehicle control
4) Granularity of information delivered via V2N for the purposes of vehicle control (lane-specific/road-specific)
5) Whether or not V2N transmission delivery methods were investigated * Whether or not there was verification of transmission range and timing

: Key points

Survey results legend

[Public interest - Scoring criteria]

- Poor: 1 to 4 participating organizations, all participants of the same type/in the same industry, no foreign-affiliated participants, no private sector investment inducement
- Fair: 5 to 10 participating organizations, two or more types of participants, participants include businesses other than automobile industry businesses. Whether or not there were foreign-affiliated participants or private sector investment inducement not considered.
- Good: 11 to 20 participating organizations, participants of two or more types (or industry, government, and academia), participants in 3 or more business categories other than the automobile industry, project includes foreign-affiliated participants, project includes private sector investment inducement
- Excellent:21 or more participating organizations, participants in industry, government, and academia, participants in 5 or more business categories other than automobile the industry, project includes foreign-affiliated participants, project includes private sector investment inducement

[Practical implementation - Scoring criteria]

- Poor: Only 1 type of vehicle, no information delivery performed
- Fair: 2 types of vehicle, 1 type of communications technology, use of information for 1 purpose, architecture either focused on data traffic load testing or practical implementation. Whether or not information was from existing systems in practical use was not taken into consideration.
- Good: 3 types of vehicle, 2 or more types of communications technology, use of information for 2 or more purposes, architecture either focused on data traffic load testing or practical implementation, information used is from existing systems in practical use
- Excellent: 4 types of vehicle, 2 or more types of communications technology, use of information for 2 or more purposes including vehicle control, architecture focused on both data traffic load testing and practical implementation, information used is from existing systems in practical use

[Scale - Scoring criteria]

- Poor: Only a small number of vehicles, small area/total distance, theoretical study
- Fair: 100 or more vehicles, small area/total distance, test course
- Good: 1,000 or more vehicles, medium area/total distance, driving on public roads (general roads only)
- Excellent: 3,000 or more vehicles, large area/total distance, driving on public roads (general roads and expressways)

[Standardization - Scoring criteria]

- Poor: Existing standards not used, verified, or coordinated with
- Fair: Existing standards were used (either national or global standards), but no existing standards were verified or coordinated with
- Good: Existing global standards were used, existing standards were verified/coordinated with
- Excellent: Existing global standards were used, existing standards were verified/coordinated with, standardization activities are being carried out or standardization has already been performed

[Functions - Scoring criteria]

- Poor: No verification of vehicle control using information delivered via V2N
- Fair: Verification of vehicle control using information delivered via V2N, either dynamic information or static information used in verification, 1 envisioned use case. The granularity of the information and verification of the information delivery method were not taken into consideration.
- Good: Verification of vehicle control using information delivered via V2N, either dynamic information or static information used in verification, 2 to 5 envisioned use cases. The granularity of the information and verification of the information delivery method were not taken into consideration.
- Excellent: Verification of vehicle control using information delivered via V2N, multiple types of either dynamic information or static information used in verification, 5 or more envisioned use cases, lane-specific information delivered, delivery method verification performed

5-2. Global benchmark survey

(2) Survey methods and scope

- The survey was performed based on internet and printed materials, etc.
- The following projects were investigated.

Project	Overview of study results
1. SIP Phase 2 FOTs in the Tokyo Waterfront Area [2019-2022]	• FOTs performed as part of SIP-adus Phase 2, starting in fiscal year 2019, for automated vehicles driving on public roads. During Phase 1 of the FOTs, which finished in fiscal year 2020, the project evaluated the effectiveness of traffic signal information for general roads and merging support information for expressways, delivered using PTPS and V2I transmission. From fiscal year 2021, the project evaluated the effectiveness of information delivered via V2I and V2N for use on general roads (traffic signal prediction information, mock emergency vehicle information for vehicles on emergency calls, and rainfall information) and for use on expressways (lane-specific road traffic information).
2. Europe - Drive Sweden CeViSS	• FOTs carried out in Sweden in 2020 by participants such as Volvo. The project verified and evaluated the collection and delivery of vehicle probe information via V2N.
3. Europe - SCOOP@F	• Cooperative ITS FOTs led by France from 2014 to 2018. V2X technologies were used for verification on a route extending through France, Austria, Spain, and Portugal with the aims of improving the safety of traffic and maintenance work, improving the efficiency of traffic management, realizing Day1 applications, etc.
4. Europe - L3Pilot	• Level 3 automated driving FOTs performed on public roads from 2017 to 2021 • Verified safety and effectiveness of vehicles with level 3 automated driving systems driving on public roads.
5. China - Wuxi City LTE-V2X City-wide Trial Project	• Collaborative ITS FOTs performed using C-V2X transmission in Wuxi, China, from 2018 to 2022. LTE-V2X transmission infrastructure was prepared and opened to automotive manufacturers and internet companies to test various use cases and deliberate regarding business models, etc.
6. U.S. - NY ITS Strategic Plan	• One of the verification locations of the "CV Pilot" ITS research and development project being led by the United States Department of Transportation ITS JPO • From 2015 to 2020, verification work was performed in New York City primarily of safety applications with the aim of completely eliminating traffic accident fatalities and injuries. The operation and maintenance phase began in September 2020.

5-2. Global benchmark survey

(3) Survey results [Public interest]

- We evaluated the programs, placing emphasis on whether or not the project involved any foreign-affiliated companies and whether or not there was inducement of private sector investment.
- The FOTs in the Tokyo Waterfront area scored highly for all Public Interest-related categories. The European L3Pilot program scored roughly equally to the FOTs in the Tokyo Waterfront area.
- There were not many participants in the European SCOOP program, and there were no academic participants in the Chinese LTE-V2X City-wide Trial.

		SIP Phase 2 FOTs in the Tokyo Waterfront Area	Drive Sweden CeViSS	EU SCOOP@F	L3Pilot	China - Wuxi City LTE-V2X City-wide Trial Project	U.S. - NY ITS Strategic Plan
Public interest	No. of participating organizations	Max. 29	5	18	34	29	16
	Types of participating organizations	Industry, government, and academia	Industry and government	Industry, government, and academia	Industry, government, and academia	Industry and government	Industry, government, and academia
	Business categories of participating organizations	Japanese OEMS/suppliers/universities/map companies/architectural consultants/measurement companies/communications companies/infrastructure equipment companies/government agencies/insurance companies Foreign OEMs/suppliers	Foreign OEMs/suppliers Swedish suppliers/communications device manufacturers/software development companies/government organizations	French OEMS/universities/government agencies/road administrators/communications companies Foreign road administrators	European OEMs/suppliers, Japanese OEMs, American OEMs/suppliers European research agencies (public agencies)/ universities/ insurance companies/government agency (Road Transport Bureau), International Automobile Federation	Chinese OEMs/ suppliers/internet companies/communications device manufacturers/ government agencies Foreign OEMs/communications device manufacturers	American transportation companies/construction companies/communications companies/electrical device manufacturers/gas companies/software development companies/education and research organizations/ government agencies/public transportation agencies
	Whether or not the project involved any foreign-affiliated companies	Yes (Foreign OEMs/suppliers)	Yes (Foreign OEMs/suppliers)	Yes (Foreign road administrators)	Yes (Foreign OEMs/suppliers, universities/research organizations from multiple European countries)	Yes (Foreign OEMs/ communications device manufacturers)	No
	Inducement of private sector investment	Yes (matching fund)	Yes (funding from Drive Sweden, a Swedish innovation program, + partnerships with participants)	Yes (50% of funding provided by the European Commission. The remainder of the funding is believed to have come from participants, so this was evaluated as being equivalent to the FOTs in the Tokyo Waterfront Area)	Yes (Some funding provided by the Horizon 2020 program. The remainder of the funding is believed to have come from participants, so this was evaluated as being equivalent to the FOTs in the Tokyo Waterfront Area)	Yes (Unknown, but due to participant conditions, this was evaluated as being equivalent to the FOTs in the Tokyo Waterfront Area)	Yes (Unknown, but due to participant conditions, this was evaluated as being equivalent to the FOTs in the Tokyo Waterfront Area)
	Evaluation	**Excellent**	**Fair**	**Good**	**Excellent**	**Good**	**Fair**

5-2. Global benchmark survey

(3) Survey results [Practical implementation]

- We evaluated the programs, placing emphasis on whether or not information from practically implemented existing systems was used with an eye towards future practical implementation.
- In the Chinese LTE-V2X City-wide Trial Project, planned testing was to use four communications technologies, including V2N (the final report, interim report, etc., are not available online, so we don't have information regarding the implementation status or the test results, etc.).
- The scope of the L3Pilot project was the measurement of the social benefits of autonomous automated vehicles. Information provision via V2N and V2I information was outside the scope of the project.

		SIP Phase 2 FOTs in the Tokyo Waterfront Area	Drive Sweden CeViSS	EU SCOOP@F	L3Pilot	China - Wuxi City LTE-V2X City-wide Trial Project	US - NY ITS Strategic Plan
Practical implementation	Type of vehicle(s) used in study	Manually driven vehicles, vehicles with safe driving assistance functions, automated vehicles, public mobility	Manually driven vehicles, vehicles with safe driving assistance functions, automated vehicles	Manually driven vehicles, vehicles with safe driving assistance functions	automated vehicles	Manually driven vehicles, vehicles with safe driving assistance functions, automated vehicles, public mobility	Manually driven vehicles, public mobility
	Communications technologies	V2I, V2N (DSRC, 760MHz, optical beacon, LTE/4G)	V2I, V2N (ITS-G5*, LTE/4G/5G)	V2V, V2I (ITS-G5)	— (using automated driving)	V2V, V2I, V2N, V2P (5.9GHz PC5, LTE)	V2V, V2I, V2P (DSRC)
	Method of using infrastructure information	Provision of information to drivers, use of information in vehicle control	Provision of information to drivers, use of information in vehicle control	Provision of information to drivers	No (there was no use of information provided by infrastructure)	Provision of information to drivers, use of information in vehicle control	Provision of information to drivers and pedestrians
	Whether or not transmission delays or data traffic load were evaluated	Yes	Yes	No	No	Yes	No
	Whether or not the architecture was examined with respect to practical implementation	Yes	Yes	Yes	No	Yes	Yes
	Actual usability of usage information	Information from practically implemented existing systems was used (traffic signal prediction information, rainfall information)	Information from practically implemented existing systems was used (road database)	Unknown	No (there was no use of information provided by infrastructure)	Information from practically implemented existing systems was used (traffic signal information * determined based on the fact that there was testing of UC using traffic signal information + testing on public roads)	Information from practically implemented existing systems was used (traffic signal information, speed limit, construction locations, large vehicle restrictions, emergency evacuation information)
	Evaluation	**Excellent**	**Excellent**	**Fair**	**Poor**	**Excellent**	**Good**

* ITS-G5: ETSI transmission standard based on IEEE802.11p. Short-range ad-hoc transmission using 5.9 GHz frequency band.
Source: NXP Semiconductors, "C-ITS: Three observations on LTE-V2X and ETSI ITS-G5—A comparison", https://www.nxp.com/docs/en/white-paper/CITSCOMPWP.pdf

5-2. Global benchmark survey

(3) Survey results [Scale]

- Several hundred vehicles were used in the European, Chinese, and American projects, and testing was performed over large areas such as entire cities or areas straddling national borders
- In the American NY ITS Strategic Plan project, testing was performed using many privately owned vehicles and commercial vehicles

		SIP Phase 2 FOTs in the Tokyo Waterfront Area	Drive Sweden CeViSS	EU SCOOP@F	L3Pilot	China - Wuxi City LTE-V2X City-wide Trial Project	US - NY ITS Strategic Plan
Scale	No. of vehicles	18	Unknown	Approx. 3,000	100	Approx. 10,000 Envisioned as covering 100,000 vehicles in 2022	Approx. 8,000 (5,850 taxis, 1,250 buses, 400 commercial vehicles, and 500 official vehicles)
	Total driving distance	107,416 km (total since 2019)	Unknown	Unknown	Approx. 424,000 km	Unknown	Equivalent to 1,600,000 km per day
	Size of FOT area	Approx. 129 km: 3 areas (Rainfall information delivery area: 300 km)	5.7 km: 1 area	Over 2,000 km: 5 area	Unknown: 14 areas in 7 countries	Through 2019: 260 km^2 Through 2021: 500 km^2 Through 2022: 1,200 km^2, target of 2,000 intersections (2022): 1 city	16 square miles (Manhattan, Harlem), 1.6 square miles (Brooklyn): 1 city
	Road category ① (general roads/expressways)	General roads and expressways	General roads	General roads and expressways	General roads, expressways, and parking areas	General roads and expressways	General roads and expressways
	Road category ② (public roads/test courses)	Public roads	Test course	Public roads	Public roads	Public roads	Public roads
	Evaluation	**Good**	**Fair**	**Excellent**	**Excellent**	**Excellent**	**Excellent**

(3) Survey results [Standardization]

- Many projects used existing standards for transmission and for message sets
- The FOTs in the Tokyo Waterfront area was the only project that coordinated with existing standards (de jure standards)
- Although none of the projects involved international standardization activities, it would be best if the Tokyo FOTs provided its results to other organizations engaging in standardization activities in Japan for reference in their future activities

		SIP Phase 2 FOTs in the Tokyo Waterfront Area	Drive Sweden CeViSS	EU SCOOP@F	L3Pilot	China - Wuxi City LTE-V2X City-wide Trial Project	US - NY ITS Strategic Plan
Standardization	Usage of existing standards in the test system	Yes [Global standard + national standard] (ISO, ARIB, ITS Forum, JASPAR)	Yes*1 [Global standard + national standard] (ETSI, CEN)	Yes*2 [Global standard + national standard] (ETSI)	No*3	Yes*4 [National standard]	Yes*5 [Global standard + national standard] (ETSI, SAE)
	Whether or not existing standards were verified or coordinated with	Yes (ADASIS)	No	No	No	No	No
	Participation in international standardization activities	No (requires active coordination with international standardization activity organizations within Japan)	No	No	No	No	No
	Evaluation	**Good**	**Fair**	**Fair**	**Poor**	**Fair**	**Fair**

*1: ITS-G5, ETSI DENM, DATEX (data exchange standards for CEN traffic management system center)
*2: ITS-G5, ETSI DENM, ETSI CAM
*3: A format for sharing vehicle data was developed through the project and has been made publicly available (it is unclear whether there are any activities aimed at making it a national standard)
*4: Standards for exchanging data for cooperative ITS use, standards for traffic signal control systems, and standards for information disclosure interfaces for traffic signal control systems
*5: J2735 (DSRC message set standard), ETSI DENM, ETSI CAM

5-2. Global benchmark survey

(3) Survey results [Functions]

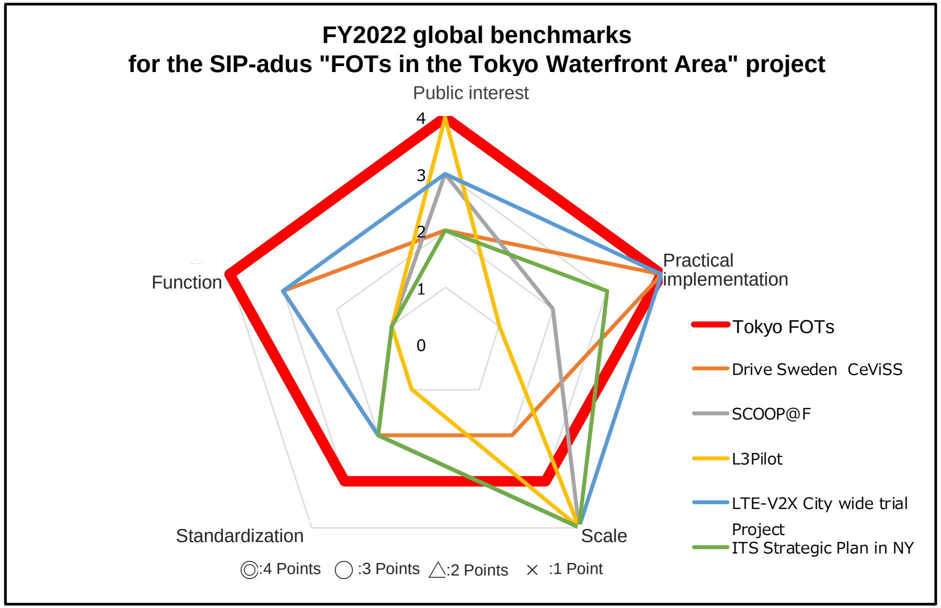
- We evaluated the programs, placing emphasis on whether or not information delivery methods were investigated with an eye towards future practical implementation of V2N information delivery.
- The FOTs in the Tokyo Waterfront area performed testing envisioning various usage cases that involved the delivery of information via V2N.
- V2N was not used in the European SCOOP@F or L3Pilot projects or in the American NY ITS Strategic Plan project.

※Used in V2N transmission/vehicle control		SIP Phase 2 FOTs in the Tokyo Waterfront Area	Drive Sweden CeViSS	EU SCOOP@F	L3Pilot	China - Wuxi City LTE-V2X City-wide Trial Project	US - NY ITS Strategic Plan
Function	Dynamic/semi-dynamic information	• Traffic signal prediction information • Lane-specific traffic information • Mock emergency vehicle information for vehicles on emergency calls • Rainfall information	• Traffic accident location information • Pedestrian location information • Stopped vehicle location information • Animal location information • Vehicle speed that should be maintained • Video on/off status	No V2N use/ vehicle control outside of project scope	No V2N use/ vehicle control outside of project scope	* Vehicle information * Traffic signal information * Traffic restriction information	No V2N use/ vehicle control outside of project scope
	Semi-static/static information	None	• Road-related information (road network locations and properties) • Information about locations of wildlife protection fences	No V2N use/ vehicle control outside of project scope	No V2N use/ vehicle control outside of project scope	Unknown	No V2N use/ vehicle control outside of project scope
	Use cases	[Traffic signal prediction information] • Dilemma avoidance • Route planning • Green wave driving [Lane-specific road traffic information] • Traffic congestion avoidance • Forking/exit traffic congestion support • Driving assistance by providing notifications regarding abnormal vehicles [Mock emergency vehicle information] • Safe driving assistance when emergency vehicles are approaching [Rainfall information] • Handover from automated driving to manual driving when rainfall is heavy enough to reduce the accuracy of on-board sensors • Route planning that avoids underpasses	• Pedestrian alerts and avoidance • Animal alerts and avoidance • Stopped vehicle alerts and avoidance • Traffic accident location avoidance	No V2N use/ vehicle control outside of project scope	No V2N use/ vehicle control outside of project scope	• Intersection collision avoidance (camera) • Green wave (passenger vehicles/buses) • Traffic congestion avoidance • Hazard location/hazard location avoidance • Cooperative lane merging • Vehicle speed control • Traffic accident area avoidance	No V2N use/ vehicle control outside of project scope
	Information granularity (lane-specific/road-specific)	Lane-specific (except rainfall information)	Lane-specific	No V2N use/ vehicle control outside of project scope	No V2N use/ vehicle control outside of project scope	Lane-specific	No V2N use/ vehicle control outside of project scope
	Investigation of transmission methods	Yes * Investigation was carried out with an eye toward the practical implementation of delivering information via V2N transmission	No * Detailed deliberations regarding the delivery of information via V2N were outside the main scope of the project	No V2N use/ vehicle control outside of project scope	No V2N use/ vehicle control outside of project scope	Unknown	No V2N use/ vehicle control outside of project scope
	Evaluation	Excellent	Good	Poor	Poor	Good	Poor

5-2. Global benchmark survey

(4) Evaluation [1/2]

Graph



Evaluation

Evaluation category	Research and development					
	Tokyo FOTs	CeViSS	SCOOP @F	L3Pilot	Wuxi City	NY
Public interest	Excellent	Fair	Good	Excellent	Good	Fair
Practical implementation	Excellent	Excellent	Fair	Poor	Excellent	Good
Scale	Good	Fair	Excellent	Excellent	Excellent	Excellent
Standardization	Good	Fair	Fair	Poor	Fair	Fair
Function	Excellent	Good	Poor	Poor	Good	Poor

5-2. Global benchmark survey

(4) Evaluation [2/2]

[Public interest]

- **The FOTs in the Tokyo Waterfront area and the European L3Pilot program featured a similar diversity of participants (members of industry, government, and academia, with companies from a wide range of industries), and used matching funds to stimulate private sector investment.**

[Practical implementation]

- **Although the implementation status of the Chinese LTE-V2X City-wide Trial Project are unknown, it is believed to have used a wide range of communications technologies (V2V/V2I/V2N/V2P).**
- **In Japan, as well, taking into consideration the delivery of information not just to vehicles but also to other traffic participants, it would be best in the future to explore diverse use cases, to perform FOTs with an eye towards practical implementation, and to promote accelerated product launches.**

[Scale]

- **Multiple projects conducted in other countries involved thousands of vehicles or more, with large test areas that covered entire cities or straddled national borders.**
- **There is room in Japan, as well, for tests over wide testing areas, such as entire cities, and conducting tests that also involve privately owned vehicles and service vehicles.**

[Standardization]

- **Taking into consideration the practical implementation and popularization of automated driving, the FOTs in the Tokyo Waterfront area applied existing standards to test systems and included deliberations with Europe's ADASIS in preparation for future international coordination.**
- **It would be best if the results of tests were provided to other organizations engaging in standardization activities in Japan for reference in their future activities.**

[Functions]

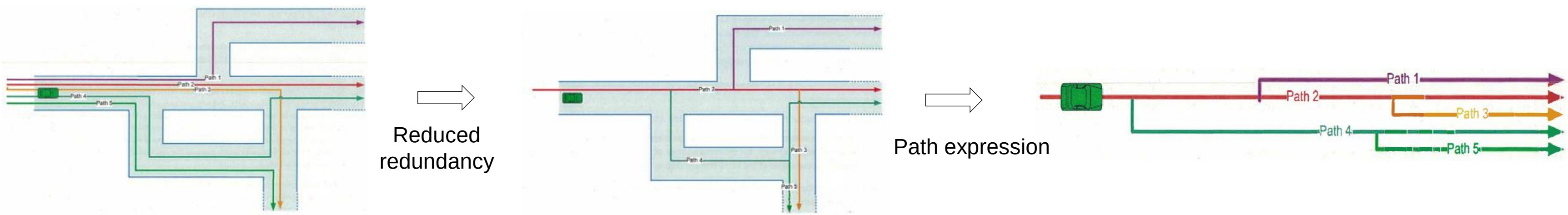
- **Many use cases were envisioned during the FOTs in the Tokyo Waterfront area, given the potential for information delivered via V2N to be used in vehicle control. Taking into account the potential for future practical implementation, the FOTs included the examination and verification of information delivery methods.**

5-3. ADASIS*1 verification

*1: Advanced Driver Assistance Systems Interface Specification

(1) What is ADASIS?

- ADASIS is a specification that defines "ADAS Horizon" as a method of communicating network information and its properties based on map data (only necessary map data for the area in front of the vehicle is extracted)
- ADAS Horizon:
  - ADAS applications require only the links in map data that are in front of the vehicle and which could be accessed in a reasonable amount of time
  - ADAS Horizon defines links in front of vehicles in an optimized manner, reducing the amount of overlap in paths that express those links
  - The depth of the path branching is selectable (Single path only/Drivable paths/All paths)

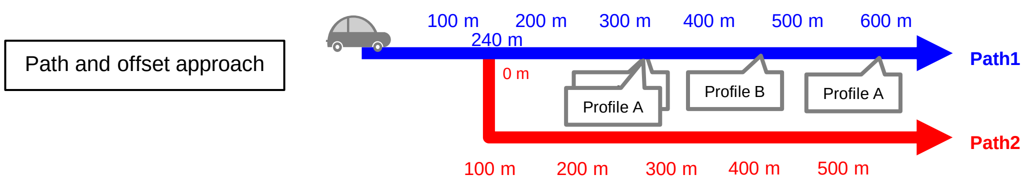


Conceptual image of ADASIS v3 Horizon

- Horizon data is expressed in the form of a tree structure with multiple paths
- These paths are linked with location information that is expressed using a format (path, offset) based on the offset value *2 of each path. The information contains attribute information such as speed limits, number of lanes, etc.

*2: Offset value Distance in centimeters from the path origin point

- Paths are linked to location information expressed using offsets to provide various profiles that contain traffic environmental information, etc.



5-3. ADASIS verification

(2) Evaluation approach

A) As part of its efforts to support SIP international cooperation, the FOTs in the Tokyo Waterfront Area Consortium participated in the SIP-adus Workshop 2021 Breakout held in November 2021 and took part in deliberations with European ADASIS members regarding ADASIS specifications.

B) The Consortium closely considered the ADASIS v3.2 specifications provided by SIP & NEDO and used the equipment from the Tokyo Waterfront City FOTs and the Waterfront City area itself to perform verification of the ADASIS specifications as understood by the Consortium (hereafter "SIP ADASIS")

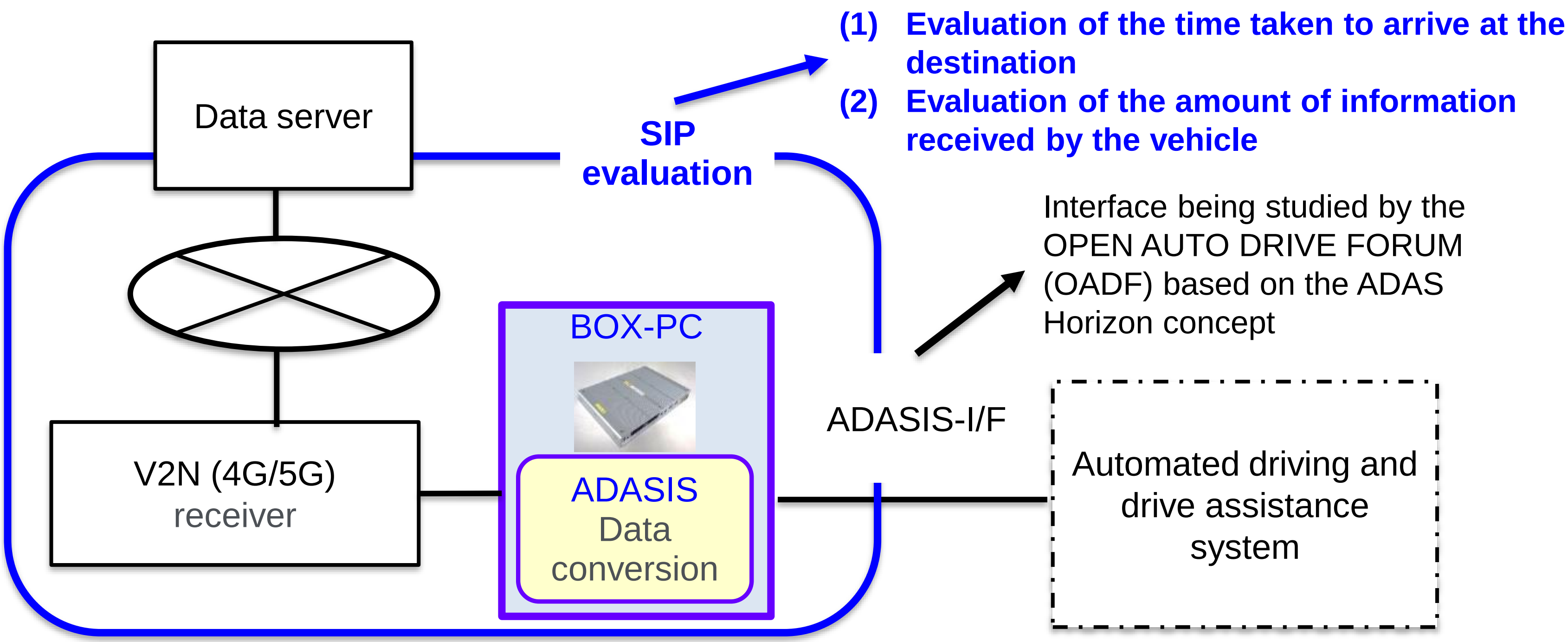
C) Verification testing and evaluation were performed from the following two perspectives
   - ✓ The objective of ADASIS is the selection of optimal routes by navigation systems and optimized driving
     (1)Evaluation of the time taken to arrive at the destination
   - ✓ SIP places great importance on the amount of information provided via V2N (communications between centers and vehicles)
     (2)Evaluation of the amount of information received by the vehicle

A conceptual diagram of the SIP evaluation is shown on the following page

5-3. ADASIS verification

(3) Scope

- The ADASIS evaluation scope is as shown below



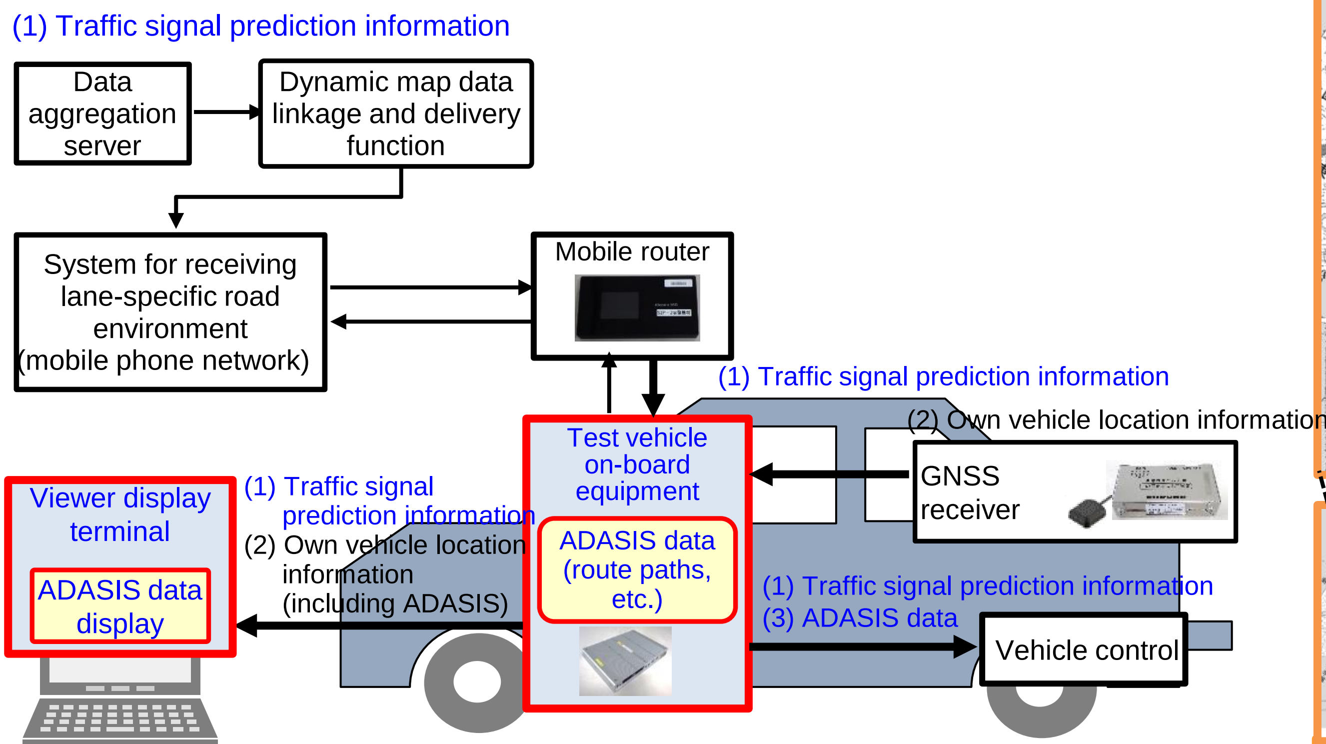
ADASIS evaluation scope

5-3. ADASIS verification

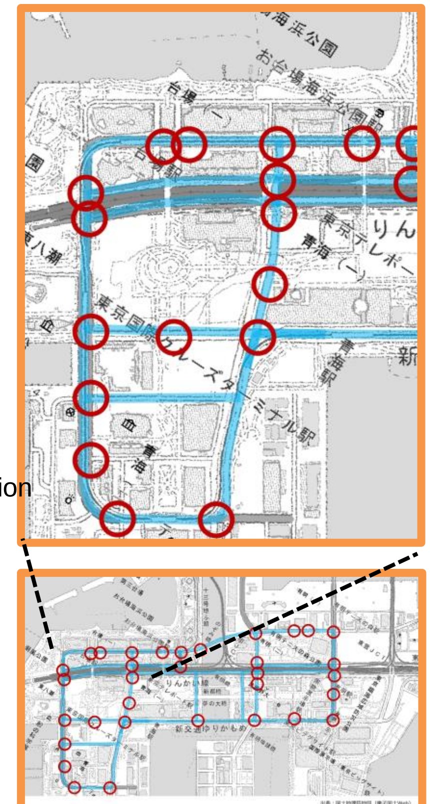
(4) Test system structure and testing area

Verified through modeling by the Consortium

- ✓ Driving routes (samples) were stored in test vehicle on-board equipment and SIP ADASIS data definitions were configured
- ✓ The vehicle was driven and driving route paths and traffic signal prediction information were output based on the vehicle's own location information



SIP ADASIS verification test system



① Waterfront City area

Source: Created by modifying Geospatial Information Authority of Japan map acquired on April 18, 2022, https://maps.gsi.go.jp/#12/35.632744/139.810982/&base=pale&ls=pale&disp=1&vs=c0j0h0k0l0u0t0z0r0s0m0f0

Testing area

5-3. ADASIS verification

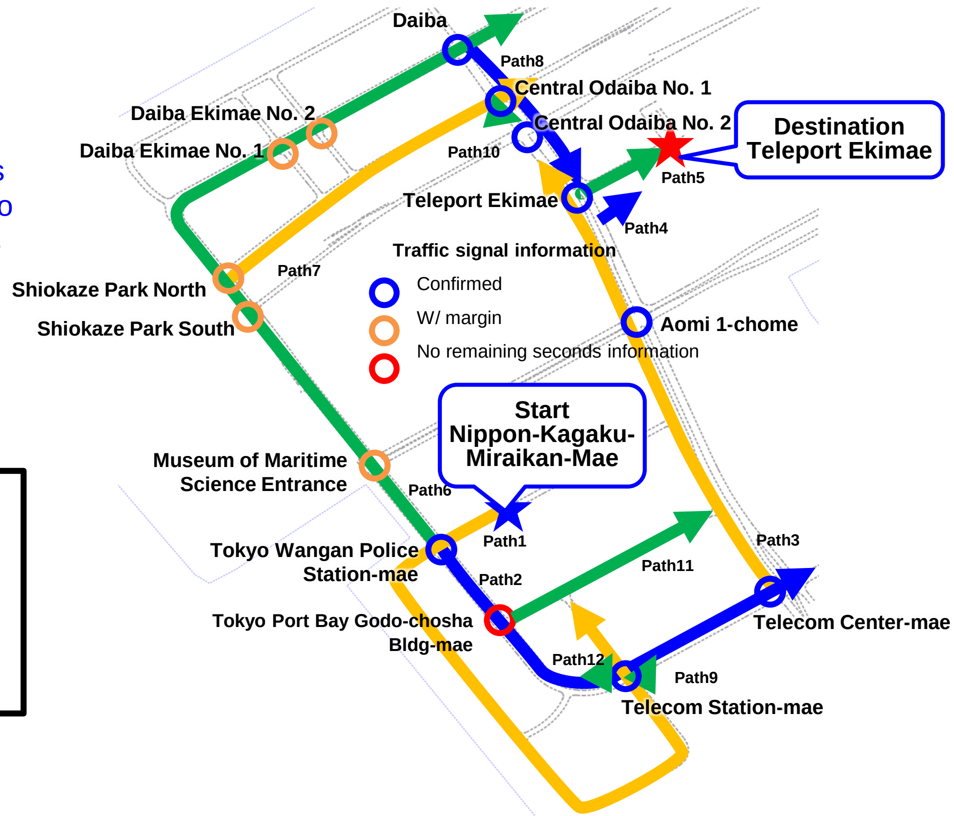
(5) Driving routes (path definition = test preparation)

- The route was a fixed route starting from [Nippon-Kagaku-Miraikan-Mae] and ending at the destination, [Teleport Ekimae]
- Traffic signal prediction information received via V2N was used to evaluate the following for each route.
  - Driving time
  - Intersection stop avoidance
  - Amount of information received via V2N

Note) The objective of ADASIS is the optimal selection of routes by navigation systems and the traversal of those routes, so systems identify road conditions and arrive at destinations in the shortest time possible

Note) In SIP, it is also important to take into consideration the amount of data received via V2N

Evaluation perspectives
ADASIS functions were used to confirm the following:
- ✓ Arrival at the destination in the shortest possible time, even if the actual distance driven was longer
- ✓ Avoidance of impediments along the way (fewer stops at intersections)

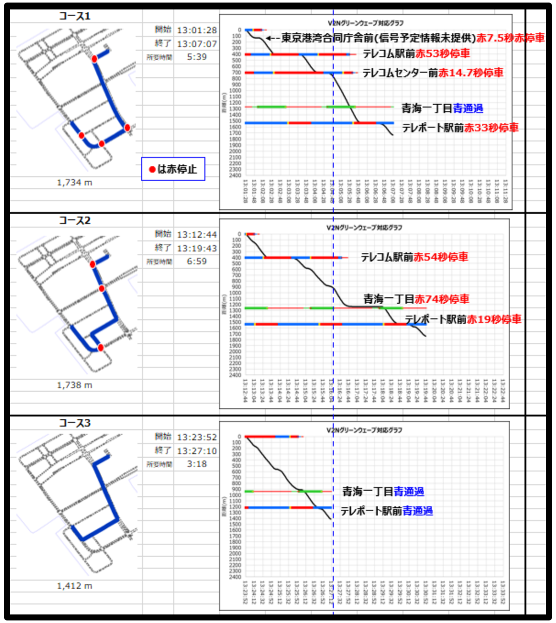


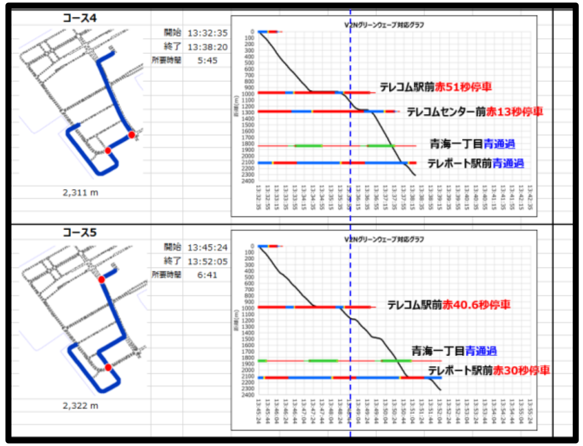
SIP ADASIS testing driving routes

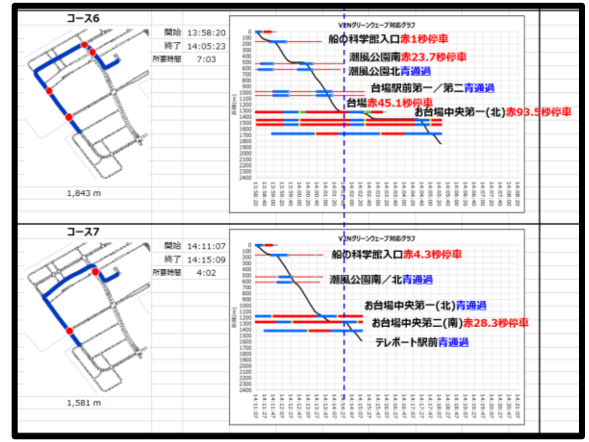
5-3. ADASIS verification

(6) Verification results (C①: Evaluation of the time taken to arrive at the destination)

- ADASIS specifications were evaluated from the perspective of ability to arrive in minimum time







	1st drive		2nd drive	
	Driving distance (m)	Time (h:m:s)	Driving distance (m)	Time (h:m:s)
Course 1	1,734	0:5:39	**1,738**	**0:4:08**
Course 2	1,738	0:6:59	1,733	0:5:28
Course 3	**1,412**	**0:3:18**	1,413	0:5:10
Course 4	2,311	0:5:45	2,310	0:7:27
Course 5	2,322	0:6:41	2,334	0:8:36
Course 6	1,843	0:7:02	1,840	0:5:42
Course 7	1,581	0:4:02	1,586	0:4:36

✓ On each course, vehicles stopped at red lights, but the shortest times to reach the destination for each drive were as follows:
1st drive: Course 3, 2nd drive: Course 1

✓ ADASIS can be used to avoid stopping at intersections

5-3. ADASIS verification

(6) Verification results (C②: Evaluation of the amount of information received by the vehicle)

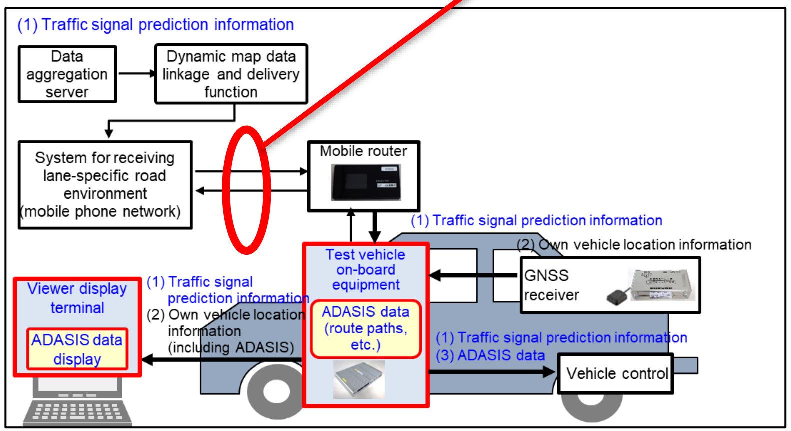
- ADASIS specifications were evaluated from the perspective of the amount of information received
- We determined the amount of information received by vehicles when receiving traffic signal prediction information with SIP ADASIS

- The amounts of information were evaluated as indicted below
  (1) Static information: Course-dependent information volume (path and profile information)
  (2) Dynamic information: Own vehicle location information (every 100 ms)
  (3) Dynamic information: Traffic signal prediction information (average of 132 seconds per cycle)

Under ADASIS specifications, (1) (static information) can be on an upper layer server or in the vehicle, depending on the implementation method

Therefore, the amount of V2N data that is received will depend on where information type (1) is stored.
- When information type (1) is stored on the server: Information (1) +(2)+(3) is transmission target
- When information type (1) is stored on the vehicle, only information (3) is transmission target

Comparison of amount of data received via V2N



5-3. ADASIS verification

(6) Verification results (C②: Evaluation of the amount of information received by the vehicle)

- Information amounts when using ADASIS specifications were as shown below.

(1) When the static information is stored on the upper layer

Course	Average required time	Size of data (bytes)			
		(1) Course-dependent ADASIS	(2) Own vehicle location information every 100 ms	(3) Traffic signal prediction information	**Total**
Course 1	5:33	10,553	262,675	6,510	279,738
Course 2	7:10	10,553	339,700	8,419	358,672
Course 3	5:04	10,553	240,160	5,952	256,665
Course 4	7:41	10,592	363,795	9,016	383,403
Course 5	8:51	10,592	419,490	10,396	440,478
Course 6	7:11	9,802	340,095	9,195	359,092
Course 7	5:42	10,098	270,180	7,304	287,582

(2) When the static information is stored on the vehicle

Course	Average required time	(3) Traffic signal prediction information
Course 1	5:33	6,510
Course 2	7:10	8,419
Course 3	5:04	5,952
Course 4	7:41	9,016
Course 5	8:51	10,396
Course 6	7:11	9,195
Course 7	5:42	7,304

- Traffic signal prediction information was output for the path. When a new path appeared while driving, the traffic signal prediction information for the new path was also added and output.
- Course-dependent static information included system constants such as time (JST or UTC) and speed (km/h or miles/h), etc., as GlobalData.
- Vehicle location information updated every 100 ms included location information (absolute coordinates or relative distance along the path).

5-3. ADASIS verification

(7) Conclusions

Contents of implemented measures	● Further testing and ongoing deliberation is required to determine if the ADASIS specifications can be used as-is. ● SIP ADASIS support evaluation testing was performed based on SIP's interpretation of the specifications.
Evaluation perspectives	① Evaluating the time taken to arrive On the initial drive, the route selected as the optimal route with the shortest time (fastest arrival at the destination) was chosen and driven, but V2N information received along the way could be used to set/select new driving routes that are more optimal/have shorter times than the current driving route (using traffic congestion information, accident information, emergency vehicle information for vehicles on emergency calls, etc., in addition to traffic signal prediction information) ② Evaluating the amount of information received by the vehicle With ADASIS specifications, the handling of implementation-dependent static information (course-dependent information) is believed to have a major impact on the amount of V2N information The amount of information received by vehicles increases roughly 15-fold depending on whether or not the static information is stored on the vehicle
Findings	● ADASIS is considered to offer the following benefits ① It makes it easy to determine the position of one's own vehicle on a path ② It makes it easy to determine the locations and distances of intersections on a path ③ It makes it easy to determine changes in the number of lanes and the locations of forks/merging positions ④ The GlobalData system state (output refreshed every 100 ms) makes it possible for the driver to determine information about whether the vehicle is following a path

- It would be best to also consider application and use in driving assistance/automated driving systems
- Ongoing opinion-sharing with European ADASIS members is also beneficial
- The linking of maps and information, which ADASIS is investigating, is a similar concept to the dynamic map concept created and verified by SIP

6. Results of Evaluation Questionnaire

6. Results of Evaluation Questionnaire

(1) F2019-2020 evaluation questionnaire

Excerpts from the FY2020 results report overview (reference material)

Evaluation in the Waterfront City area

- **Roughly half** of the participants used **traffic signal color information** and **roughly 40%** of the participants used **traffic signal remaining seconds information** in vehicle control.
- Many participants indicated that they intend to use traffic signal information in **automated driving systems and drive assist systems**.
- Traffic signal color information was confirmed to be effective in all six situations of "backlighting," "direct lighting," "concealment/obstruction," "blending into the background," "nighttime," and "raindrops." A particularly large number of participants indicated that it was **effective for "concealment/obstruction" and "backlighting."**
- Traffic signal remaining seconds information was confirmed to be effective when traffic signals were obstructed, at intersections with high speeds, and at intersections in close proximity. Some participants also used it for appropriate acceleration and deceleration, preparation to accelerate from a start, and the provision of information for following vehicles.
- **Traffic signal color information/traffic signal remaining seconds information was confirmed to be effective for all intersections.**
  Many participants indicated that traffic signal color information was effective at Aomi 1-chome, where backlighting and obstructions, etc. are major factors.
  Many participants indicated that traffic signal remaining seconds information was effective at Telecom Station-mae, where the timing of visual recognition of the traffic signal color is late due to a curve.
- Some participants indicated that instead of defining individual intersections where the provision of traffic signal information is prioritized, **they would prefer that automated driving areas were defined and infrastructure prepared accordingly**.
- Many participants indicated that the current frequency and range of information provision are appropriate. Some participants also indicated that if communication stability were ensured, the frequency and range could even be decreased somewhat.
- Multiple participants stated that **they wanted confirmed traffic signal remaining seconds information, not traffic signal remaining seconds information with margins**.
- Some participants commented that drivers of ordinary vehicles should be informed of the behavior of vehicles that receive traffic signal information (such as preliminary deceleration). = Improved public acceptability
- Some participants indicated that they wanted system design to reflect global trends.

6. Results of Evaluation Questionnaire

(1) F2019-2020 evaluation questionnaire

Excerpts from the FY2020 results report overview (reference material)

Evaluation on Metropolitan Expressway routes connecting Haneda Airport and the Waterfront City area, etc.

- **Some participants** used both ETC gate passing support and merging support information **for vehicle control and as information provided to drivers**. Other participants received and evaluated information for use in development.
- Some participants indicated that they intend to use ETC gate passing support and merging support information in **automated driving systems and drive assist systems**.
- **ETC gate passing support information is effective for all toll booths.** In particular, it appears likely to be particularly effective for toll booths whose operating status cannot be visually confirmed until late and toll booth areas with numerous toll booths.
- Each participant has recognized **issues with cruising line conditions changing after merging support information was received during the FOTs (requiring handling of changes in vehicle speeds on the cruising line)**. **Many participants requested sensing across entire areas and continuous communications.** However, cruising line vehicle speed and vehicle spacing information is effective as information to be provided to drivers. In particular, participants desire installation in locations where cruising line conditions are difficult to assess from merging lanes.
- Multiple participants indicated that they **wanted notifications of approaching merging vehicles to be provided to cruising line vehicles.**
- Some participants indicated that they wanted a **test area other than the Metropolitan Expressway test area to be prepared**, and that they wanted an **impact assessment to be performed for expressways.**

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd04/103s.pdf)

6. Results of Evaluation Questionnaire

(1) F2019-2020 evaluation questionnaire

Excerpts from the FY2020 results report overview (reference material)

Evaluation in the Haneda Airport area

- Participants confirmed the effectiveness of traffic signal information in the same way as in the Waterfront City area.
- **Magnetic markers** were used for vehicle control and evaluated as a promising technology for the societal deployment of automated buses.
- All of the bus test participant teams said that **the Haneda Airport area SWG was very valuable** as it made it possible to engage in intensive discussions focused on the bus testing in the Haneda Airport area.

Ref. 4. Evaluation of general road map data

- The only specific comments from test participants concerned lane node linkage within intersections.
- Many participants indicated that lane node linkage within intersections, which should be prepared as a cooperative area measure, **must connect to all exit route lanes for both left and right turns.**
- **Requests regarding lane node linkage within intersection varied between participants, so some participants indicated that sufficient links should be prepared as a cooperative area measure, and all other links should be prepared as competitive area measures.**

Map data specification guidelines will be created based on the above.

6. Results of Evaluation Questionnaire

(1) F2019-2020 evaluation questionnaire

Excerpts from the FY2020 results report overview (reference material)

Achieving automated driving by using cooperative infrastructure

- **Roughly 40% of the participants performed driving tests as initially planned.** Roughly 60% of the participants did not make as much testing progress as planned due to COVID-19 and factors pertaining to individual companies, but **most participants intend to develop infrastructure cooperative systems**.
- Some participants indicated that they **wanted test environments to be maintained and expanded**, and that in the future they wanted automated driving areas to be defined and **infrastructure to be prepared for the entire areas.**

FOT management

- The FOT working group serves not only as a space for explanations and discussions of the contents of the FOTs, but also as a **place where participants can learn about the direction being taken by other participants.**
- Many participants pointed out improvements to be made in the long-term operation of the FOTs, such as improvements relating to the holding of online meanings, the sharing of information using communication tools, and the methods of submitting test data.
- Many participants indicated that they wanted **video from fixed-point cameras (general road cameras+ expressway cameras) to be provided.**
- Many participants indicated that when participant data is used, **they wished for the data to be anonymized.**

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd04/103s.pdf)

6. Results of Evaluation Questionnaire

(2) FY2021 evaluation questionnaire

Excerpts from the FY2021 results report overview (main section)

[Rainfall information]

- There were many comments requesting information other than rainfall
  (flooding, snowfall, icing, wind speeds, fog, earthquakes, tsunamis, etc.)

[Requests for information other than rainfall information]

- All participants requested that wind speed and road surface snow accumulation information be provided.
- "In addition to rainfall information, we would also like consideration to be given to delivering information about other weather conditions that could affect driving (such as snowfall and wind speed information).
  We are envisioning using the information in vehicle control when there are sudden downpours or showers in localized areas and when rainclouds are moving quickly, so we think the smaller the blocks of delivered rainfall information, the better."
- "We would like for pinpoint road flooding information and pinpoint road icing information to be provided."
- Locations where there is the danger of slipping, such as areas with road icing
- Fog information: "When there is fog, the detection capabilities of vehicle cameras are impaired, so we believe that receiving information in advance would be effective for automated driving mode selection, route selection (fog avoidance), and the like."
- Information regarding natural disasters, such as earthquakes and tsunamis

[Other]

- "We expect there to be a need for information regarding distant locations and routes, linked to navigation systems. Instead of just delivering information based on the vehicle's current location, we'd like for the system to be expanded to make it possible to designate locations and road sections for which to receive information."

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd05/102s_main.pdf)

6. Results of Evaluation Questionnaire

(2) FY2021 evaluation questionnaire

Excerpts from the FY2021 results report overview (main section)

[Lane-specific road traffic information]

- There were many comments stating that the delivered information needed to better match actual traffic conditions

[Improvement requests]

- "The content of the information differed significantly from actual traffic conditions (traffic congestion tail end locations and traffic congestion lane information were wrong, traffic congestion front ends and tail ends weren't paired up, traffic congestion information was received when there was no actual traffic congestion, etc.)."
- "We need information that can be used to determine the reliability of the provided information, such as information regarding system limitations (delay time between information detection and delivery), data processing limitations (conditions under which inaccurate information might be provided), changes at traffic congestion locations (traffic congestion areas growing longer), etc."
- "It would be better if the average vehicle speed were indicated for the location in the traffic congestion tail end information." "We think the provided vehicle speed information could be used together with the test vehicle's own speed and location to decide when to start decelerating and to provide support information to the driver."
- "Shortening the information collection cycle and the information delivery cycle has the potential to shrink the gap between actual conditions and the delivered information."

[Other]

- "We didn't encounter enough traffic congestion tail ends."

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd05/102s_main.pdf)

6. Results of Evaluation Questionnaire

(2) FY2021 evaluation questionnaire

Excerpts from the FY2021 results report overview (main section)

[Mock emergency vehicle information for vehicles on emergency calls]

- In addition to current location information, there were also comments requesting the provision of information such as traveling direction, planned route, and turn signal status.

[Effectiveness of delivered information]

- "With this information, we can determine the relative positions and relative speeds of emergency vehicles with respect to our vehicle, so we think it would be extremely effective when the approach of an emergency vehicle would affect our own vehicle's behavior."
- “Both when informing the driver and when controlling automated driving, it would be best to make a stop determination roughly 20 seconds in advance to gradually bring the vehicle to a stop from 60 km/h. The vehicle control wouldn't need to be based on the emergency vehicle's exact location, so a delay of 2 or 3 seconds would be acceptable."

[Improvement requests]

- "The information would be even more effective if it included the emergency vehicle's traveling direction and (if possible) information on its planned route."
- "We would like to have planned route information, turn signal status information, and the like for emergency vehicles."
- "Even if we know the current location of the emergency vehicle, we don't know what route it will take in the future, so we determined that this information wasn't enough for us to make route changes for our own vehicle."
- "When the emergency vehicle stops, we need to know if it's temporarily stopped on its way to its destination, or if it has stopped because it reached its destination. Knowing the intentions of the emergency vehicle would make the information even more effective."
- "It would be best if the information were linked with a high accuracy map to properly distinguish if emergency vehicles are currently on elevated roads or on frontage roads."

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd05/102s_main.pdf)

6. Results of Evaluation Questionnaire

(2) FY2021 evaluation questionnaire

Excerpts from the FY2021 results report overview (main section)

[Traffic signal prediction information]

- There were comments regarding time deviations between actual traffic signal color changes and traffic signal prediction information, requests for the provision of traffic signal prediction information for intersections that provide information with margins, other requests regarding societal deployment, etc.

[Time deviations between actual traffic signal color changes and traffic signal prediction information]

- "Actual traffic signal aspects differed from predictions (times when signals were predicted to change) by up to two seconds. A deviation of two seconds is large enough to negate any dilemma zone avoidance benefits. A deviation of roughly ±300 ms would be within acceptable bounds."
- "There's too much of a gap between actual traffic signal changes and the timing predicted in the information that was supplied."

[Provision of traffic signal prediction information for intersections that provide information with margins]

- "We believe that, during the cycle, information needs to be updated after the preliminary finalization of the number of seconds and after the information with margins aspect step. For traffic signals providing information with margins, we would like for traffic signal aspect information to be delivered via V2N."

[Other (preparation for societal deployment)]

- "If information delivery services are available for some traffic signals but not for others within the same area, the information would be less effective. It would be best if information were delivered for all intersections in areas where information is provided."
- "We would like for societal deployment to occur in 2023. The sooner the better."

SIP Phase 2: Automated Driving (Expansion of Systems and Services), FY2021 "Implementation of FOTs in the Tokyo Waterfront Area" report overview (https://www.sip-adus.go.jp/rd/rddata/rd05/102s_main.pdf)

6. Results of Evaluation Questionnaire

(3) FY2022 evaluation questionnaire

1) Evaluations of the public acceptability of automated driving based on the impact assessment

[Impact of autonomous vehicles on the surrounding traffic environment]

(Behavior)

- When autonomous vehicles drove slowly, **following vehicles approached or passed, etc., in a dangerous manner**.
- Participants also indicated that following vehicles passed the autonomous vehicles of their own accord, **so no traffic congestion occurred**.
- Participants indicated that **they needed to be able to share information about their autonomous vehicle's behavior with following vehicles when the autonomous vehicle received ITS wireless cycle information and began to decelerate.**

(Appearance)

- **HMI were used to indicate to following vehicles that the test vehicles were autonomous vehicles, and to indicate their status**, in order to prevent concern, tailgating/road rage, passing, and the like.
- To eliminate the problems caused by lack of eye contact, **HMI was used to indicate to crosswalk pedestrians that "This car waits for pedestrians"**.

[Impact of the surrounding traffic environment on autonomous vehicles]

- **There were cases of large trucks blocking the view of test vehicles, preventing them from determining conditions in front of the vehicle.**
- There were cases in which there were no pedestrians or bicycles on the road but the vehicle mistakenly identified them as being present.
- Changes to the number of remaining in seconds for intersections with margins made it necessary to make changes to vehicle control.
- **For autonomous vehicles driving at slow speeds, traffic signal colors changed to yellow and then red while they were still traversing large intersections, so they had to speed up.**

6. Results of Evaluation Questionnaire

(3) FY2022 evaluation questionnaire

2) Achieving automated driving by using cooperative infrastructure

- In the FY2022 FOTs, there a great deal of traffic signal information and traffic signal prediction information usage, provision of information to drivers, and confirmation work performed using the test room.
- Testing was performed based on the objectives of individual participants and FOTs data was used in development work by individual participants
  - ✓ Japanese participants: Primarily **gained insights regarding the verification of the information that was provided** and the **acquisition of data while driving an autonomous vehicle on public roads**
  - ✓ Overseas participants: Primarily **gained insights regarding coordination with infrastructure**
- Participants **made the following requests** regarding cooperative ITS systems.
  - ✓ **Extension/expansion into other areas** (major roads, specified areas such as the areas in front of train stations, nationwide expansion)
  - ✓ **Expansion/enrichment of areas where information is delivered, content of information, etc.** (urban areas, rural areas), **comprehensive provision of traffic signal information for entire automated driving areas**
  - ✓ **International standardization** (delivered data, data formats, systems, equipment specifications/interfaces, etc.) = avoid Galápagos syndrome (automobiles must be positioned as internationally standardized products)
  - ✓ **Reduce delivery delays**

6. Results of Evaluation Questionnaire

(3) FY2022 evaluation questionnaire

3) Secretariat operations

When performing similar testing in the future, we propose the following regarding the operation of the Secretariat based on the results and issues identified in the FOTs.

- There were various suggestions about promising working group agenda items, such as **discussing the effectiveness of traffic environmental information, investigating the situation with respect to parking on the street, and sharing key points which individual participants believed presented dangers**. (Participants made suggestions based on the contents of presentations by individual participants during working group meetings.)
- Participants reported **the communication tool (kintone) was effective** because it provided convenient access to materials and software, it was easy to use because it kept logs, it made it easy to make inquiries, etc.
- Some participants commented on the **technical support system** during testing (there were slight delays in investigating and responding to inquiries).

7. Discussion topics provided by test participants

7. Discussion topics provided by test participants

(1) FY2019-2020 (V2I)

- In the FOTs, in order to promote the sharing of opinions between test participants in cooperative areas, test participants were asked to provide discussion topics at each of the FOTs working group meetings.
- The following topics were reported on at each of the working group meetings.

WG meeting	Test participant	Contents of report (excerpted from meeting minutes)
4th Working Group Meeting November 20, 2019	Sompo Japan Nipponkoa Insurance Inc.	• Overview of the results of the driving route survey in the Waterfront City area
	Continental Automotive Corporation	• Overview of Continental Automotive's automated driving initiatives • Overview of plans for testing of traffic signal information, HMI, etc. in the Waterfront City area
	Kanazawa University	• Overview of Kanazawa University's autonomous automated vehicle • Overview of other initiatives carried out as part of SIP Phase 2 - Automated Driving (Expansion of Systems and Services) • Overview of test plans for the Waterfront City area and the Haneda area
5th Working Group Meeting January 29, 2019	Sompo Japan Nipponkoa Insurance Inc.	• Overview of the results of the driving route survey of the Metropolitan Expressway
	Saitama Institute of Technology	• Overview of the Saitama Institute of Technology's autonomous vehicle • Overview of the results of autonomous bus testing carried out as part of SIP Phase 1 • Overview of SIP Phase 2 test plans
	Honda Motor Company	• Overview of the status of traffic signal information testing in the Waterfront City area

7. Discussion topics provided by test participants

WG meeting	Test participant	Contents of report (excerpted from meeting minutes)
9th Working Group Meeting September 16, 2020	Suzuki Motor Corporation	• Overview of Suzuki's automated driving initiatives • Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
	Volkswagen Group Japan K.K.	• Overview of Volkswagen's automated driving initiatives • Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
	Kanazawa University	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of automated bus testing in the Haneda area
	JTEKT Corporation	• Reporting on the status of automated bus testing in the Haneda area
	BOLDLY Inc.	• Overview of BOLDLY's automated vehicle driving management platform • Reporting on the status of automated bus testing in the Haneda area
	Saitama Institute of Technology	• Overview of the Saitama Institute of Technology's buses with retrofitted automated driving functions • Reporting on the status of automated bus testing in the Haneda area
10th Working Group Meeting November 18, 2020	Valeo Japan Co., Ltd.	• Overview of Valeo Japan's automated driving assistance system • Reporting on the status of traffic signal information testing and impact assessment-related testing in the Waterfront City area
	Subaru Corporation	• Reporting on the status of traffic signal information testing in the Waterfront City area
	BMW AG	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
	Nagoya University	• Overview of Nagoya University's dynamic map 2.0 platform • Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of cruising line merging support information on the Metropolitan Expressway • Reporting on evaluation testing of the accuracy of location estimation performed using data fusion
	Honda Motor Company	• Overview of Honda's automated driving initiatives • Reporting on the status of traffic signal information testing and pedestrian communication testing in the Waterfront City area

7. Discussion topics provided by test participants

WG meeting	Test participant	Contents of report (excerpted from meeting minutes)
12th Working Group Meeting January 28, 2021	Toyota Motor Corporation	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
	Toyota Motor Corporation /Hino Motors, Ltd.	• Reporting on the status of automated bus testing in the Haneda area
	Daihatsu Motor Co., Ltd.	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of cruising line merging support information on the Metropolitan Expressway
13th Working Group Meeting February 17, 2021	Mitsubishi Electric Corporation	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
	Mazda Motor Corporation	• Reporting on the status of traffic signal information testing in the Waterfront City area
	Nissan Motor Company	• Overview of Nissan's automated driving initiatives • Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
14th Working Group Meeting March 17, 2021	Mercedes-Benz Japan Co., Ltd.	• Overview of Mercedes-Benz's automated driving assistance system • Reporting on the status of traffic signal information testing in the Waterfront City area
	Tier IV, Inc.	• Overview of Tier IV's automated driving initiatives • Reporting on the status of traffic signal information testing in the Waterfront City area
	Bosch Corporation	• Reporting on the status of traffic signal information testing in the Waterfront City area • Reporting on the status of testing of cruising line merging support information on the Metropolitan Expressway

7. Discussion topics provided by test participants

(2) FY2021-2022 (V2N)

WG meeting	Test participant	Contents of report (excerpted from meeting minutes)
25th Working Group Meeting April 20, 2022	Suzuki Motor Corporation	• Reporting on status of testing related to rainfall information • Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information
	Nissan Motor Company	• Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls
	Sompo Japan Insurance Inc.	• Overview of Sompo Japan's automated driving initiatives • Overview of in-house motor vehicle accident analysis solution for evaluating automated driving risk • Reporting of results of risk evaluation in the Waterfront City area
26th Working Group Meeting May 18, 2022	Kanazawa University	• Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls
	Continental Automotive Corporation	• Reporting on status of testing related to traffic signal prediction information
	Volkswagen Group Japan K.K.	• Overview of Volkswagen's automated driving assistance system • Reporting on status of the FY2019-2020 FOTs • Reporting on plans for FY2021 FOTs
	Mazda Motor Corporation	• Reporting on status of testing related to traffic signal prediction information
27th Working Group Meeting June 29, 2022	Subaru Corporation	• Reporting on status of testing related to traffic signal prediction information
	BMW AG	• Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information
	Honda Motor Company	• Reporting on status of testing related to rainfall information • Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information

7. Discussion topics provided by test participants

WG meeting	Test participant	Contents of report (excerpted from meeting minutes)
27th Working Group Meeting June 29, 2022	Toyota Motor Corporation	• Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information • Reporting on the status of testing of ETC gate passing support/cruising line merging support information on the Metropolitan Expressway
28th Working Group Meeting July 20, 2022	Saitama Institute of Technology	• Overview of the Saitama Institute of Technology's buses with retrofitted automated driving functions • Reporting on the status of automated bus testing in the Haneda area
	Daihatsu Motor Co., Ltd.	• Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information
	Tier IV, Inc.	• Overview of project aimed at creating a service model that uses 5G to provide automated mobility services in the Western Shinjuku area
29th Working Group Meeting August 24, 2022	Veoneer Japan Ltd.	• Reporting on status of testing related to rainfall information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information
	Nagoya University	• Overview of Nagoya University's automated driving initiatives • Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls • Reporting on status of testing related to traffic signal prediction information
	Bosch Corporation	• Reporting on status of testing related to lane-specific road traffic information • Reporting on status of testing related to mock emergency vehicle information for vehicles on emergency calls
30th Working Group Meeting November 20, 2022	Valeo Japan Co., Ltd.	• Overview of Valeo Japan's automated driving initiatives • Reporting on status of testing related to traffic signal prediction information