TF3-21-005-2 Ⅲ6

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

- 2020 Results Report Overview (Attachment A) -

FOTs in the Tokyo Waterfront Area Consortium

Mitsubishi Electric Corporation (representative)

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

May 2021

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[Attachment A]

1. List of test participants in the FOTs in the Tokyo Waterfront area

	Japan	Overseas
Automotive manufacturers	● Suzuki Motor Corporation ● Subaru Corporation ● Daihatsu Motor Co., Ltd. ● Toyota Motor Corporation ● Nissan Motor Co., Ltd. ● Hino Motors, Ltd. ● Honda R&D Co., Ltd. ● Mazda Motor Corporation ● Mitsubishi Motors Corporation	● BMW Japan Corp. ● Volkswagen Group Japan KK ● Bosch Corporation ● Mercedes-Benz Japan Co., Ltd.
Component manufacturers	● Aisan Technology Co., Ltd. *2 ● JTEKT Corporation*3 ● Mitsubishi Electric Corporation	● Valeo Japan Co., Ltd. ● Continental Automotive Corporation
Universities	● Kanazawa University*4 ● Saitama Institute of Technology ● Chubu University*4 ● Nagoya University*4 ● Meijo University*4	
Others	● Sompo Japan Insurance Inc.*2 ● Tier IV, Inc. *2 ● Field auto Inc.*2 ● BOLDLY Inc. *3 ● Advanced Smart Mobility Co., Ltd.	● Epitomical limited

*1:Toyota Motor Corporation participated independently in the "FOTs in the Waterfront City area" and the "FOTS on expressway routes connecting Haneda Airport and the Waterfront City area, etc.," and Toyota Motor Corporation and Hino Motors, Ltd. participated as a team in the "FOTs in the Haneda Airport area"

*2:Aisan Technology Co., Ltd., Sompo Japan Insurance Inc., Tier IV, Inc., and Field Auto Inc. participated as a team

*3:JTEKT Corporation, BOLDLY Inc., and Advanced Smart Mobility Co., Ltd. participated as a team

*4:Kanazawa University, Chubu University, and Meijo University participated as a team

2. Data and communication media

- The data used in the FOTs, based on the four levels dynamic map structure, is 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)

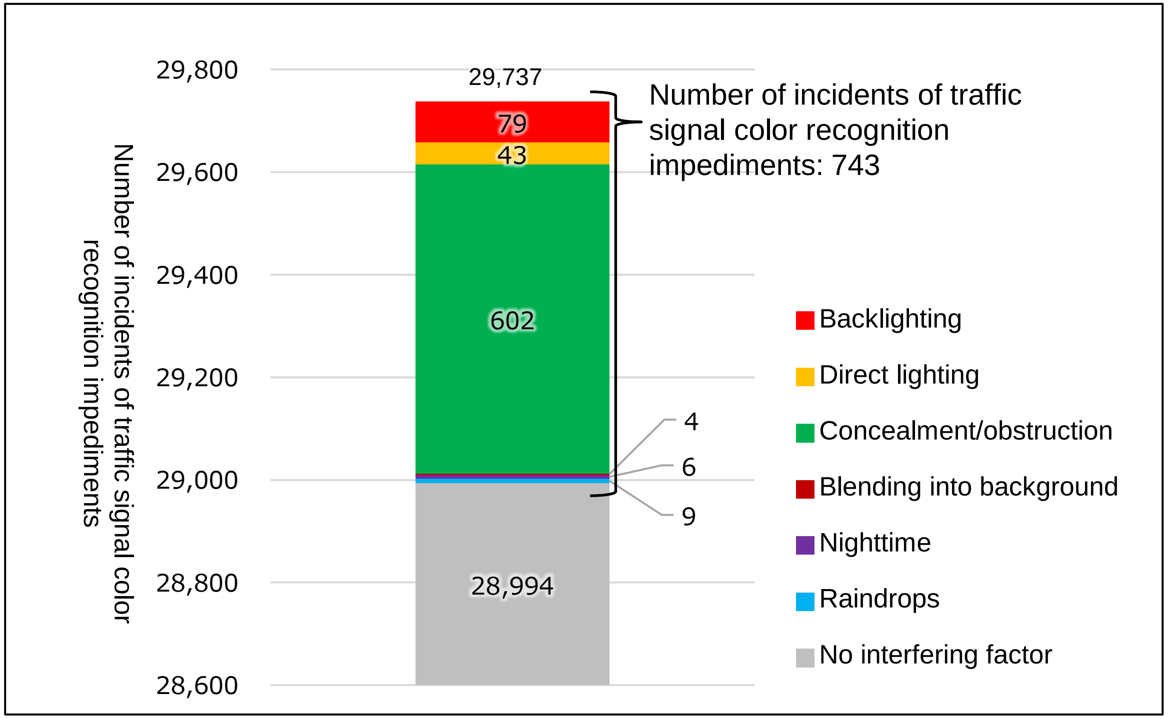
- Road shoulder
- Center line
- Lane line
- Carriageway edge
- Stop line
- Pedestrian crossing
- Road marking
- Traffic signal
- Road sign
- Road node linkage
- Lane link
- Intersection area
- Lane node linkage within intersection
- Lane node linkage within intersection
- CRP node

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	–

3. Results of the FOTs in the Waterfront City area

3-1 Effectiveness of traffic signal color information

Of the 29,728 total intersection traversals*, the number of cases of backlighting, direct lighting, concealment/obstruction, blending into the background, nighttime, and raindrops were confirmed



Number of incidents of traffic signal color recognition impediments: 743

Number of incidents of each type of traffic signal color recognition impediment in all traversals of intersections during the FOTs in the Tokyo Waterfront area

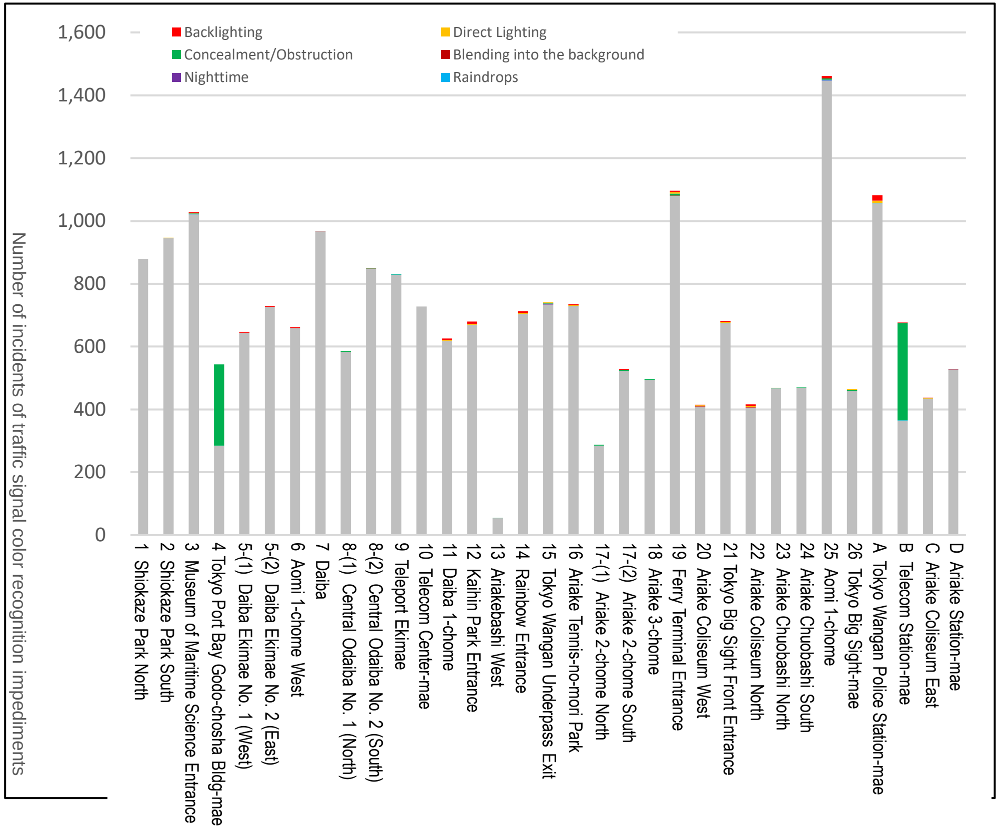
* * In 9 of the intersection traversals there were multiple impediments, so the total number of incidents of impediments is greater than the total number of intersection traversals.

Factors that interfere with signal color recognition
Backlighting
Direct lighting
Concealment/obstruction
Blending into background
Nighttime
Raindrops

3. Results of the FOTs in the Waterfront City area

3-1 Effectiveness of traffic signal color information

The number of incidences of “backlighting,” “direct lighting,” “concealment/obstruction,” “blending into the background,” “nighttime,” and “raindrops” color recognition failures was confirmed for each intersection



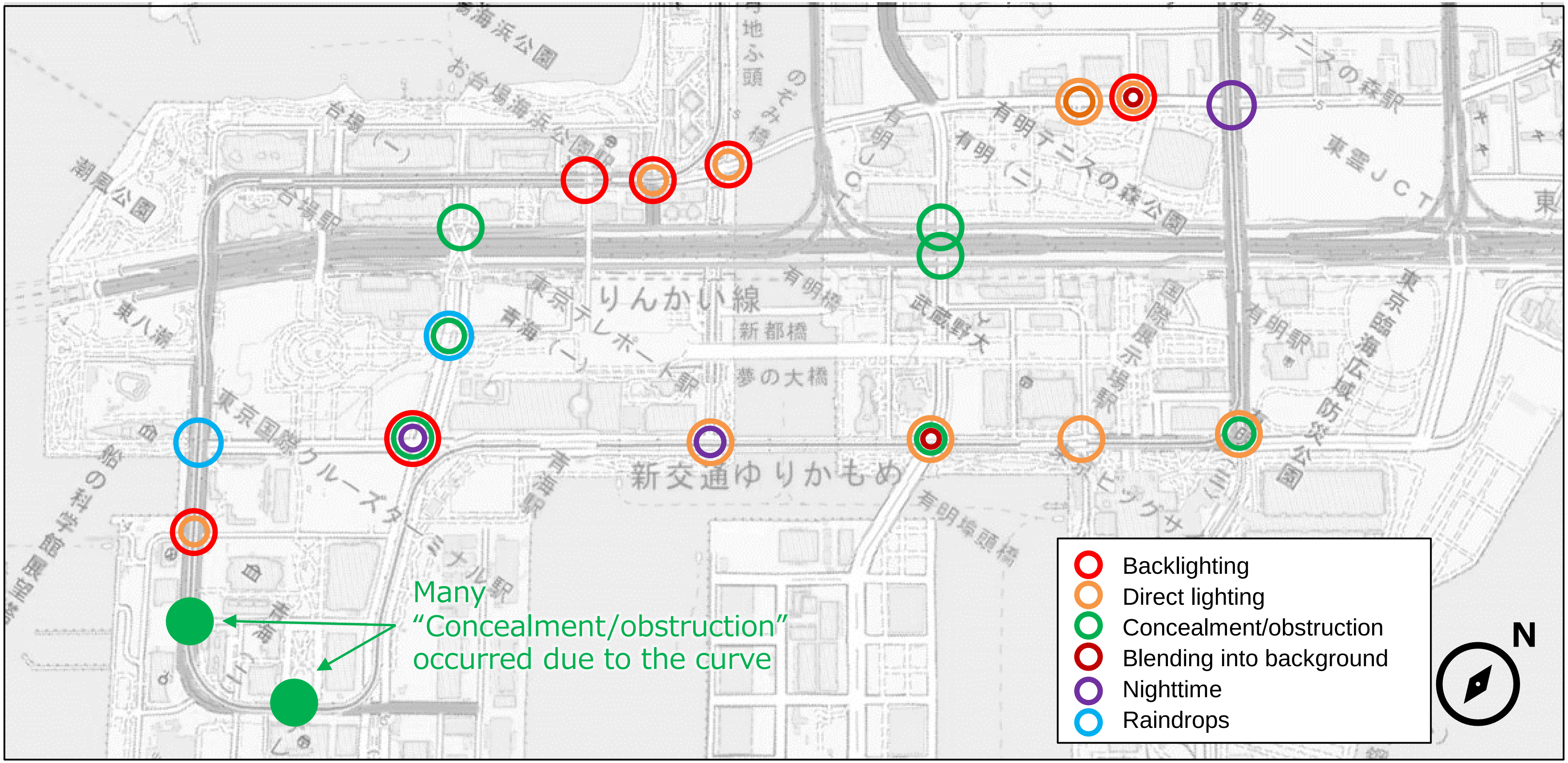
Number of incidences of factors that interfere with traffic signal color recognition

Name of intersection	No. of intersection						
		Backlighting	Direct lighting	Concealment/ obstruction	Blending into background	Nighttime	Raindrops
Shiokaze Park North	879	—	—	—	—	—	—
Shiokaze Park South	947	—	1	—	—	—	—
Museum of Maritime Science Entrance	1,028	3	1	1	—	—	2
Tokyo Port Bay Godo-chosha Bldg-mae	543	—	—	258	—	—	1
Daiba Ekimae No. 1 (West)	647	3	—	—	—	—	—
Daiba Ekimae No. 2 (East)	729	2	—	—	—	—	—
Aomi 1-chome West	661	3	—	—	—	—	—
Daiba	968	1	—	—	—	—	—
Central Odaiba No. 1 (North)	586	—	1	2	—	—	—
Central Odaiba No. 2 (South)	850	1	—	1	—	—	—
Teleport Ekimae	832	—	—	2	—	—	2
Telecom Center-mae	728	—	—	—	—	—	—
Daiba 1-chome	626	5	2	—	—	—	—
Kaihin Park Entrance	680	7	3	—	—	—	—
Ariakebashi West	55	—	—	1	—	—	—
Rainbow Entrance	712	5	3	—	—	—	—
Tokyo Wangan Underpass Exit	741	—	3	1	—	3	—
Ariake Tennis-no-mori Park	735	3	2	1	—	—	—
Ariake 2-chome North	288	—	—	3	—	—	—
Ariake 2-chome South	528	2	—	3	—	—	—
Ariake 3-chome	497	—	—	2	—	—	—
Ferry Terminal Entrance	1,096	4	5	6	1	—	—
Ariake Coliseum West	415	2	3	—	1	—	—
Tokyo Big Sight Front Entrance	682	3	3	1	—	—	—
Ariake Coliseum North	416	5	3	—	2	—	—
Ariake Chuobashi North	469	—	1	1	—	—	—
Ariake Chuobashi South	470	—	—	1	—	—	—
Aomi 1-chome	1,462	8	—	4	—	2	1
Tokyo Big Sight-mae	465	—	3	3	—	—	—
Tokyo Wangan Police Station-mae	1,082	17	8	—	—	—	1
Telecom Station-mae	677	2	—	310	—	—	1
Ariake Coliseum East	437	2	1	1	—	1	—
Ariake Station-mae	528	1	—	—	—	—	1
Total	22,459	79	43	615	4	6	9

3. Results of the FOTs in the Waterfront City area

3-1 Effectiveness of traffic signal color information

Trends in the incidences of “backlighting,” “direct lighting,” “concealment/obstruction,” “blending into the background,” “nighttime,” and “raindrops” color recognition failures at each intersection were confirmed on a map (some intersections have multiple failure factors)



Many “Concealment/obstruction” occurred due to the curve

3. Results of the FOTs in the Waterfront City area

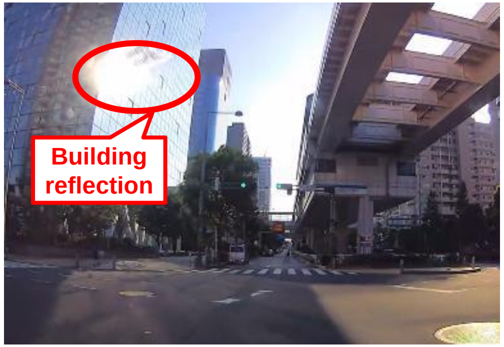
3-1 Effectiveness of traffic signal color information

1) Effectiveness of traffic signal color information when there is backlighting

[Participant feedback to Consortium analysis results]

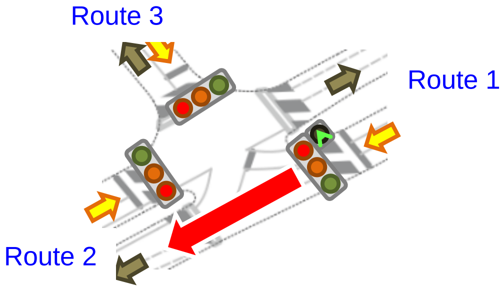
- Backlighting made it difficult to recognize traffic signal colors at times, so having traffic signal information was valuable
- The amount of time that recognition accuracy fell was extremely short, so traffic signal colors immediately before and after were identified by on-board cameras and traffic signal colors were identified throughout driving

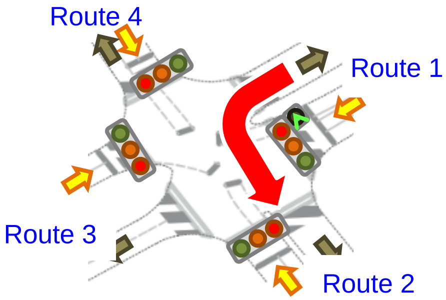
<2020/1/20 15:59 Daiba 1-chome>

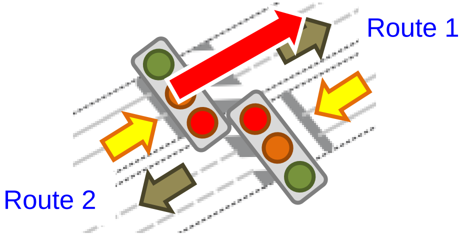


<2020/8/25 16:15 Kaihin Park Entrance>

<2020/9/15 21:17 Aomi 1-chome West>







3. Results of the FOTs in the Waterfront City area

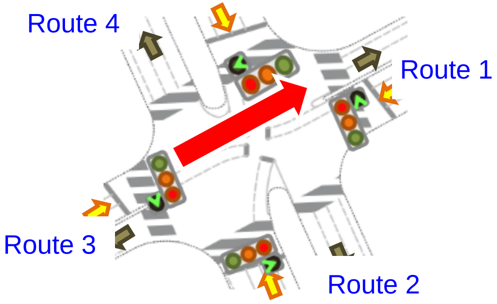
3-1 Effectiveness of traffic signal color information

2) Effectiveness of traffic signal color information when there is direct lighting

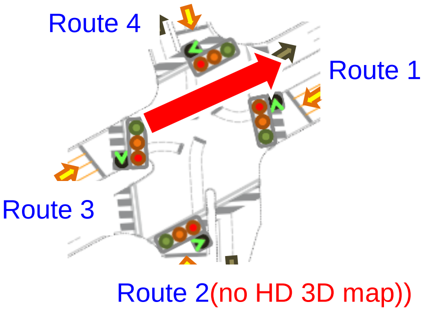
[Participant feedback to Consortium analysis results]

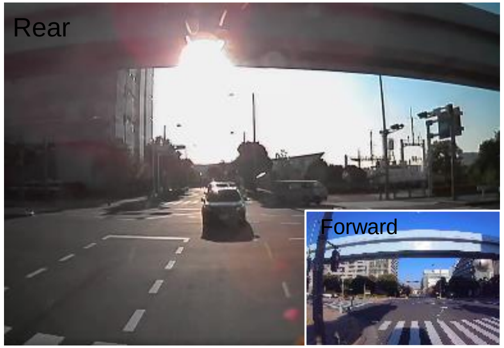
- The traffic signal color recognition accuracy of the camera dropped slightly for just a moment
- The drop in the traffic signal color recognition accuracy of the camera was only momentary, so it had no impact on intersection traversal decision-making

<2020/8/25 17:23 Aomi 1-chome>

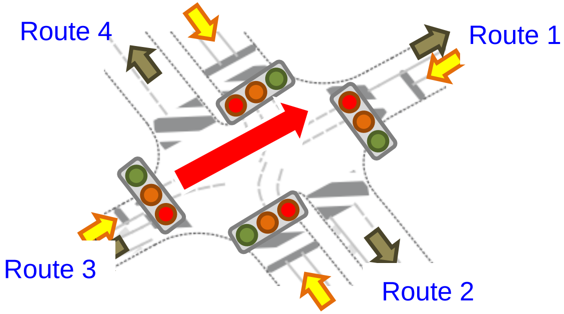


<2020/10/20 16:23 Ferry Terminal Entrance>





<2020/11/13 15:01 Tokyo Wangan Police Station-mae>



3. Results of the FOTs in the Waterfront City area

3-1 Effectiveness of traffic signal color information

3) Effectiveness of traffic signal color information when there is concealment/obstruction

[Participant feedback to Consortium analysis results]

- A large truck concealed the traffic light, so when the traffic signal color changed to green, the vehicle did not recognize the change for four seconds. Using the traffic signal remaining seconds information made it possible to prepare to move forward even before the traffic signal color could be seen
- Traffic signal information was received before reaching the traffic signal, which made it possible to perform appropriate vehicle control, such as preliminary deceleration.


Traffic signal color could not be recognized

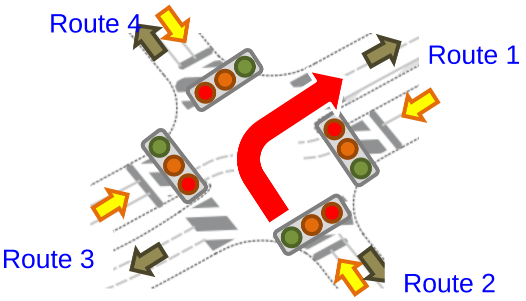
<2020/10/26 16:32 Telecom Station-mae>

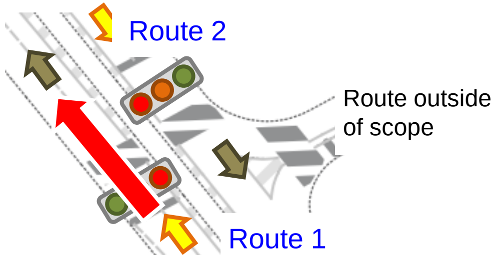

Traffic signal color could not be recognized

<2020/11/25 14:32 Tokyo Port Bay Godo-chosha Building>

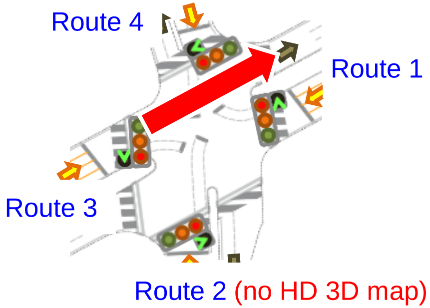

Traffic signal color could not be recognized

<2020/9/8 15:40 Ferry Terminal Entrance>





Two routes only due to pedestrian traffic signal



3. Results of the FOTs in the Waterfront City area

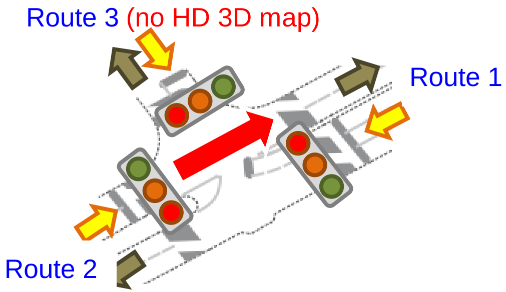
3-1 Effectiveness of traffic signal color information

4) Effectiveness of traffic signal color information when traffic lights blend into the background

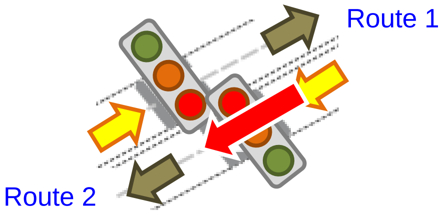
[Participant feedback to Consortium analysis results]

- The color of the traffic signal could be determined, but the traffic signal’s outline, etc. blended in with the building behind it or other background elements, reducing the reliability of traffic signal detection.

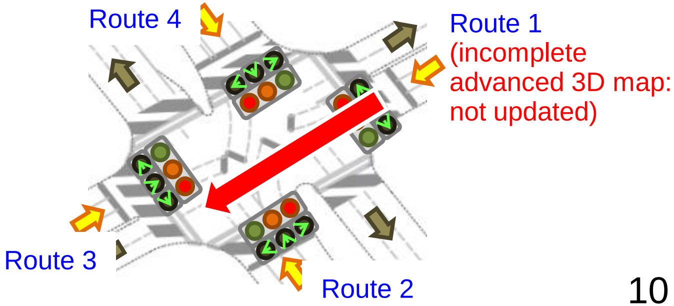
<2020/11/5 14:25 Ariake Coliseum North>



<2020/12/18 14:16 Ariake Coliseum West>



<2020/10/28 11:35 Ariake Coliseum East>



3. Results of the FOTs in the Waterfront City area

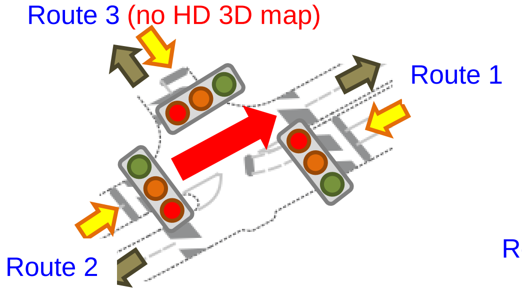
3-1 Effectiveness of traffic signal color information

5) Effectiveness of traffic signal color information at night

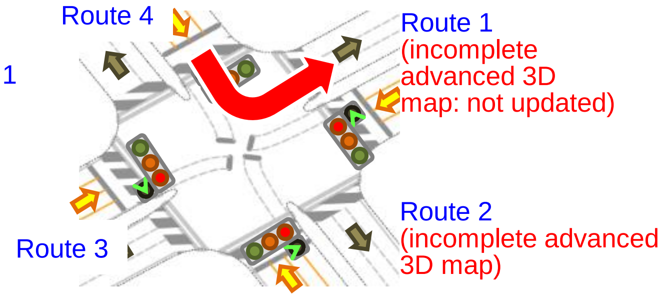
[Participant feedback to Consortium analysis results]

- At night, there were light sources such as street lamps and building lights that made traffic signal color recognition difficult.

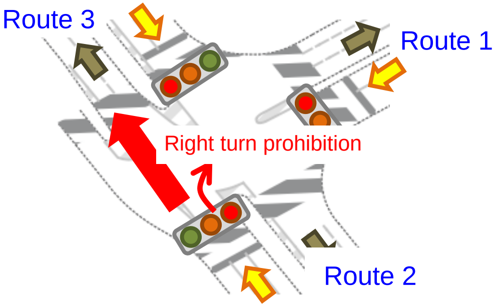
<2020/9/15 21:29 Ariake Coliseum North>



<2020/9/15 21:32 Tokyo Big Sight-mae>



<2020/3/17 21:11 Museum of Maritime Science Entrance>



3. Results of the FOTs in the Waterfront City area

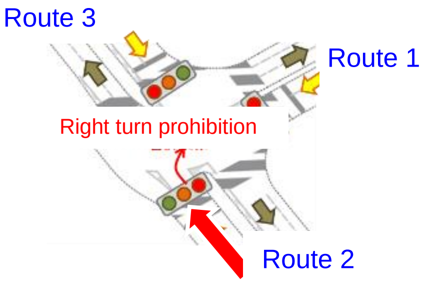
3-1 Effectiveness of traffic signal color information

6) Effectiveness of traffic signal color information when there are raindrops

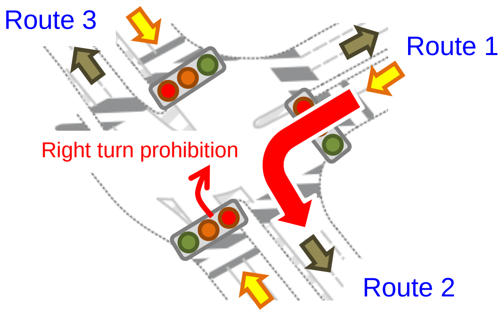
[Participant feedback to Consortium analysis results]

- Sometimes, rain fell on the front camera, making traffic signal color recognition difficult.

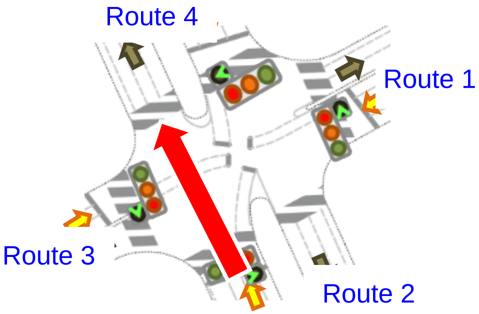
<2020/1/28 10:02 Museum of Maritime Science Entrance>



<2020/6/19 14:08 Museum of Maritime Science Entrance>



<2020/6/19 14:31 Aomi 1-chome>

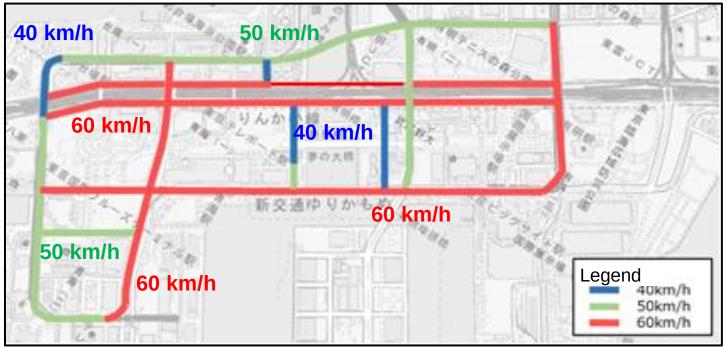


3. Results of the FOTs in the Waterfront City area

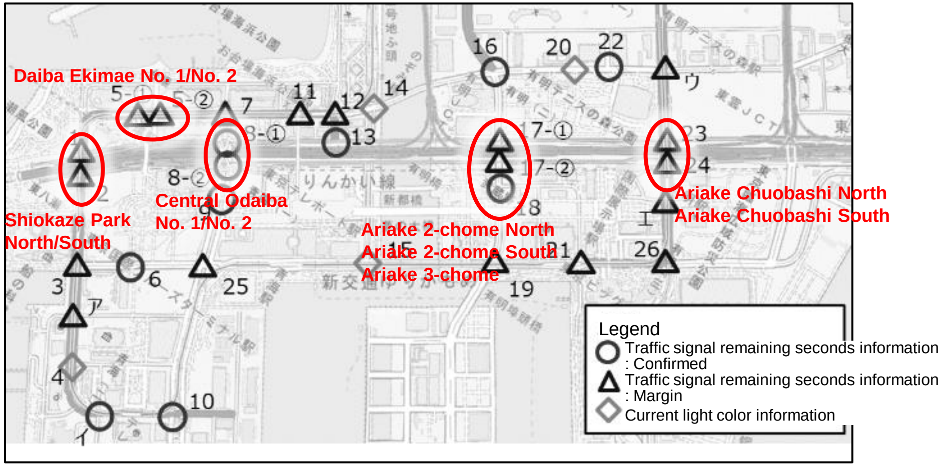
3-2 Effectiveness of traffic signal remaining seconds information:

The ratios of intersection traversal decision-making differences per intersection during test participant drives were analyzed and considered from the following perspectives

I. Distance from adjacent intersection with traffic signal
II. Speed limit
III. Yellow signal time
IV. Confirmed / Margin



(II) Speed limits in the Waterfront City area



(I) Example of intersections located short distances from other intersections

(IV) Intersection Traffic signal remaining seconds information: Confirmed / Margin in the Waterfront City area

(III) Intersection yellow light times in the Waterfront City area

3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

Name of intersection	Manual	Auto-mated	Traversal decision diff. *1	Traversal decision diff. ratio (traversals)	Traversal decision diff. ratio (%)	Speed restrictions*2
Shiokaze Park North	555	214	9	9/769	1.17%	Route1:60/Route2,3:40
Shiokaze Park South	646	217	15	15/863	1.74%	Route1:60/Route2:50/Route3:40
Museum of Maritime Science Entrance	737	208	2	2/945	0.21%	Route1:60/Route2,3:50
Tokyo Port Bay Godo-chosha Bldg-mae	377	166	0	0/543	0.00%	Route1,2:50
Daiba Ekimae No. 1 (West)	396	208	2	2/604	0.33%	Route1,3:50
Daiba Ekimae No. 2 (East)	441	204	5	5/645	0.78%	Route1,3:50
Aomi 1-chome West	530	49	5	5/579	0.86%	Route1,2:60
Daiba	576	306	4	4/882	0.45%	Route1,3:50/Route2:60
Central Odaiba No. 1 (North)	310	270	9	9/580	1.55%	Route1,2,3,4:60
Central Odaiba No. 2 (South)	509	299	17	17/808	2.10%	Route1,2,3,4:60
Teleport Ekimae	489	276	1	1/765	0.13%	Route2,3:60
Telecom Center-mae	447	164	0	0/611	0.00%	Route3:50/Route4:60
Daiba 1-chome	432	122	1	1/554	0.18%	Route1,2:50
Kaihin Park Entrance	477	121	8	8/598	1.34%	Route1,3:50/Route2:40
Ariakebashi West	50	5	0	0/55	0.00%	Route1,2:60/Route3:40
Rainbow Entrance	484	114	1	1/598	0.17%	Route1,3:50
Tokyo Wangan Underpass Exit	591	45	0	0/636	0.00%	Route1,2:60/Route3:50
Ariake Tennis-no-mori Park	508	111	2	2/619	0.32%	Route1,2,3:50
Ariake 2-chome North	216	2	0	0/218	0.00%	Route1,3:60/Route2,4:50
Ariake 2-chome South	407	4	1	1/411	0.24%	Route1,3:60/Route2,4:50
Ariake 3-chome	400	1	0	0/401	0.00%	Route2,3:50
Ferry Terminal Entrance	806	120	4	4/926	0.43%	Route1,2:60/Route3:50
Ariake Coliseum West	301	110	0	0/411	0.00%	Route1,2:50
Tokyo Big Sight Front Entrance	491	118	1	1/609	0.16%	Route1,3:60
Ariake Coliseum North	297	115	0	0/412	0.00%	Route1,2:50
Ariake Chuobashi North	357	108	2	2/465	0.43%	Route2,3,4:60
Ariake Chuobashi South	359	107	2	2/466	0.43%	Route2,3,4:60
Aomi 1-chome	1007	317	1	1/1324	0.08%	Route1,2,3,4:60
Tokyo Big Sight-mae	339	122	0	0/461	0.00%	Route3,4:60
Tokyo Wangan Police Station-mae	800	262	0	0/1062	0.00%	Route1,2,4:50
Telecom Station-mae	514	163	6	6/677	0.89%	Route1,3:50
Ariake Coliseum East	323	111	0	0/434	0.00%	Route2:60/Route3:50
Ariake Station-mae	377	144	5	5/521	0.96%	Route1,3:60

*1 Number of dilemmas (traversals/stops), traversals in stopping areas, and stops in traversal areas.

*2 Speed restrictions are abbreviated in the following manner: “R1:60” = “Route 1 speed limit = 60 km/h”.

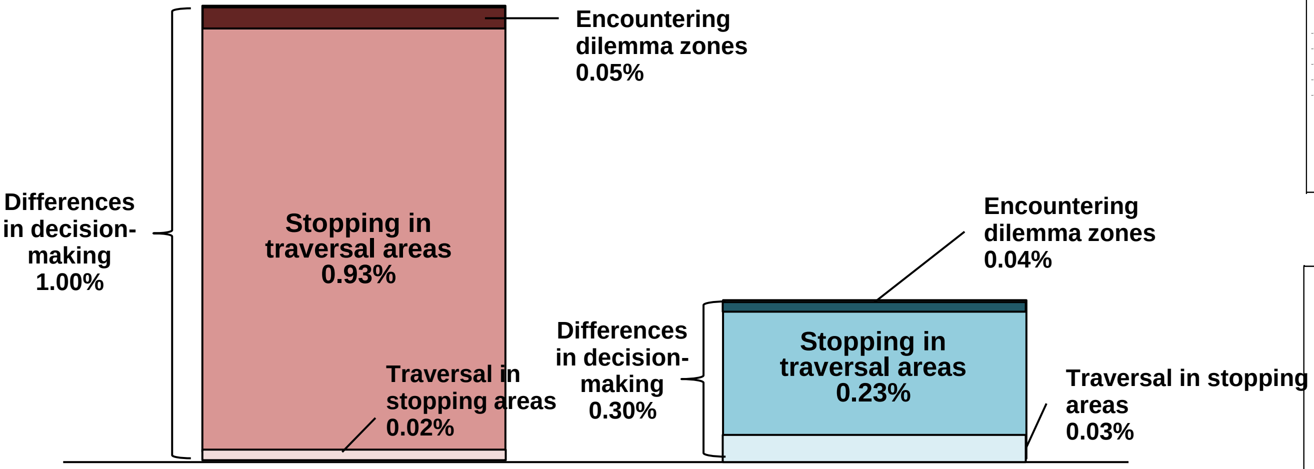
3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

- Distance from adjacent intersection with traffic signal

When the decision regarding whether to traverse the following intersection is made after traversing the nearest intersection, the vehicle may not be able to deal with the situation in time, causing it to encounter a dilemma zone.

➡ **Traffic signal information reaches 100 meters or further, so "following intersection" traversal/stopping decisions can be made in advance**



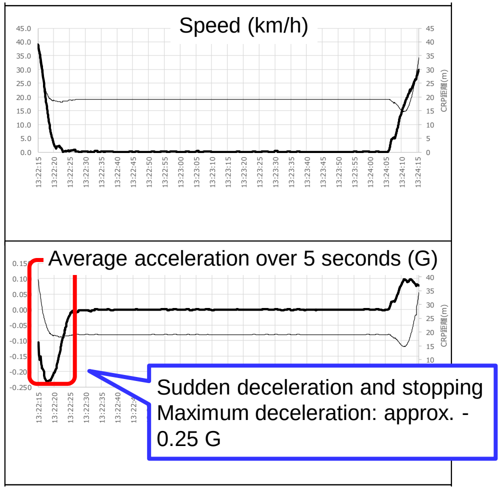
Dilemma incidence rate for intersections spaced less than 100 meters apart

Dilemma incidence rate for intersections spaced 100 meters or more apart

■ Encountering dilemma zones ■ Stopping in traversal areas ■ Traversal in stopping areas ■ Encountering dilemma zones ■ Stopping in traversal areas ■ Traversal in stopping areas

Intersections spaced less than 100 meters apart:
1. Shiokaze Park North, 2. Shiokaze Park South, 5-(1). Odaiba Ekimae No. 1 (West), 5-(2). Daiba Ekimae No. 2 (East), 8-(1). Central Odaiba No. 1 (North), 8-(2). Central Odaiba No. 2 (South), 17-(1). Ariake 2-chome North, 17-(2). Ariake 2-chome South, 18. Ariake 3-chome, 23. Ariake Chuobashi North, 24. Ariake Chuobashi South

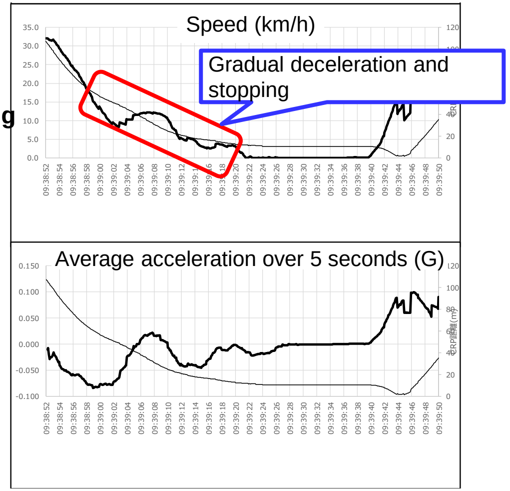
Example of intersection spacing of less than 100 meters


Speed (km/h)

Average acceleration over 5 seconds (G)

Sudden deceleration and stopping
Maximum deceleration: approx. -0.25 G

Example of intersection spacing of 100 meters or more


Speed (km/h)

Gradual deceleration and stopping

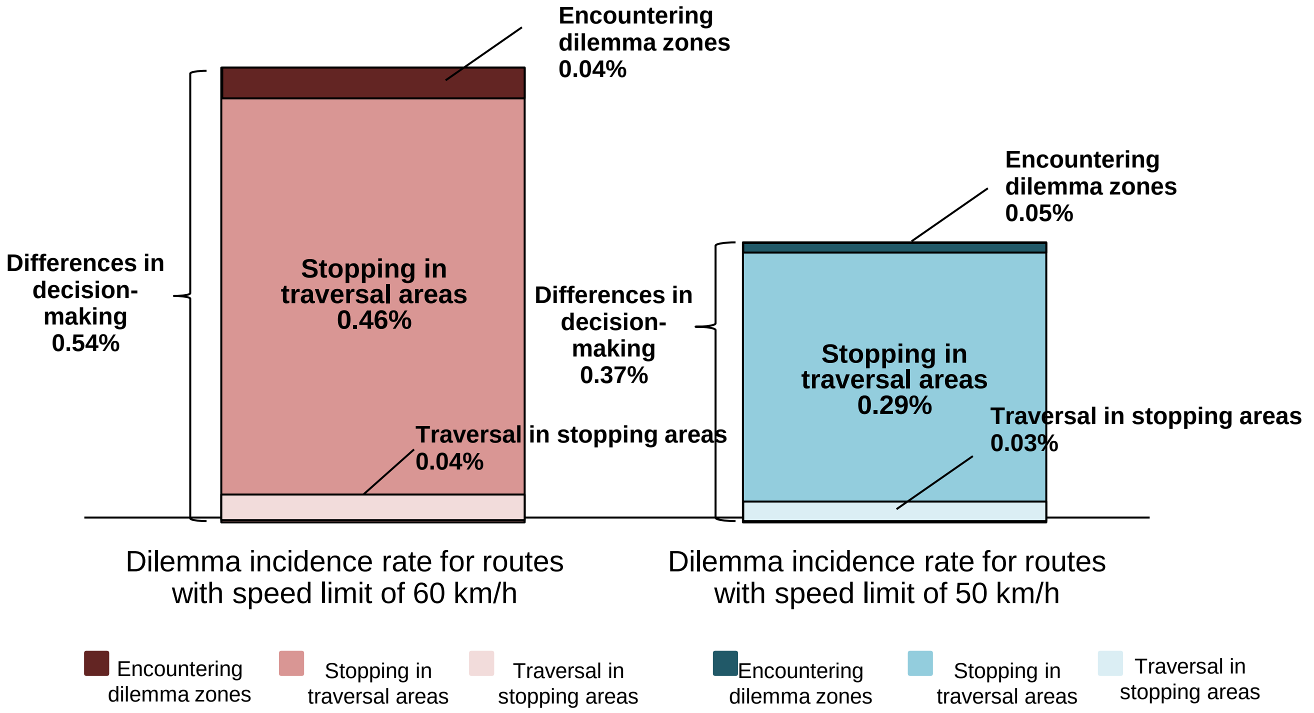
Average acceleration over 5 seconds (G)

3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

- Speed limit

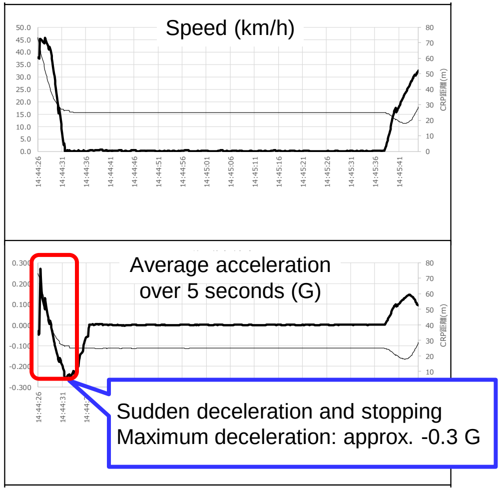
The number of cases of stopping in traversal areas was high for routes with 60 km/h speed limits.



Dilemma incidence rate for routes with speed limit of 60 km/h

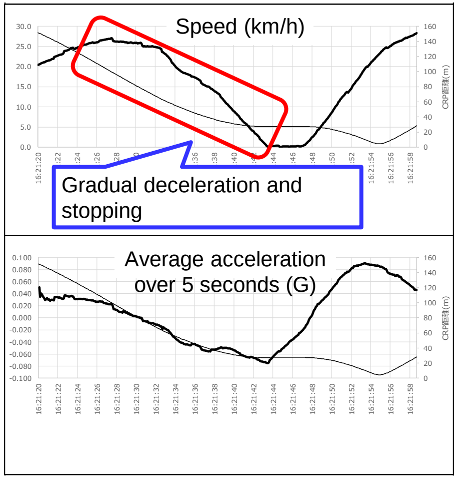
Dilemma incidence rate for routes with speed limit of 50 km/h

Example of route with speed limit of 60 km/h



Sudden deceleration and stopping
Maximum deceleration: approx. -0.3 G

Example of route with speed limit of 50 km/h



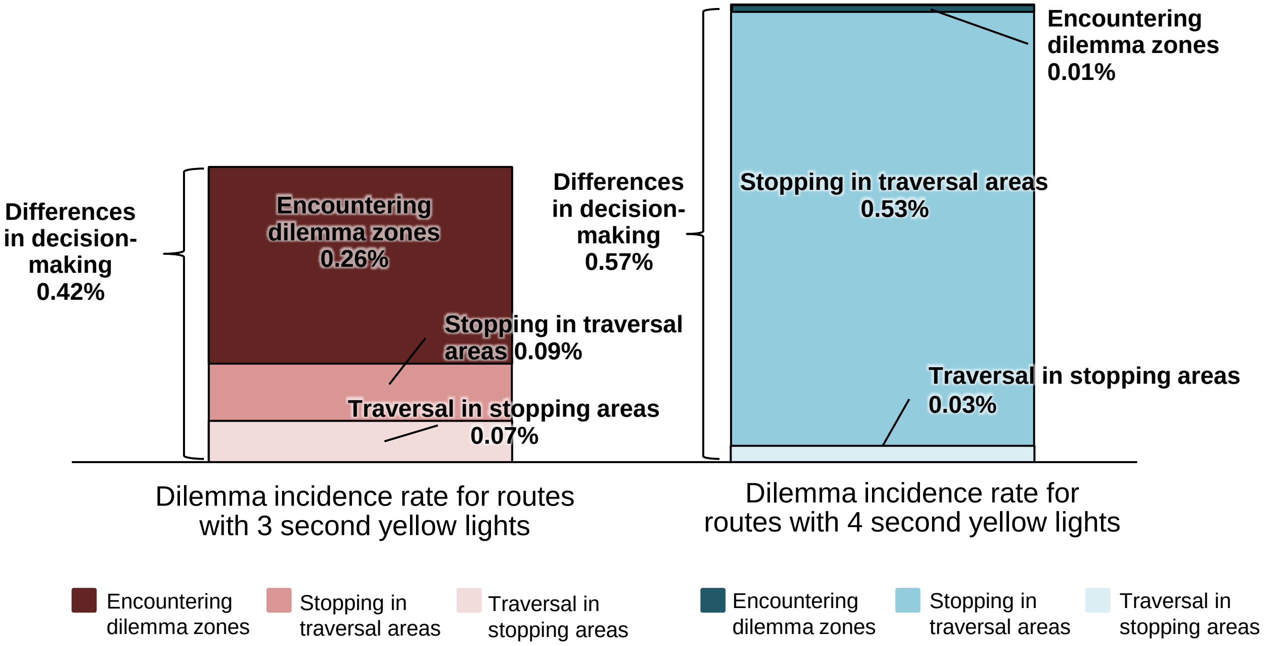
Gradual deceleration and stopping

3. Results of the FOTs in the Waterfront City area

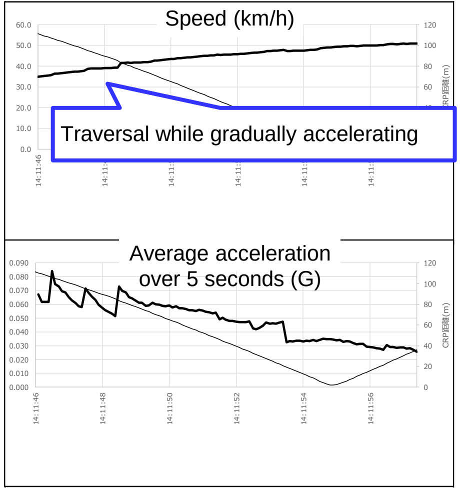
3-2 Effectiveness of traffic signal remaining seconds information:

- Yellow signal time

The rate of encountering dilemma zones was higher for 3-second yellow lights than it was for 4-second yellow lights.
(The rate of stopping in traversal areas was higher for 4-second yellow lights)

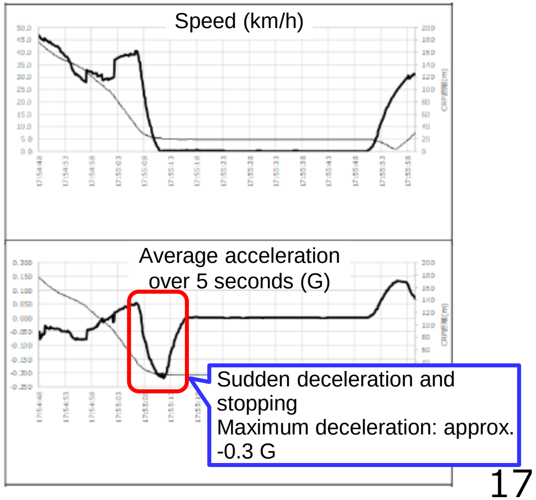


Example of route with 3 second yellow light



Traversal while gradually accelerating

Example of route with 4 second yellow light



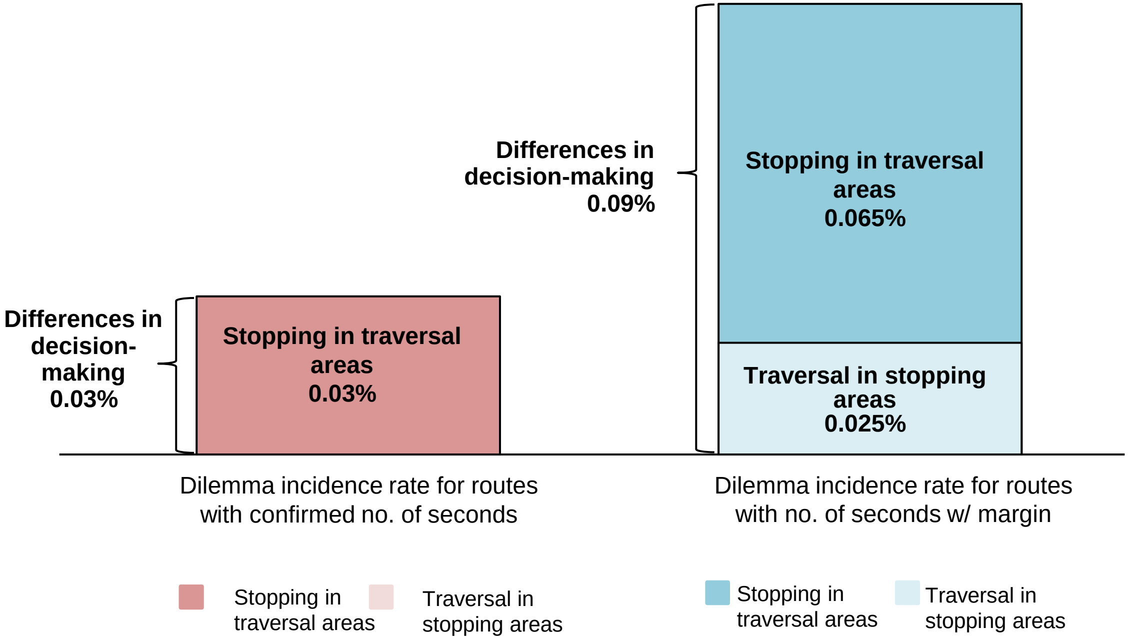
Sudden deceleration and stopping
Maximum deceleration: approx. -0.3 G

3. Results of the FOTs in the Waterfront City area

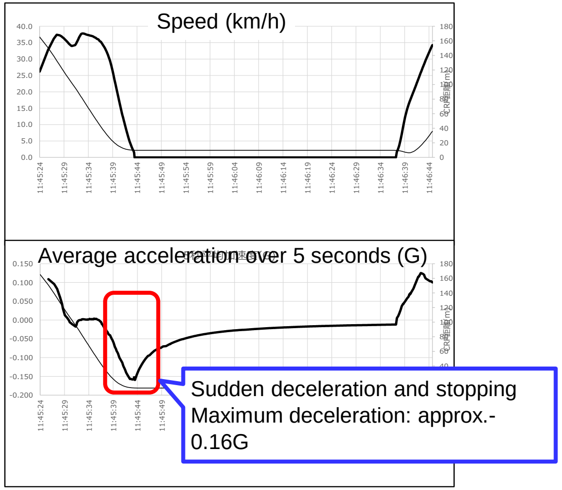
3-2 Effectiveness of traffic signal remaining seconds information:

- Remaining seconds

The incidence of stopping in traversal areas and traversal in stopping areas was high for intersections that provided traffic signal remaining seconds information with margins.

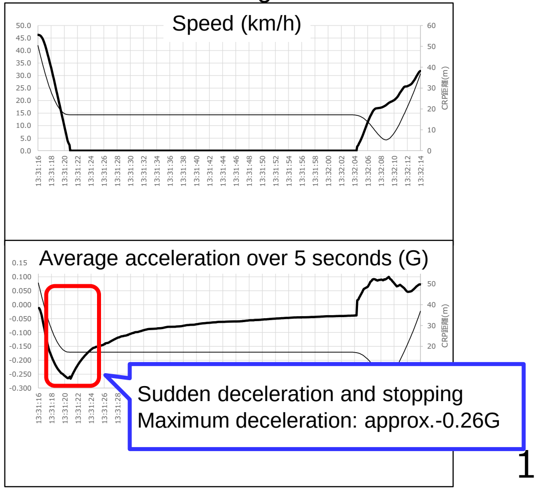


Examples of route with confirmed number of seconds



Sudden deceleration and stopping
Maximum deceleration: approx.-0.16G

Examples of route with number of seconds with margin



Sudden deceleration and stopping
Maximum deceleration: approx.-0.26G

3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

For routes **with 3 second yellow lights**, the distributions of speeds and distances from stop lines were checked when lights turned yellow

- When performing driving without using traffic signal remaining seconds information, multiple cases were observed near dilemma zones of dilemma driving, stopping in traversal areas, and traversal in stopping areas

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: 3.0[s]

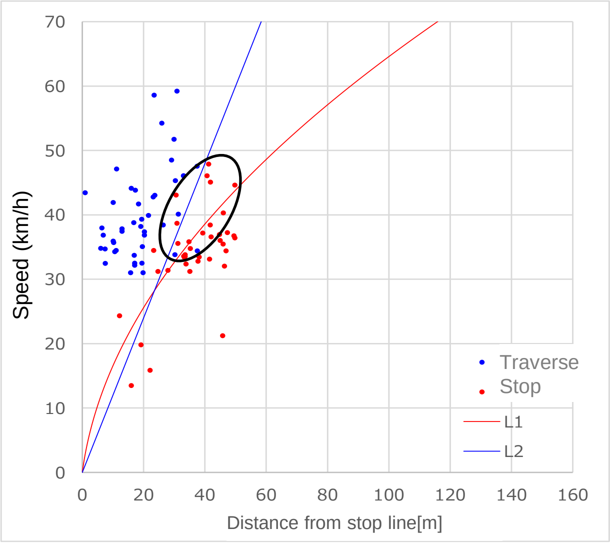


Fig.: Distribution of intersection traversal decisions during **manual driving**

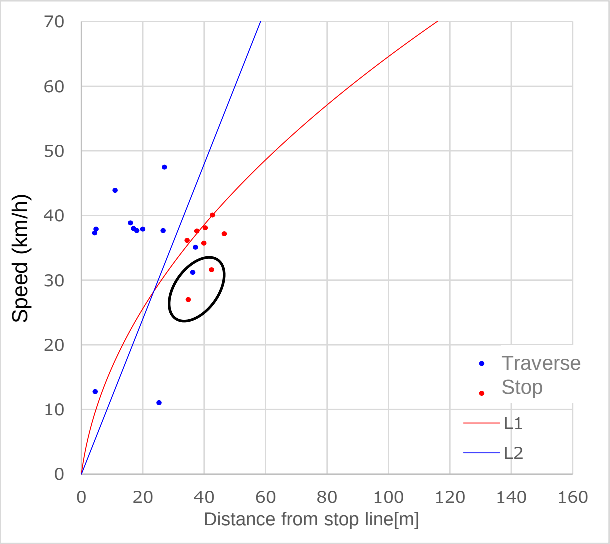


Fig.: Distribution of intersection traversal decisions during **automated driving (cooperative [without remaining seconds info]/autonomous)**

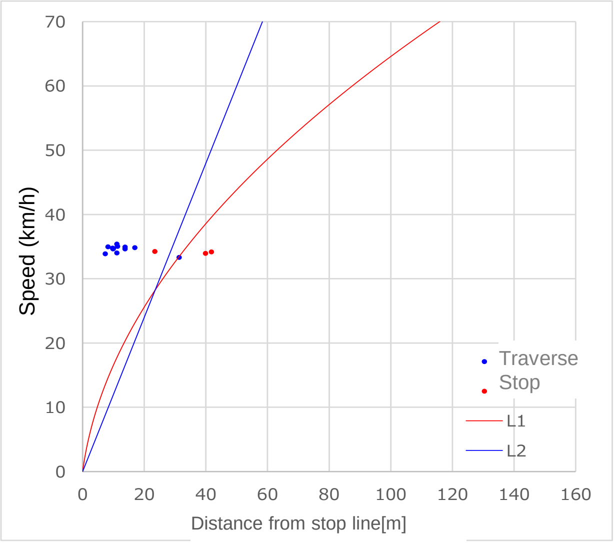


Fig.: Distribution of intersection traversal decisions during **automated driving (cooperative [with remaining seconds info])**

3. Results of the FOTs in the Waterfront City area

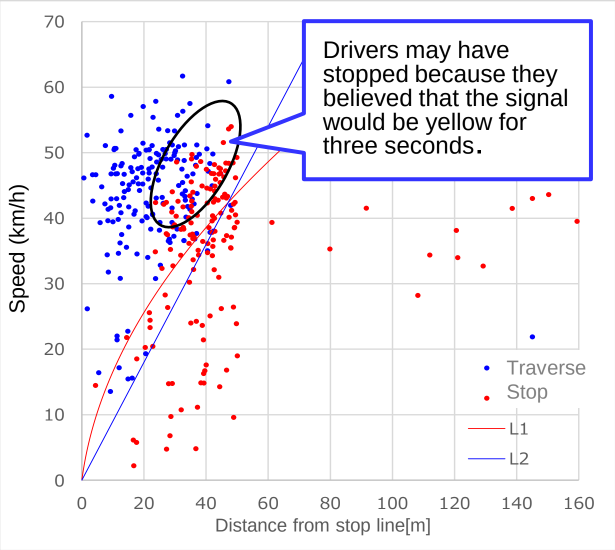
3-2 Effectiveness of traffic signal remaining seconds information:

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.

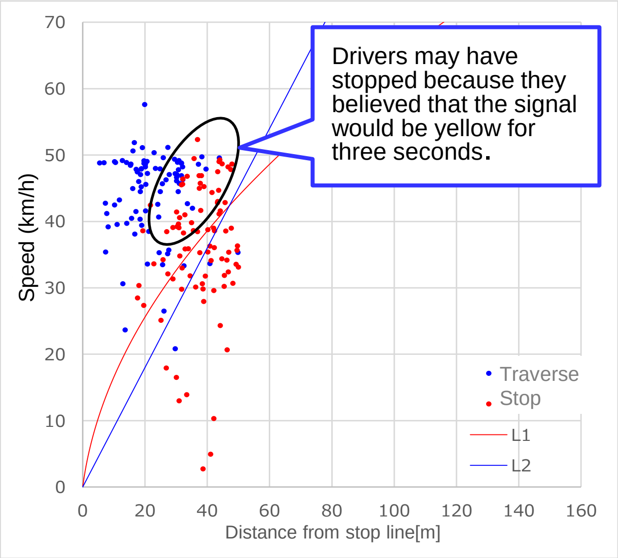
The distribution diagrams and parameters for both, for driving straight only, are as shown below

• Allowable deceleration: 0.2[G], reaction time: 1.0[s], yellow signal duration: 4.0[s]



Drivers may have stopped because they believed that the signal would be yellow for three seconds.

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



Drivers may have stopped because they believed that the signal would be yellow for three seconds.

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

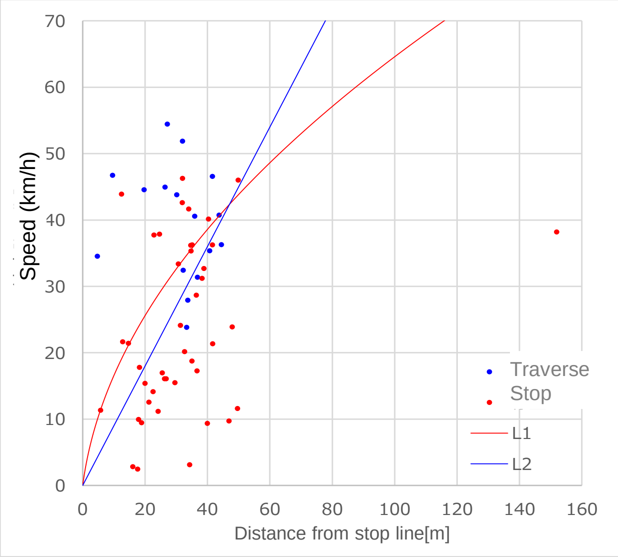
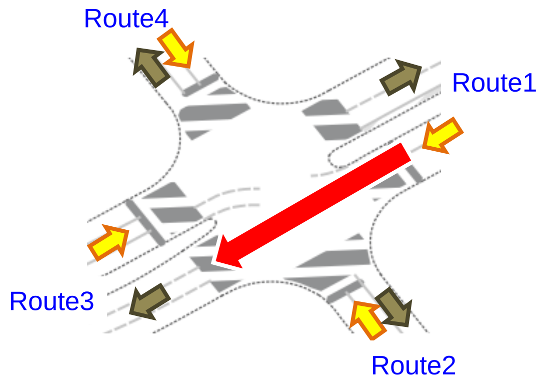


Fig.: Distribution of intersection traversal decisions during **automated driving (cooperative [remaining seconds])**

3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

1) Routes with 3 remaining seconds of yellow light (stopping in traversal areas)

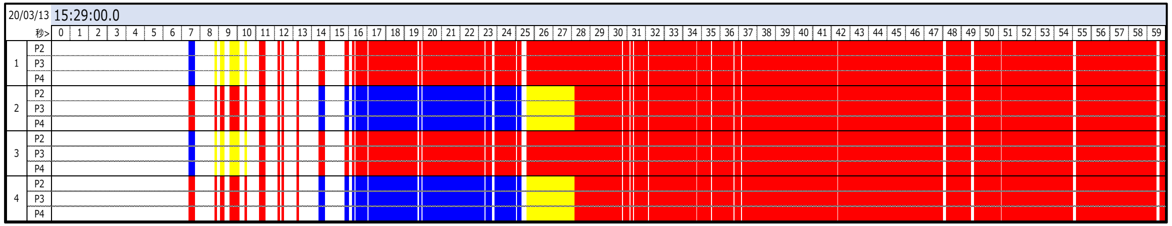


🟥 Entry/exit route

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

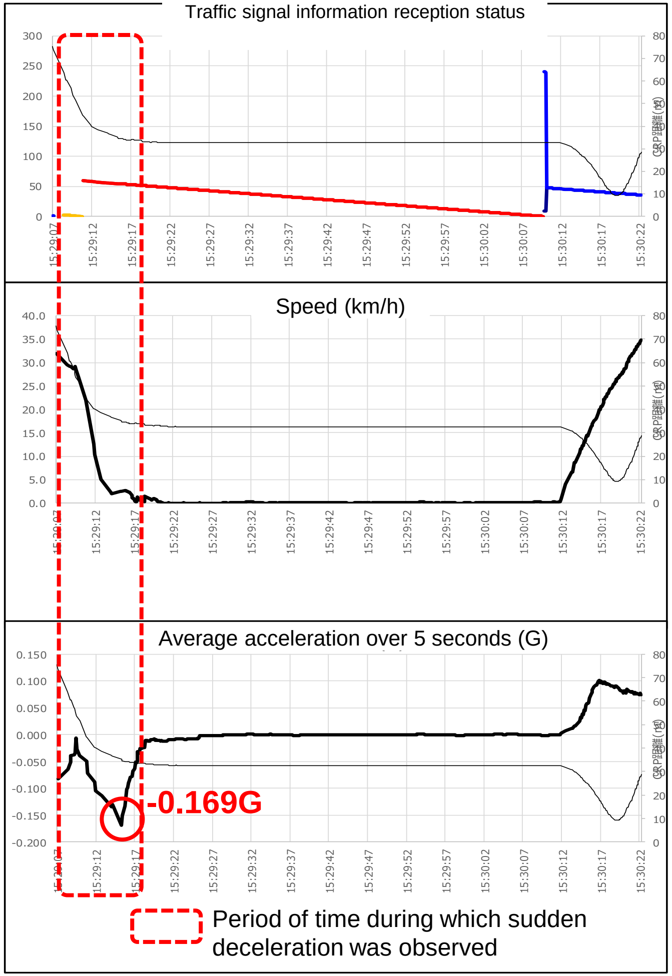
Driving speed		Type of remaining seconds
Entry route	Exit route	
50 km/h	50 km/h	Confirmed

Yellow remaining seconds	Impact on vehicle control	Deceleration following changing to yellow
3 seconds	Sudden deceleration and stopping	-0.169G



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

- When a test vehicle attempted to drive straight from route 1 to route 3 of the Telecom Station-mae intersection, it was confirmed to have stopped within the traversal area.
- The vehicle was confirmed to decelerate suddenly, and had a maximum deceleration of -0.169G.

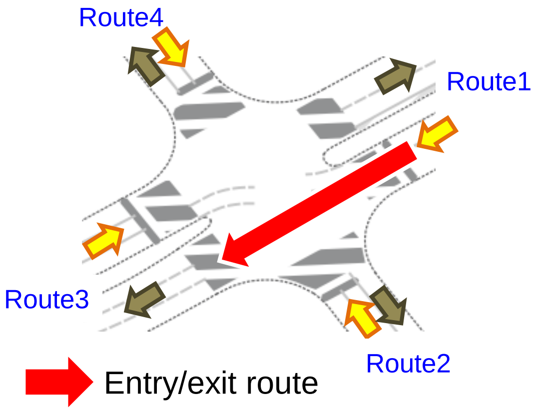


Period of time during which sudden deceleration was observed

3. Results of the FOTs in the Waterfront City area

3-2 Effectiveness of traffic signal remaining seconds information:

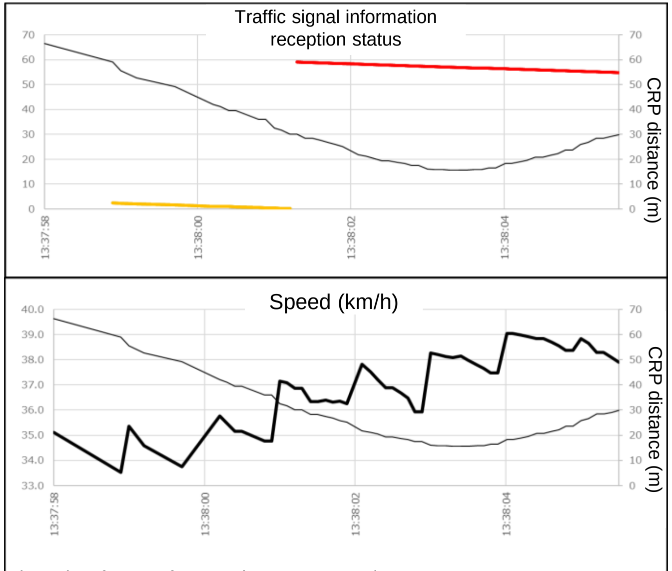
1) Routes with 3 remaining seconds of yellow light (traversal in stopping areas)



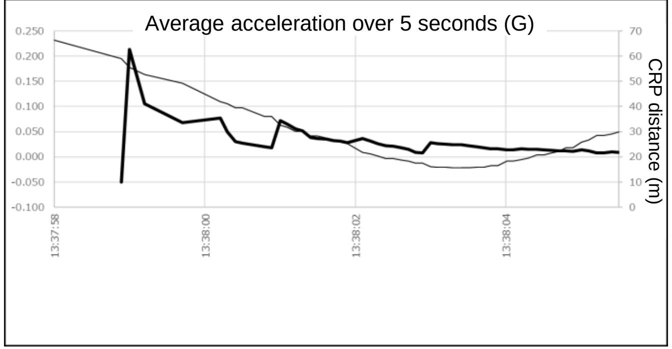
Name of intersection	Intersection no.	Entry route	Exit route
Telecom Station-mae	B	Route 1	Route 3

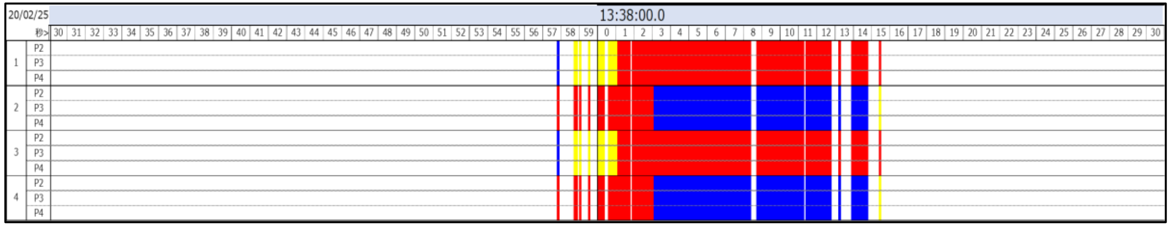
Driving speed		Type of remaining seconds
Entry route	Exit route	
50 km/h	50 km/h	Confirmed

Yellow remaining seconds	Impact on vehicle control	Deceleration following changing to yellow
3 seconds	Traverse	-



(Results of output from equipment prepared by the participant)





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

- When a test vehicle attempted to drive straight from route 1 to route 3 of the Telecom Station-mae intersection, it was confirmed to have traversed the stop area.
- When the traffic signal turned yellow, the vehicle was moving at 33.5 km/h and was roughly 37.1 meters from the stop line.

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

- Evaluation item

00_Macro data evaluation (graphs and statistical evaluation)

11_Micro data evaluation (characteristic behavior and special cases)

- 01_Evaluation of processing when turning left/right

Comparison of processing times in mixed transportation environments (01 left turn, 02 left turn)

Comparison of number of processed vehicles in mixed transportation environments (03 left turn, 04 right turn)

05 Evaluation of gap acceptance when turning right

11 Impact of automated driving behavior on following vehicles when traffic signals change when turning right

12 Behavior of nearby vehicles when turning right

- 02_Behavior of nearby vehicles when driving straight

01 Comparison of automated/non-automated driving speeds

02 Comparison of traffic flow in mixed transportation environments

11 Analysis of close calls such as cutting or passing by nearby vehicles

12 Characteristic behavior of nearby vehicles

- 03_Stopping at red lights when driving straight

01 Stopping behavior conditions in mixed transportation environments (speed and acceleration)

02 Evaluation of stop behavior at red traffic signals

11 Evaluation of autonomous vehicle stop behavior at red traffic signals

12 Impact on following vehicles, etc., at red traffic signals

- 04_Handling of on-street parking

01 (First and second lane categories after left turns)

02 Vehicle behavior in first cruising lane (vehicles parked on street)

11 Impact of avoidance on nearby vehicles

12 (Own vehicle behavior during avoidance)

- 05_Crossing pedestrians when going straight, turning right, or turning left

Analysis of automated/non-automated driving behavior in pedestrian crossing zones (01 left turn, 02 right turn, 03 basic road section)

02 Analysis of V2P distance, etc.

03 Speed when approaching pedestrian crossings

11 Analysis of vehicle behavior

12 Analysis of pedestrian behavior

13 Analysis of hazardous events (legal compliance perspective)

- 06_Handling of bicycles and motorcycles

(mass data analysis methods are currently being considered)

11 Characteristic behavior of autonomous vehicles during encounters

12 Characteristic behavior of motorcycles during encounters

- 51～_Other

01 Impact of COVID-19 (reduction in traffic volume)

(11 Unexpected, sudden stopping)

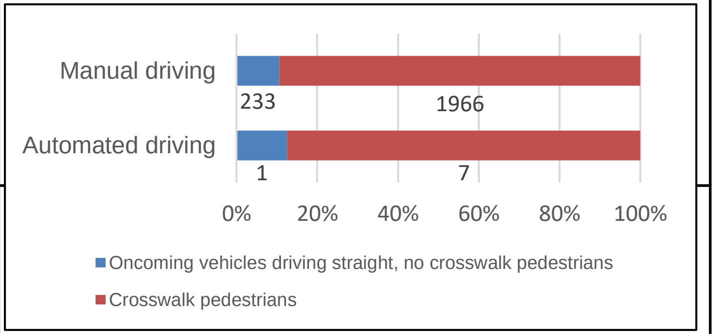
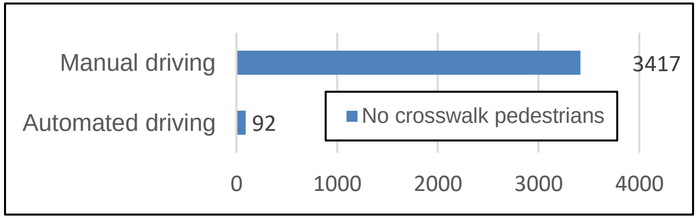
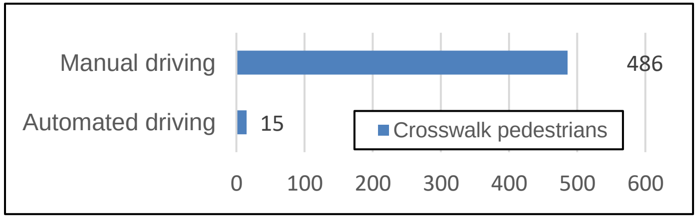
→ Vehicle behavior data is collected but individual vehicle evaluations are not performed

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

■ The following number of samples were collected for five intersections and five routes during the first intensive driving period (October 26 to November 6, 2020)

- Manual driving: The number of samples necessary for evaluation and analysis were collected from ordinary vehicles.
- Automated driving: Evaluation and analysis were performed taking into consideration the fact that the number of samples was low compared to the number of samples from manual driving

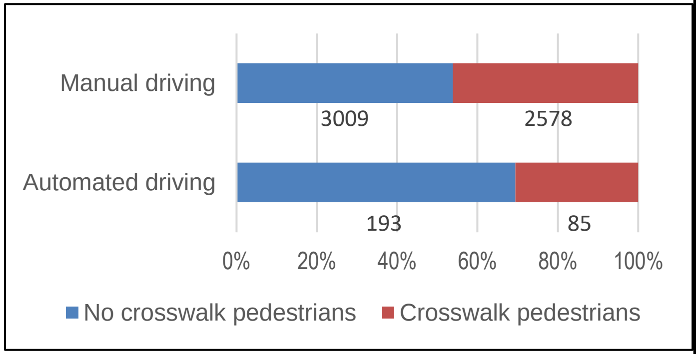
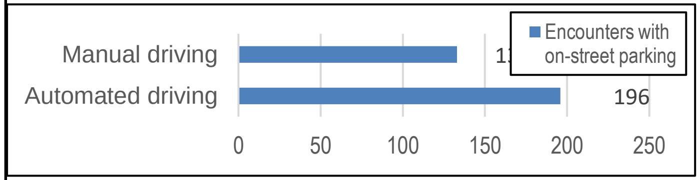
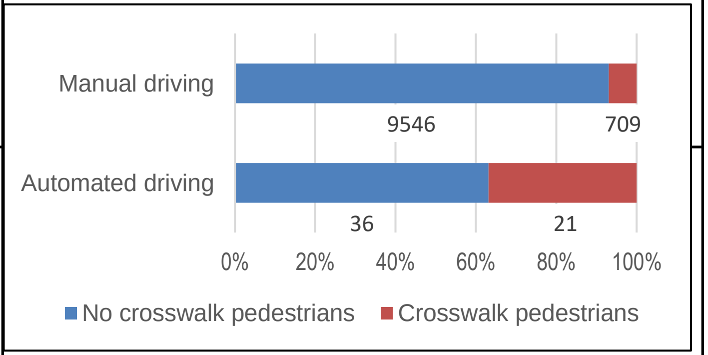
Intersection/route		Situation	Evaluation item	No. of samples acquired
(26) Tokyo Big Sight-mae (right turn)		No crosswalk pedestrians present. Oncoming vehicles driving straight present.	Gap acceptance evaluation(*1)	
		Crosswalk pedestrians present.	Evaluation of impact on crosswalk pedestrians	
(c) Ariake Coliseum East (right turn)		No crosswalk pedestrians present. * Separate signals for right turns and straight traffic	Evaluation of processing when turning right	
(A) Aomi 2-chome (driving straight)		Crosswalk pedestrians present.	Evaluation of impact on crosswalk pedestrians	

*1: The number of inflow gap samples was tabulated

* Definition of “inflow gap”: Only gaps in which vehicles turning right passed between oncoming vehicles driving straight forward, and only when those gaps were 15 seconds or less in duration

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

<table>
<tr><th colspan="2">Intersection/route</th><th>Situation</th><th>Evaluation item</th><th>No. of samples acquired</th></tr>
<tr><td rowspan="3">(10) Telecom Center-mae (left turn)</td><td rowspan="3">
</td><td>No crosswalk pedestrians present.</td><td>Evaluation of processing when turning left</td><td rowspan="2">
</td></tr>
<tr><td>Crosswalk pedestrians present.</td><td>Evaluation of impact on crosswalk pedestrians</td></tr>
<tr><td>Vehicles parked on the street(*1, *2)</td><td>Evaluation of handling of on-street parking</td><td>
</td></tr>
<tr><td rowspan="2">(25) Aomi 1-chome (left turn)</td><td rowspan="2">
</td><td>No crosswalk pedestrians present.</td><td>Evaluation of processing when turning left</td><td rowspan="2">
</td></tr>
<tr><td>Crosswalk pedestrians present.</td><td>Evaluation of impact on crosswalk pedestrians</td></tr>
</table>

*1: The evaluation of the handling of on-street parking can be performed whether or not crosswalk pedestrians are present, so a separate diagram was used

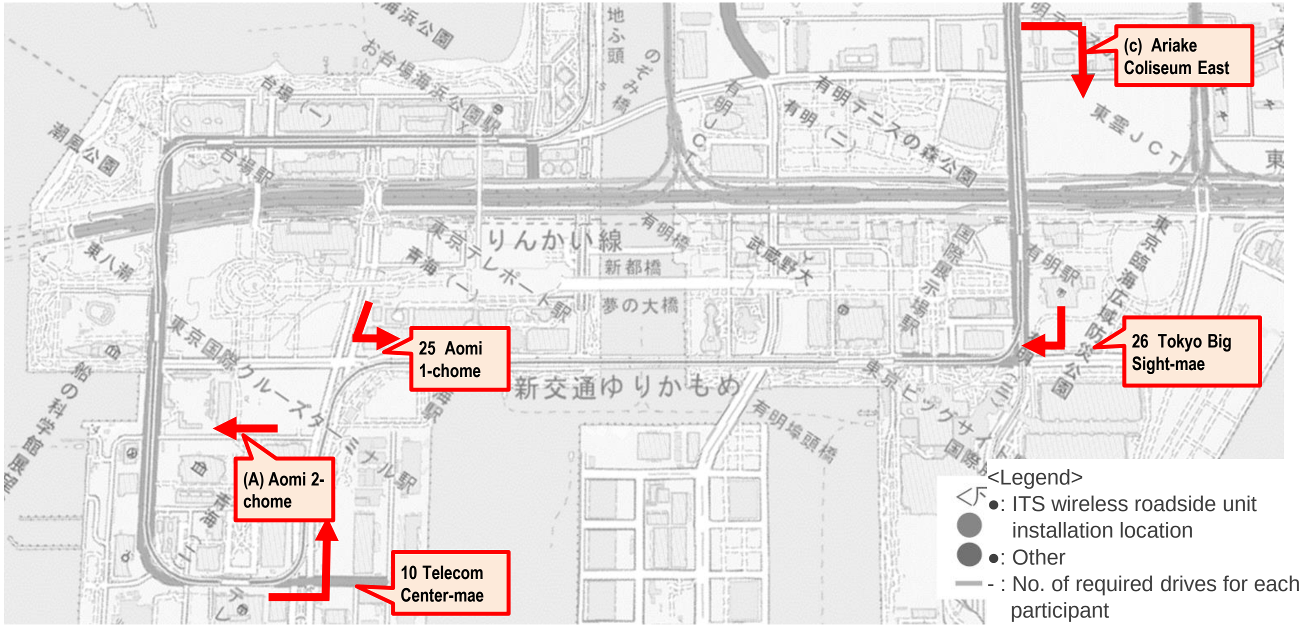
*2: Evaluation was performed using a number of manual driving samples close to the number of automated driving samples.

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

■ Status of data collection

- Data submitted by participants was tabulated and the following **numbers of automated driving samples** were collected for the locations of the fixed-point cameras installed in October and November
  - Period (intensive driving period): Oct. 26 to Nov. 6, 2020
  - Submission method: Intersection traversal samples were extracted by the visualization system



First intensive driving period (Oct. 26 to Nov. 6)

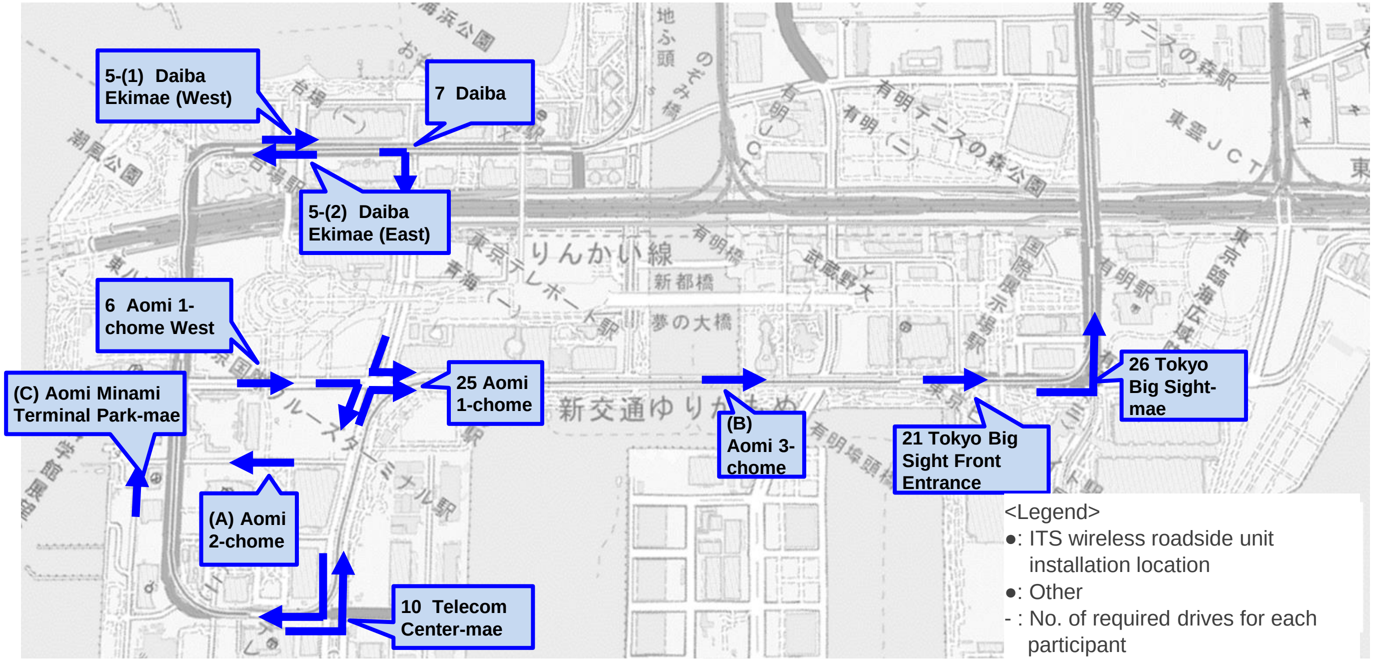
Intersec-tion no.	Name of intersection	Direction	Automated driving samples
10	Telecom Center-mae	Left turn	205
25	Aomi 1-chome	Left turn	62
26	Tokyo Big Sight-mae	Right turn	8
(c)	Ariake Coliseum East	Right turn	92
(A)	Aomi 2-chome	Forward	57

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

■ Status of data collection

- Data submitted by participants was tabulated and the following **numbers of automated driving samples** were collected for the locations of the fixed-point cameras installed in February
  - ➢ Period (intensive driving period): Feb. 8 to Feb. 19, 2021
  - ➢ Submission method: Intersection traversal samples were extracted by the visualization system



Second intensive driving period (Feb. 8 to Feb. 19, 2021)

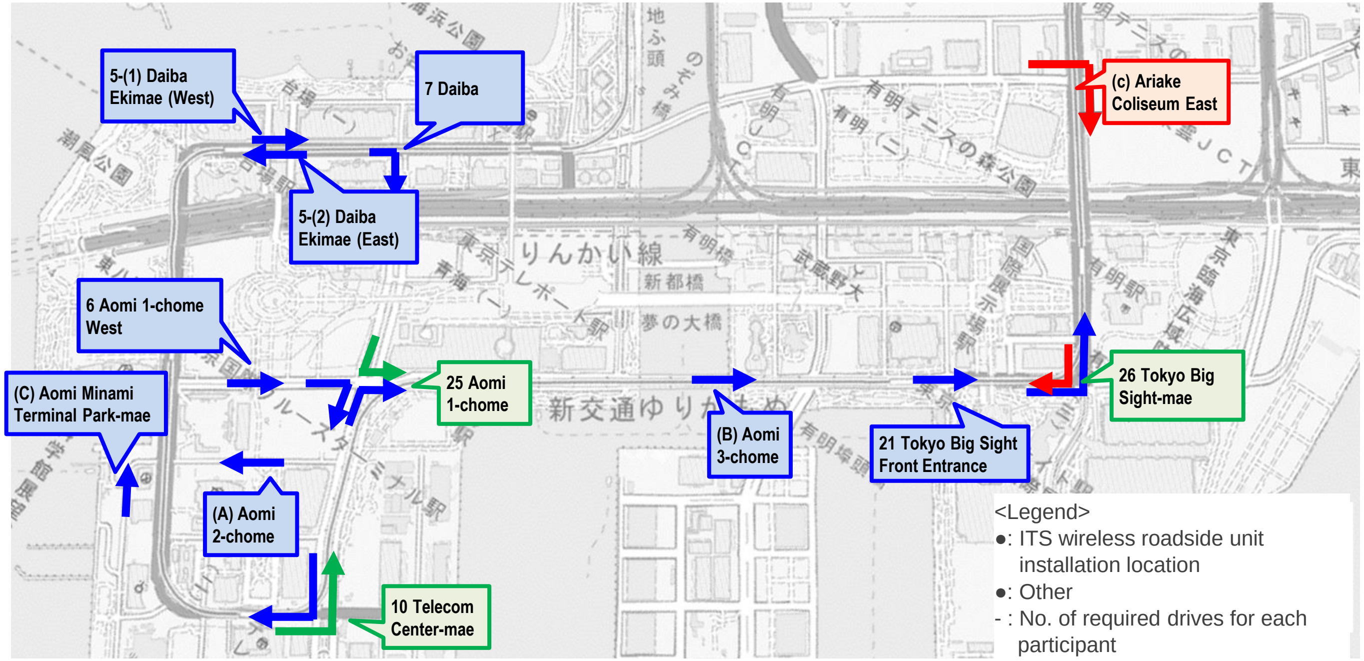
Intersec-tion no.	Name of intersection	Direc-tion	Automated driving samples
5-(1)	Daiba Ekimae (West)	Forward	0
5-(2)	Daiba Ekimae (East)	Forward	43
6	Aomi 1-chome West	Forward	20
7	Daiba	Right turn	0
10	Telecom Center-mae	Left turn	121
10	Telecom Center-mae	Right turn	16
21	Tokyo Big Sight Front Entrance	Forward	37
25	Aomi 1-chome	Left turn	0
25	Aomi 1-chome	Right turn (2→1)	44
25	Aomi 1-chome	Right turn (3→1)	0
26	Tokyo Big Sight-mae	Left turn	37
(A)	Aomi 2-chome	Forward	36
(B)	Aomi 3-chome	Forward	73
(C)	Aomi Minami Terminal Park-mae	Forward	0

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

■ Status of data collection

- Data submitted by participants was tabulated and the following **numbers of automated driving samples** were collected for the locations of the fixed-point cameras installed in October, November, and February
  - ➢ Period (intensive driving period): Oct. 26 to Nov. 6, 2020, and Feb. 8 to Feb. 19, 2021
  - ➢ Submission method: Intersection traversal samples were extracted by the visualization system



Fixed point cameras installed from October 26 to November 6

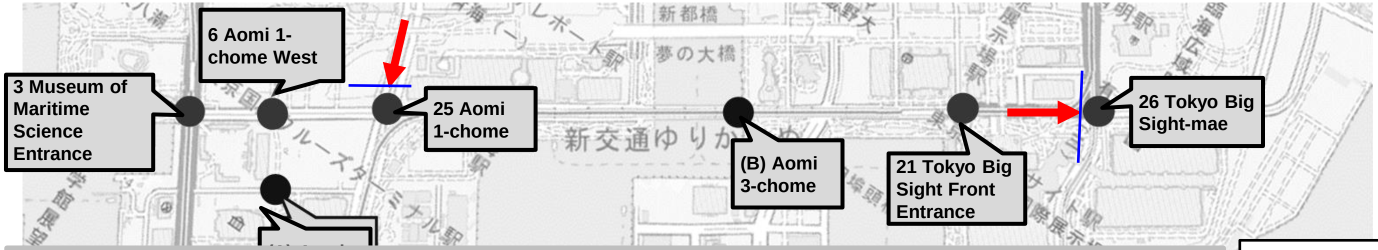
Fixed point cameras installed from February 8 to February 19

Fixed point cameras installed From October 26 to November 6 and from February 8 to February 19

Intersection no.	Name of intersection	Direction	Automated driving samples
5-(1)	Daiba Ekimae (West)	Forward	0
5-(2)	Daiba Ekimae (East)	Forward	43
6	Aomi 1-chome West	Forward	20
7	Daiba	Right turn	0
10	Telecom Center-mae	Left turn	326
10	Telecom Center-mae	Right turn	16
21	Tokyo Big Sight Front Entrance	Forward	37
25	Aomi 1-chome	Left turn	62
25	Aomi 1-chome	Right turn (2→1)	44
25	Aomi 1-chome	Right turn (3→1)	0
26	Tokyo Big Sight-mae	Left turn	37
26	Tokyo Big Sight-mae	Right turn	8
(c)	Ariake Coliseum East	Right turn	92
(A)	Aomi 2-chome	Forward	93
(B)	Aomi 3-chome	Forward	73
(C)	Aomi Minami Terminal Park-mae	Forward	0

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved (Adjustment based on changes in traffic volume before and during COVID-19)

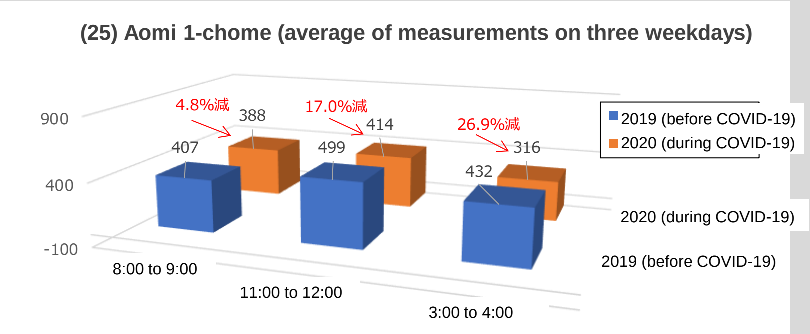


* Confirmation cross-sections: (25) Aomi 1-chome (south) and (26) Tokyo Big Sight-mae (east)
* Measurement dates: Nov. 28, Nov. 29, and Dec. 3, 2019, Oct. 27, Oct. 29, and Nov. 5, 2020 * rainy dates excluded
* Times of day: Counted all cross section vehicles from 8:00 a.m. to 9:00 a.m., 11:00 a.m. to 12:00 p.m., and 3:00 p.m. to 4:00 p.m.
* Measurement method: Automatic detection using image processing AI

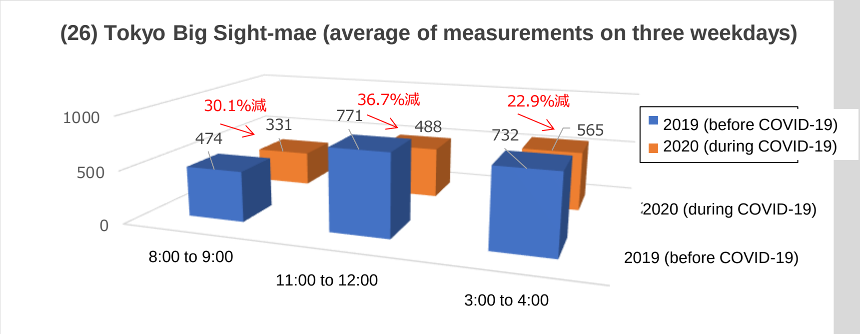
Measured route
Reference line

Through observation of traffic volume on three weekdays at selected measurement times, it was confirmed that overall traffic volume decreased

(25) Aomi 1-chome (average of measurements on three weekdays)



(26) Tokyo Big Sight-mae (average of measurements on three weekdays)




2019 (expanded view)

Average 16.2% decrease


2020 (expanded view)


2019 (expanded view)

Average 29.9% decrease


2020 (expanded view)

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved (Adjustment based on changes in traffic volume before and during COVID-19)

(25) Aomi 1-chome

2019

Date	Time of day	Traffic volume (vehicles/hour)				
		Total no.	Large vehicles	Mix (%)	Ordinary vehicles	Mix (%)
11/28(Thu.)	8:00 to 9:00	**384**	125	32.6%	259	67.4%
	11:00 to12:00	**516**	211	40.9%	305	59.1%
	15:00 to16:00	**416**	150	36.1%	266	63.9%
11/29(Fri.)	8:00 to 9:00	**415**	148	35.7%	267	64.3%
	11:00 to12:00	**478**	179	37.4%	299	62.6%
	15:00 to16:00	**414**	142	34.3%	272	65.7%
12/3(Tue.)	8:00 to 9:00	**422**	136	32.2%	286	67.8%
	11:00 to12:00	**502**	227	45.2%	275	54.8%
	15:00 to16:00	**465**	153	32.9%	312	67.1%
Three day average	8:00 to 9:00	**407**	136	33.5%	271	66.5%
	11:00 to12:00	**499**	206	41.2%	293	58.8%
	15:00 to16:00	**432**	148	34.4%	283	65.6%

2020

Date	Time of day	Traffic volume (vehicles/hour)				
		Total no.	Large vehicles	Mix (%)	Ordinary vehicles	Mix (%)
10/27(Tue.)	8:00 to 9:00	**390**	163	41.8%	227	58.2%
	11:00 to12:00	**391**	196	50.1%	195	49.9%
	15:00 to16:00	**317**	154	48.6%	163	51.4%
10/29(Thu.)	8:00 to 9:00	**366**	173	47.3%	193	52.7%
	11:00 to12:00	**379**	201	53.0%	178	47.0%
	15:00 to16:00	**294**	127	43.2%	167	56.8%
11/ 5 (Tue.)	8:00 to 9:00	**407**	184	45.2%	223	54.8%
	11:00 to12:00	**472**	255	54.0%	217	46.0%
	15:00 to16:00	**336**	187	55.7%	149	44.3%
Three day average	8:00 to 9:00	**388**	173	44.7%	214	55.3%
	11:00 to12:00	**414**	217	52.5%	197	47.5%
	15:00 to16:00	**316**	156	49.4%	160	50.6%

Amount and percentage of decrease

	Difference (vehicles/hour)				Decrease (difference vs. 2019) (%)			
	Time of day	Traffic volume (vehicles/hour)			Time of day	Traffic volume (vehicles/hour)		
		Total no.	Large vehicles	Ordinary vehicles		Total no.	Large vehicles	Ordinary vehicles
2020 to 2019	8:00 to 9:00	**-19**	37	-56	8:00 to 9:00	**4.8%**	-27.1%	20.8%
	11:00 to12:00	**-85**	12	-96	11:00 to12:00	**17.0%**	-5.7%	32.9%
	15:00 to16:00	**-116**	8	-124	15:00 to16:00	**26.9%**	-5.2%	43.6%

(26) Tokyo Big Sight-mae

2019

Date	Time of day	Traffic volume (vehicles/hour)				
		Total no.	Large vehicles	Mix (%)	Ordinary vehicles	Mix (%)
11/28(Thu.)	8:00 to 9:00	**442**	333	75.3%	109	24.7%
	11:00 to12:00	**701**	339	48.4%	362	51.6%
	15:00 to16:00	**781**	297	38.0%	484	62.0%
11/29(Fri.)	8:00 to 9:00	**510**	254	49.8%	256	50.2%
	11:00 to12:00	**904**	486	53.8%	418	46.2%
	15:00 to16:00	**852**	397	46.6%	455	53.4%
12/3(Tue.)	8:00 to 9:00	**470**	212	45.1%	258	54.9%
	11:00 to12:00	**707**	370	52.3%	337	47.7%
	15:00 to16:00	**563**	288	51.2%	275	48.8%
Three day average	8:00 to 9:00	**474**	266	56.2%	208	43.8%
	11:00 to12:00	**771**	398	51.7%	372	48.3%
	15:00 to16:00	**732**	327	44.7%	405	55.3%

2020

Date	Time of day	Traffic volume (vehicles/hour)				
		Total no.	Large vehicles	Mix (%)	Ordinary vehicles	Mix (%)
10/27(Tue.)	8:00 to 9:00	**357**	185	51.8%	172	48.2%
	11:00 to12:00	**521**	293	56.2%	228	43.8%
	15:00 to16:00	**607**	334	55.0%	273	45.0%
10/29(Thu.)	8:00 to 9:00	**325**	180	55.4%	145	44.6%
	11:00 to12:00	**466**	275	59.0%	191	41.0%
	15:00 to16:00	**619**	305	49.3%	314	50.7%
11/ 5 (Tue.)	8:00 to 9:00	**312**	160	51.3%	152	48.7%
	11:00 to12:00	**477**	279	58.5%	198	41.5%
	15:00 to16:00	**468**	267	57.1%	201	42.9%
Three day average	8:00 to 9:00	**331**	175	52.8%	156	47.2%
	11:00 to12:00	**488**	282	57.9%	206	42.1%
	15:00 to16:00	**565**	302	53.5%	263	46.5%

Amount and percentage of decrease

	Difference (vehicles/hour)				Decrease (difference vs. 2019) (%)			
		Traffic volume (vehicles/hour)			Time of day	Traffic volume (vehicles/hour)		
		Total no.	Large vehicles	Ordinary vehicles		Total no.	Large vehicles	Ordinary vehicles
2020 to 2019	8:00 to 9:00	**-143**	-91	-51	8:00 to 9:00	**30.1%**	34.3%	24.7%
	11:00 to12:00	**-283**	-116	-167	11:00 to12:00	**36.7%**	29.1%	44.8%
	15:00 to16:00	**-167**	-25	-142	15:00 to16:00	**22.9%**	7.7%	35.1%

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

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

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved (Adjustment based on changes in traffic volume before and during COVID-19)

1) Evaluation items: Changes in left turn processing time resulting from the presence of autonomous vehicles (no crosswalk pedestrians)

- Areas of focus: (a) Does the presence of autonomous vehicles in traffic affect processing time?
  (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: (25) Aomi 1-chome - left turn(※2)

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

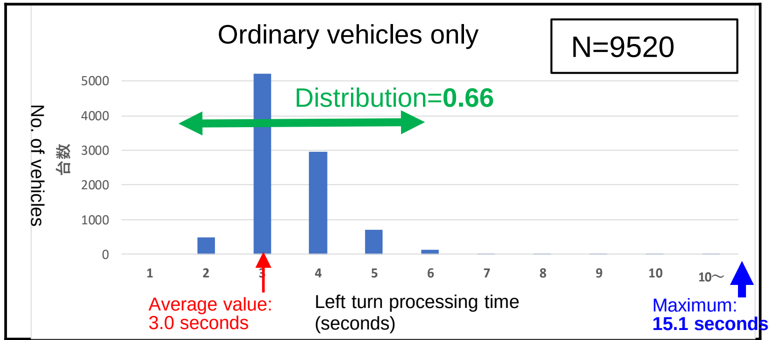
- The average processing times for ordinary vehicles was low, but the maximum values were high.
- When there are autonomous vehicles in traffic, average processing times, including the behavior of following vehicles, tends to be longer (but the maximum values are stable).

3) Observations and future prospects

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


(25) Aomi 1-chome - left turn

Reference line

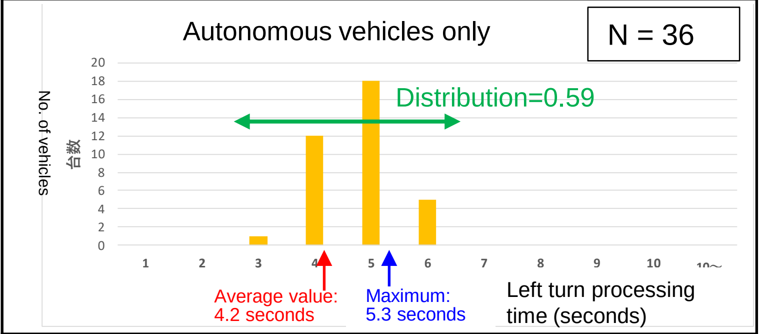

Ordinary vehicles only

N=9520

Distribution=**0.66**

Average value: 3.0 seconds

Maximum: **15.1 seconds**

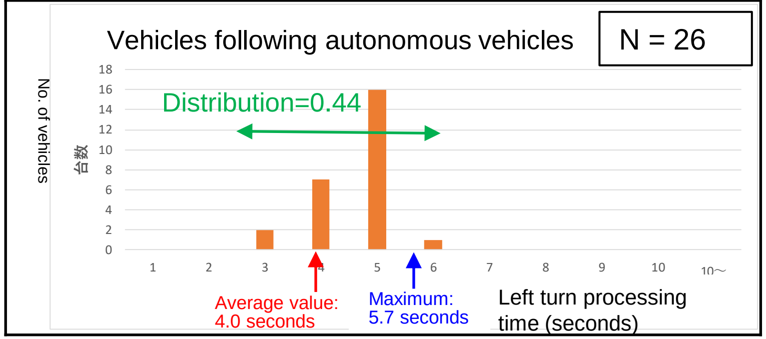

Autonomous vehicles only

N = 36

Distribution=0.59

Average value: 4.2 seconds

Maximum: 5.3 seconds


Vehicles following autonomous vehicles

N = 26

Distribution=0.44

Average value: 4.0 seconds

Maximum: 5.7 seconds

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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 autonomous vehicles
(no crosswalk pedestrians or oncoming vehicles driving straight forward)

- Areas of focus: (a) Does the processing time change for the autonomous 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

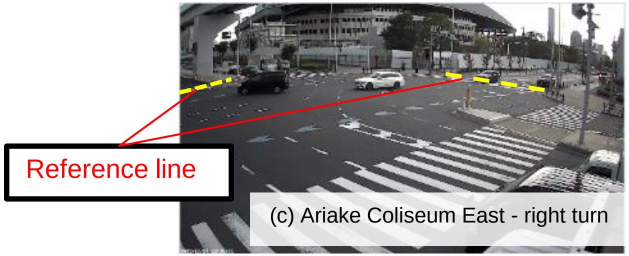
2)Results: Target intersection: (c) Ariake Coliseum East - right turn(*2)

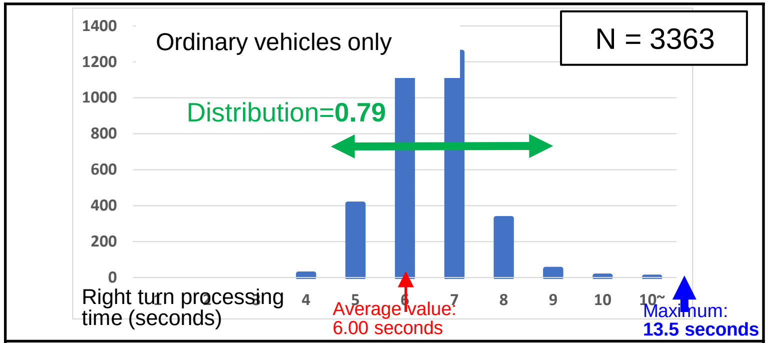
*2: All of the vehicles following the autonomous vehicle at this intersection were ordinary vehicles (not involved in the testing)

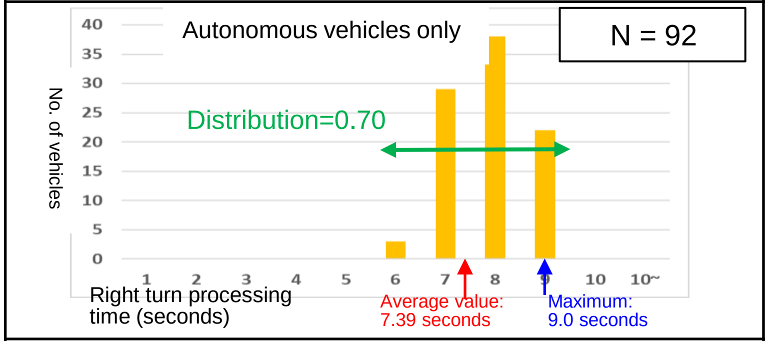
- The average processing times for ordinary vehicles was low, but the maximum values were high.
- Average processing times were high for autonomous vehicles and nearby vehicles (following vehicle), but maximum values were low. There was also little variation for nearby vehicles.

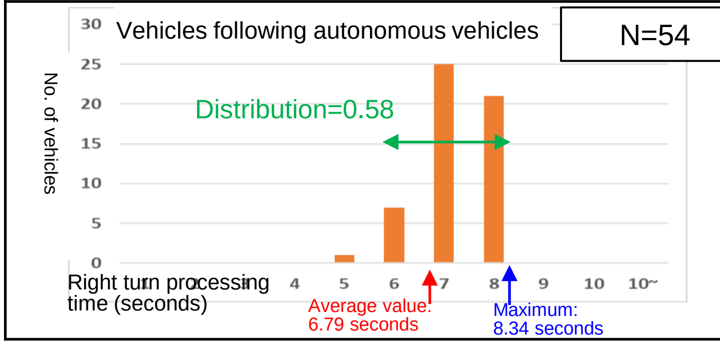
3)Observations and future prospects

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









4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

1)Evaluation items: Changes in behavior of surrounding vehicles when driving straight (sudden braking, cutting in, etc.) resulting from the presence of autonomous vehicles

- Areas of focus:
  - ➢ Changes in behavior when sudden braking and cutting in occurred
  - ➢ What were the causes of sudden braking and cutting in?
- Evaluation method:

  Analyze the causes of phenomena based on data from evaluation vehicle drive recorder video and movement management data

2)Results

- We focused on sudden deceleration (0.35G or greater), which can trigger changes in the behavior of nearby vehicles, and performed individual analysis (details are shown below)

  → The causes of sudden deceleration were analyzed based on drive recorder data (141 automated driving situations and 73 manual driving situations).

3)Observations and future prospects

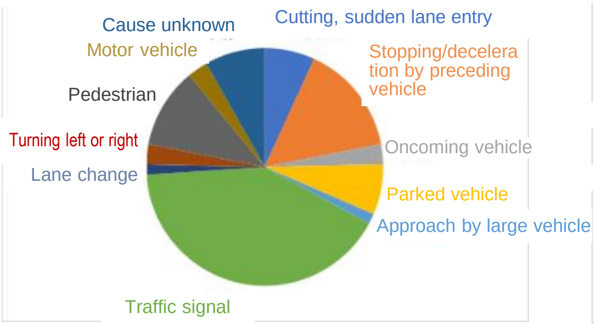
- We confirmed that the causes of sudden deceleration differed for automated driving and manual driving.

  → Autonomous vehicles were confirmed as often being influenced by the vehicles in front of them

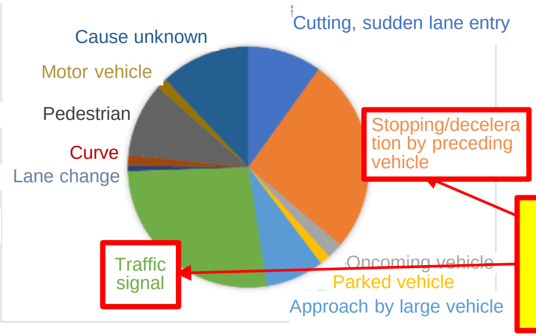
  → Analysis confirmed the risk of following vehicle behavior being affected by sudden braking by autonomous vehicles

  ➡ This suggests that the support provided by cooperative infrastructure is highly important

Manual driving - Causes of sudden deceleration



Automated driving - Causes of sudden deceleration



Case of sudden deceleration

Situations in which sudden deceleration occurs due to preceding vehicles stopping or traffic signals changing

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

■ Sudden braking when approaching a large vehicle in the right turn lane

ID: 23955

* In preparation to turn right, the test vehicle followed the large vehicle in the second lane.
The test vehicle entered the right turn lane and rapidly approached the stopped large vehicle. Rapid braking and stop

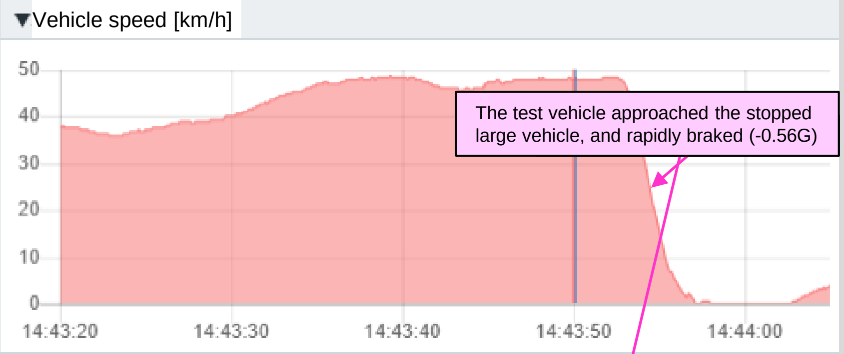
The test vehicle followed the large vehicle in the second lane at the legal speed (approx. 50 km/h). The preceding vehicle drove straight through the intersection.

The test vehicle entered the right turn lane, rapidly approached the stopped large vehicle, and rapidly braked (-0.56G)

When the right turn arrow turned green, driving resumed (the vehicle stopped without passing through during a single signal cycle), and there was no impact on following vehicles.

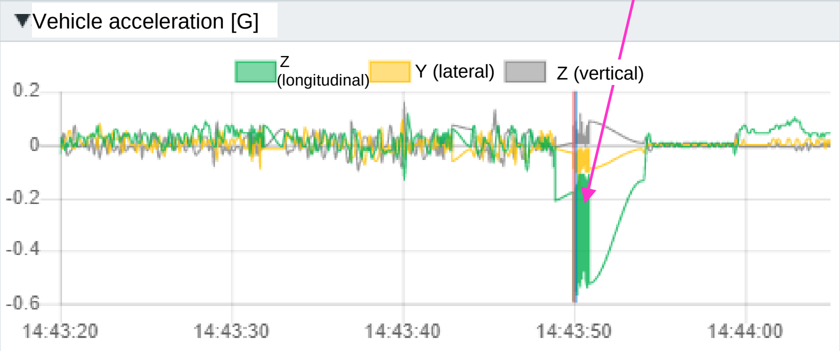
Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing

▼Vehicle speed [km/h]



The test vehicle approached the stopped large vehicle, and rapidly braked (-0.56G)

▼Vehicle acceleration [G]



Analysis: When the vehicle in front of a test vehicle is a large vehicle, it makes it difficult to determine conditions in front of the vehicle (traffic signal status, right turn queue, etc.), which results in rapid braking.

* The preceding vehicle drove straight, so it approached the intersection without reducing its speed. The test vehicle rapidly approached the large vehicle at the back of the queue without first assessing the traffic signal status or right turn queue, so it suddenly decelerated.

* If traffic signal information, right turn queue information, or similar information had been provided by the infrastructure, the test vehicle might have been able to decelerate appropriately, even behind the large vehicle, and avoid sudden braking.

4. Results of the Impact assessment

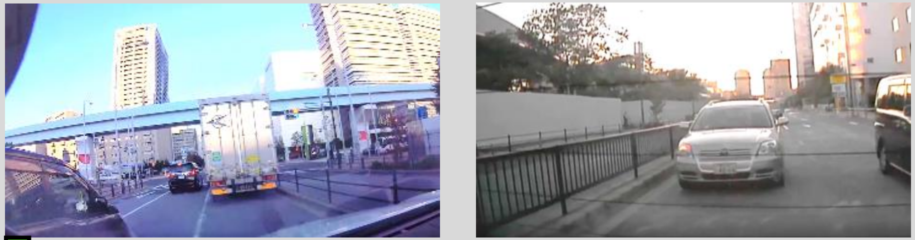
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

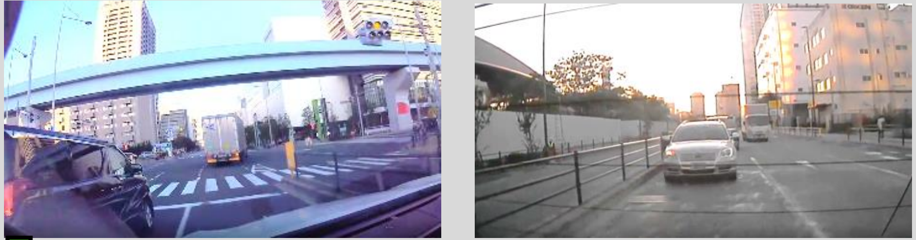
■ **Behavior of automated driving when the traffic signal changes when driving straight forward, etc. (right turn)**

ID: 16161

* Case of an autonomous 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 autonomous vehicle in front of it stopped, resulting in the risk of a rear-end collision



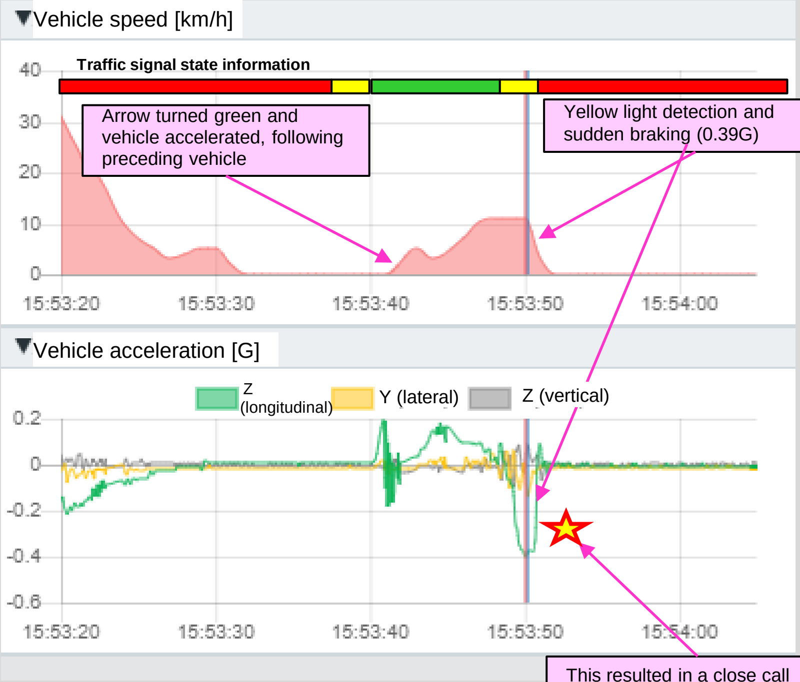
A group of cars was waiting to turn right. The right turn traffic signal turned green and vehicles accelerated (following timing was somewhat slow). Following vehicles also lined up.



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.

Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing



Arrow turned green and vehicle accelerated, following preceding vehicle

Yellow light detection and sudden braking (0.39G)

This resulted in a close call involving the following vehicle

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. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking

1)Evaluation items: Changes in behavior of nearby vehicles in areas with vehicles parked on the street resulting from the presence of autonomous vehicles

- Areas of focus:
  - Behavior of following vehicles, etc., after changes to behavior to avoid vehicles parked on the street
    (Does this behavior cause congestion or conflict? Are there changes to close calls? etc.)
- Evaluation method:
  - Confirm behavior of vehicles when encountering vehicles parked on the street
  - Analyze impact on behavior of nearby vehicles
  - Focused on case of a vehicle entering the first lane

(10) Telecom Center-mae - left turn

[Confirmation of vehicle behavior and items used in analysis separately of impact on nearby vehicles]

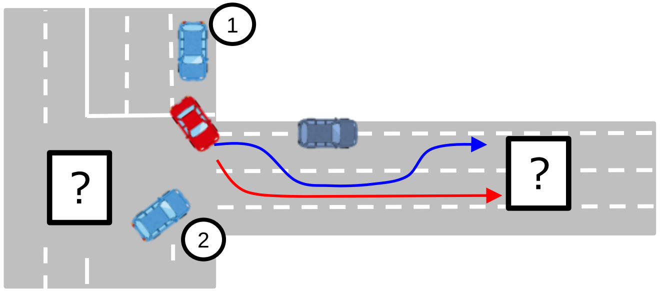
With avoidance		
1-1-1	Avoidance (no deceleration)	Congestion
1-1-2		No congestion
1-2-1	Avoidance (with deceleration)	Congestion
1-2-2		No congestion
1-3-1	Deceleration, switch to manual driving, and avoidance	Congestion
1-3-2		No congestion
1-4	No nearby vehicles present	-

Automated driving and manual driving were evaluated

No avoidance		
2-1	--	No congestion
2-2	--	Congestion
2-3	No nearby vehicles present	-

* [Congestion] : Congestion involving following vehicles (including oncoming vehicles turning right) (refer to (1) and (2) below)

[Cause analysis (visual depiction of vehicle trajectory)]



[Legend]
🟥 Autonomous vehicle
▨ Vehicle parked on the street
🟦 Ordinary vehicle

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

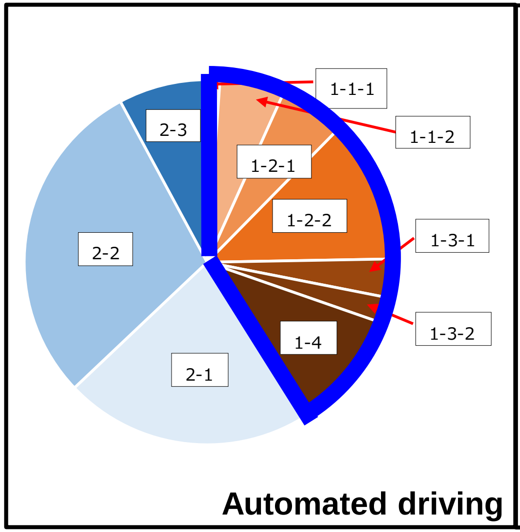
A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking

2) Results: Target Intersections (10) Telecom Center-mae - left turn

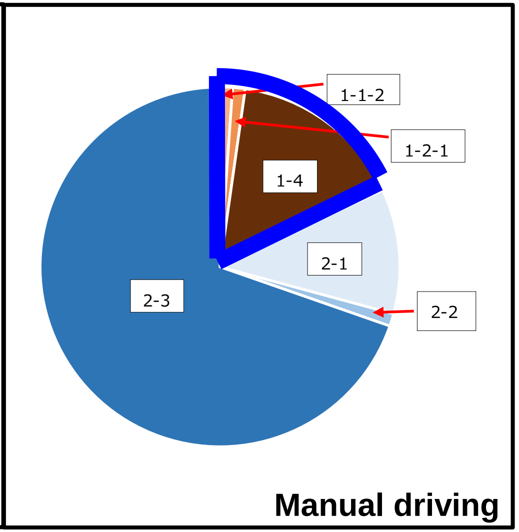
- There were cases of autonomous vehicles decelerating or stopping during avoidance, but similar cases were also observed for manually driven vehicles
- For autonomous vehicles, there were also confirmed cases of switchover to manual driving and risk avoidance
- For both autonomous vehicles and manually driven vehicles, there were confirmed cases of congestion involving nearby vehicles

3) Observations and future prospects

- There were confirmed cases of similar avoidance behavior by autonomous vehicles and ordinary vehicles when encountering vehicles parked on the street
- Although there were cases of autonomous vehicles being switched to manual driving to avoid risks, the evaluations received so far show little difference between driving in mixed transportation environments and driving in environments consisting of ordinary vehicles only



Automated driving



Manual driving

With avoidance			Automated Driving	Manual Driving
1-1-1	Avoidance (no deceleration)	Congestion	1	0
1-1-2		No congestion	5	1
1-2-1	Avoidance (with deceleration)	Congestion	5	1
1-2-2		No congestion	11	0
1-3-1	Deceleration, switch to manual driving, and avoidance	Congestion	3	0
1-3-2		No congestion	2	0
1-4	No nearby vehicles present	-	9	14
	Total		36	16

No avoidance			Automated Driving	Manual Driving
2-1	―	No congestion	20	10
2-2	―	Congestion	26	1
2-3	No nearby vehicles present	-	7	62
	Total		53	73

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

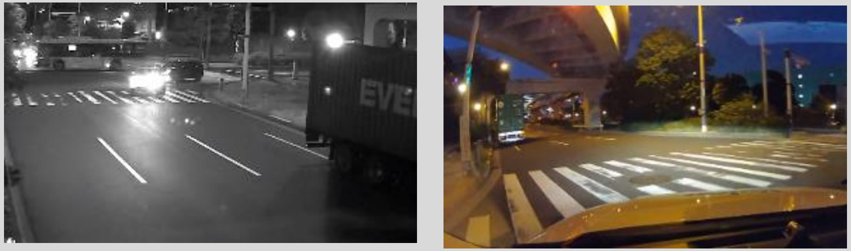
A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking


Vehicle travel route

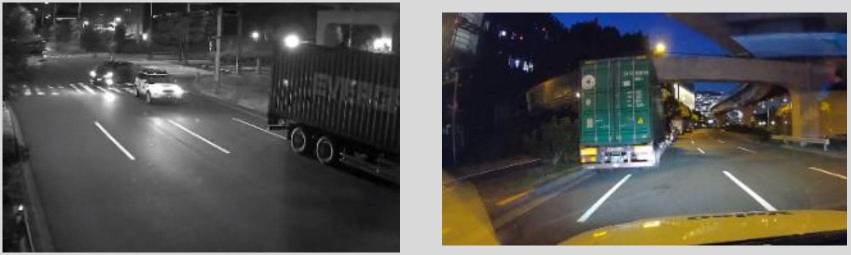
■ **Behavior of autonomous vehicles when turning left and encountering vehicles parked on the street**(1/X)

* Case of a test vehicle encountering a vehicle parked on the street after turning left at an intersection.
The test vehicle slowed down and was passed by the vehicle following it.

ID: 16078



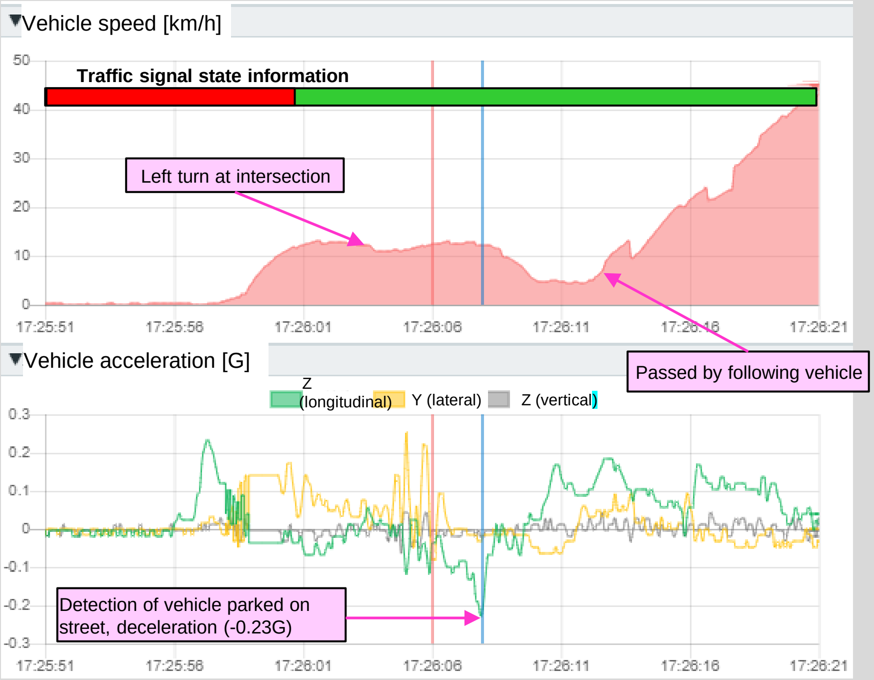
Turning left at an intersection.



After the vehicle turned left, it detected a vehicle parked on the street and decelerated.

After decelerating, it was passed by the vehicle that was following it.

Autonomous vehicle attributes: Passenger vehicle | No cooperative infrastructure use | Image processing


▼Vehicle speed [km/h]

Traffic signal state information

Left turn at intersection

Passed by following vehicle

▼Vehicle acceleration [G]

Detection of vehicle parked on street, deceleration (-0.23G)

Analysis: When the test vehicle encountered a vehicle parked on the street, it decelerated to avoid it. When it did so, it was passed by the vehicle behind it (this same situation often occurs with ordinary vehicles as well)

* This suggests the importance of assessing the surrounding environment

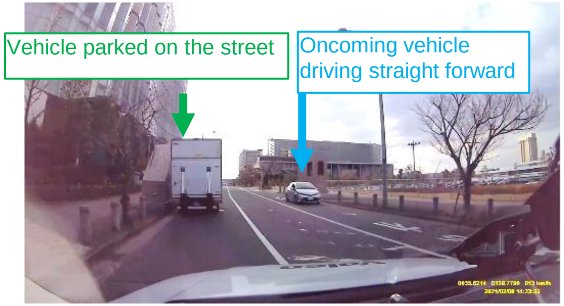
4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking

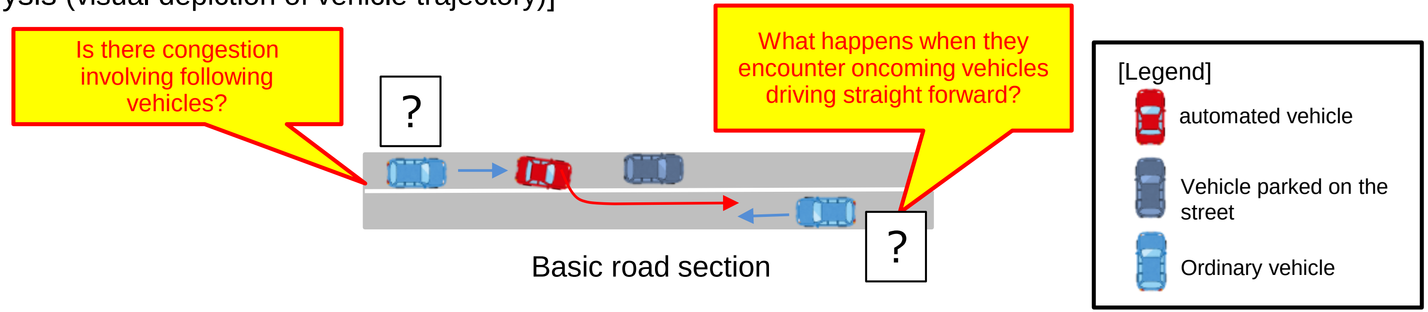
1) Evaluation items: Changes in behavior of nearby vehicles in areas with vehicles parked on the street resulting from the presence of automated vehicles

- Areas of focus:
  - ➢ Behavior of following vehicles, etc., after changes to behavior to avoid vehicles parked on the street
    (Does this behavior cause congestion or conflict? Are there changes to close calls? etc.)
- Evaluation method:
  - ➢ Confirm behavior of vehicles when encountering vehicles parked on the street
    (a) Do the vehicles engage in avoidance behavior?
    (b) Do the vehicles decelerate?
    (c) Do the vehicles suddenly decelerate or suddenly turn (to the right)?
  - ➢ Analyze impact on surrounding vehicles (following vehicles, oncoming vehicles driving straight forward)
    (a) Is there congestion involving following vehicles?
    (b) How do the vehicles behave when encountering oncoming vehicles driving straight forward?
    (Do they wait for the oncoming vehicles driving straight forward to pass before driving? Are there close calls?)



(A) Aomi 2-chome - driving straight

[Cause analysis (visual depiction of vehicle trajectory)]



Basic road section

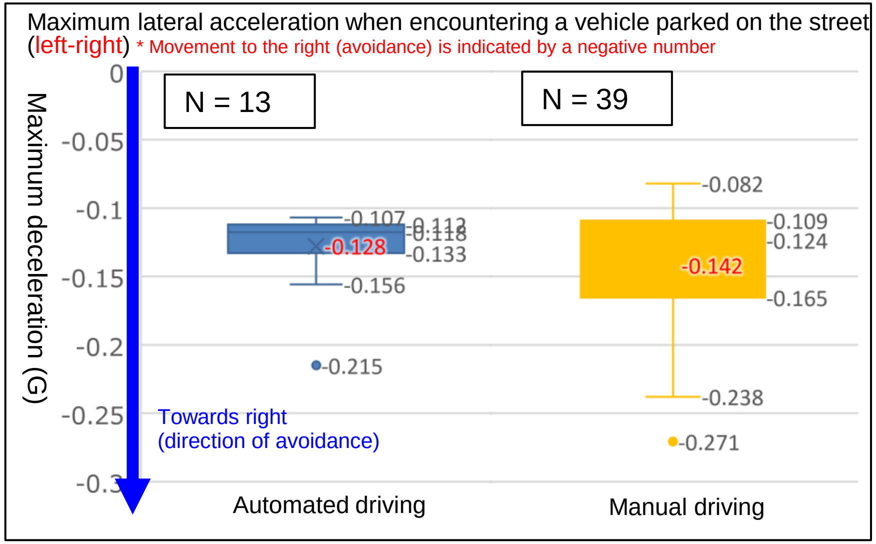
4. Results of the Impact assessment

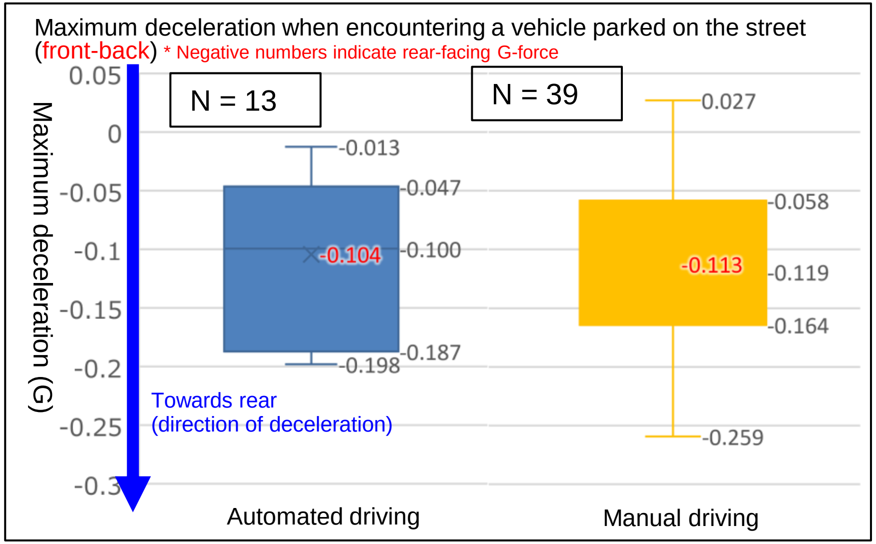
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking

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

- We confirmed that when encountering a vehicle parked on the street, the maximum deceleration to the right (lateral G-force, produced by avoiding the parked vehicle) was less for automated vehicles than for manually driven vehicles
  → When approaching an oncoming vehicle driving straight forward, the automated vehicles consistently decelerated and engaged in smooth avoidance behavior
- The maximum deceleration (braking G-force) when encountering a vehicle parked on the street was equivalent for automated vehicles and manually driven vehicles
  → There were two cases in which there were following vehicles. Of these, one case resulted in congestion involving the following vehicle.


Maximum lateral acceleration when encountering a vehicle parked on the street (left-right) * Movement to the right (avoidance) is indicated by a negative number


Maximum deceleration when encountering a vehicle parked on the street (front-back) * Negative numbers indicate rear-facing G-force

3) Observations and future prospects

- We confirmed that when automated vehicles encountered vehicles parked on the street, the automated vehicles engaged in safe avoidance behavior
- There were no close call situations involving oncoming vehicles driving straight forward, which indicates that autonomous driving may be suitable in mixed transportation environments as well
- There was one case of congestion involving a following vehicle, so consideration must be given to the impact on following vehicles

4. Results of the Impact assessment

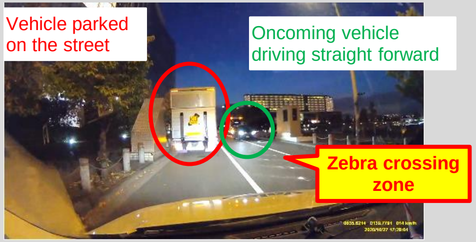
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

A) Impact on surrounding environment (driving space)　(iv) Evaluation of handling of on-street parking

■ Behavior of automated vehicles when encountering vehicles parked on the street

* We confirmed that when automated vehicles encounter vehicles parked on the street, they wait for oncoming vehicles driving straight forward to pass before driving* Areas with zebra crossing zones

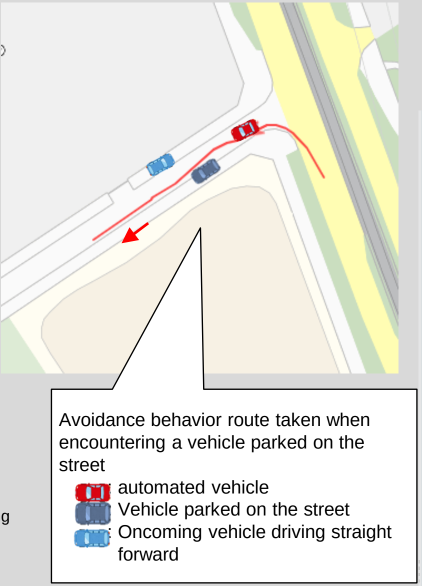
ID: 15910



There was an oncoming vehicle driving straight forward when the test vehicle encountered a vehicle parked on the street.

The test vehicle decelerated to wait for the oncoming vehicle driving straight forward to pass.

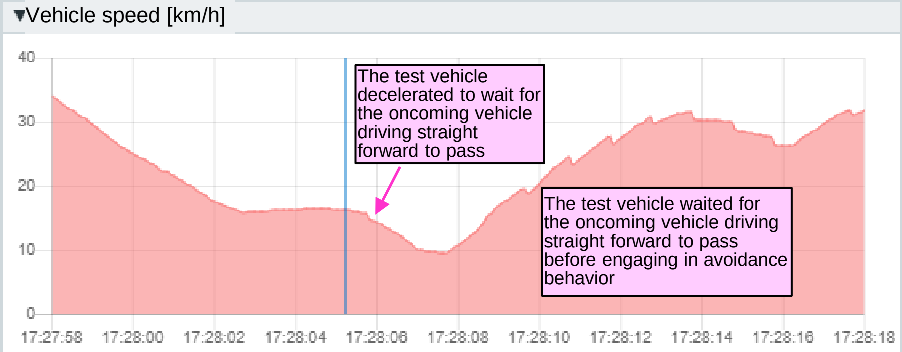
The test vehicle waited for the oncoming vehicle driving straight forward to pass and then engaged in avoidance behavior



Avoidance behavior route taken when encountering a vehicle parked on the street

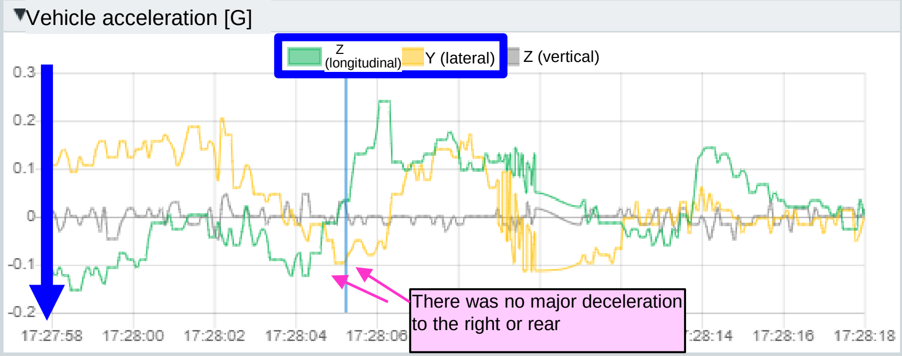
- 🟥 automated vehicle
- ▨ Vehicle parked on the street
- 🟦 Oncoming vehicle driving straight forward

Autonomous vehicle attributes	Passenger vehicle	Cooperative infrastructure used	Image processing



The test vehicle decelerated to wait for the oncoming vehicle driving straight forward to pass

The test vehicle waited for the oncoming vehicle driving straight forward to pass before engaging in avoidance behavior



There was no major deceleration to the right or rear

Right side (direction of avoidance)

Rear (direction of deceleration)

Analysis: No impact on surrounding vehicles (oncoming vehicles driving straight forward) were observed when test vehicles encountered vehicles parked on the street

* Vehicle acceleration (left-right and front-back) was checked using logs and we confirmed that test vehicles engaged in the same avoidance behavior as manually driven vehicles

* Test vehicles engaged in safe driving by waiting for oncoming vehicles driving straight forward to pass before engaging in parked vehicle avoidance behavior

4. Results of the Impact assessment

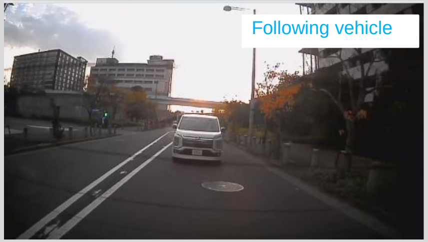
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

A) Impact on surrounding environment (driving space) (iv) Evaluation of handling of on-street parking

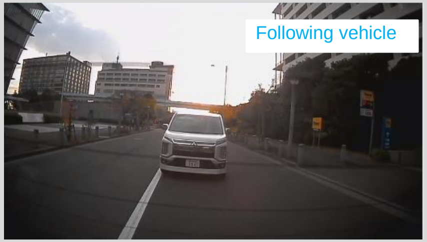
■ **Behavior of automated vehicles when encountering vehicles parked on the street**

ID: 36314

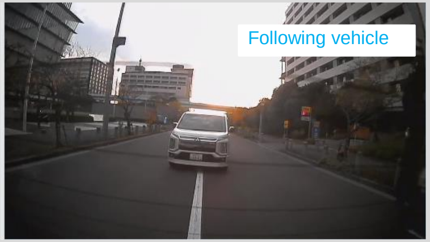
* We confirmed congestion involving a following vehicle when test vehicles engaged in avoidance behavior when encountering a vehicle parked on the street



A following vehicle was present when the test vehicle encountered a vehicle parked on the street

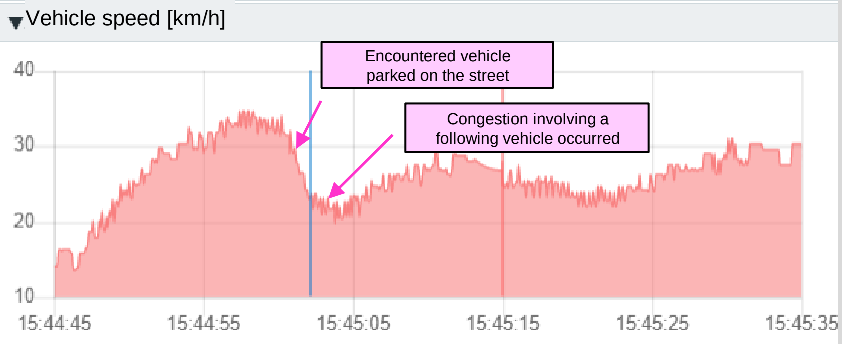


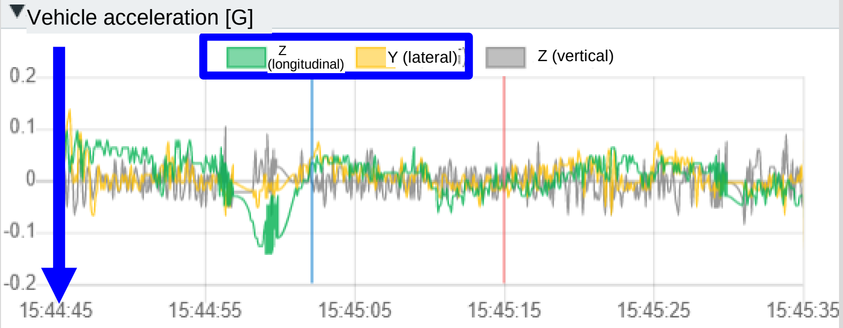
When the test vehicle engaged in avoidance behavior, it caused congestion involving a following vehicle.
The test vehicle began avoidance behavior roughly 30 to 10 meters before reaching the parked vehicle



The test vehicle engaged in avoidance behavior and passed the parked vehicle. There were three parked vehicles in a row, so the test vehicle engaged in avoidance driving for a long distance.

Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure	Image processing





Rear (direction of deceleration), right (direction of avoidance)

Analysis: We confirmed a situation in which congestion involving nearby vehicles (following vehicles) was caused when a test vehicle encountered a vehicle parked on the street

* We confirmed that, as with ordinary vehicles, when automated vehicles encounter vehicles parked on the street, there is a risk of congestion involving following vehicles

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

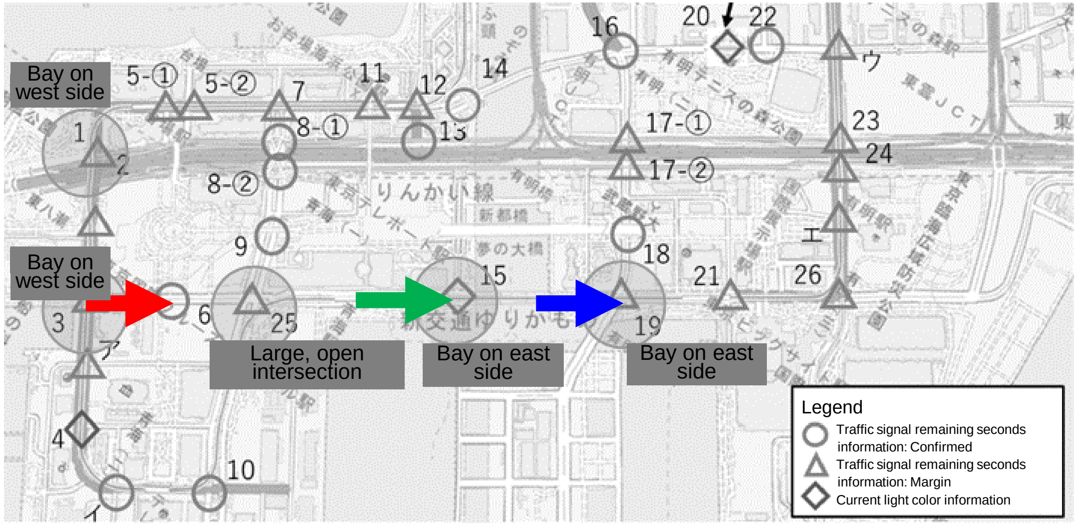
1) Evaluation items: Changes in behavior when stopping at a red light when driving straight

- Areas of focus: (1) Were there any changes to stopping behavior?
  →Focus on speed distribution and maximum deceleration when stopping
  (2) Were there any changes due to the provided infrastructure information?
  →Focus on the absence/presence of current light color information or remaining seconds information (confirmed, w/ margin)
- Evaluation method:
  (1) Behavior when stopping at a red light was extracted from the visualization system data
  (2) The speed distribution and maximum deceleration were evaluated
  (3) To obtain data for intersections at which different infrastructure information is provided, the following intersections were selected
  (The status of participants' traffic signal information usage, driving routes, etc., were also taken into consideration)

[Evaluation intersections]
1. Current light color information only
   →(15) Tokyo Wangan Underpass Exit - Straight

2. Current light color information + traffic signal remaining seconds information (w/ margin)
   →(19) Ferry Terminal Entrance - Straight

3. Current light color information + traffic signal remaining seconds information (confirmed)
   →(6) Aomi 1-chome West - Straight



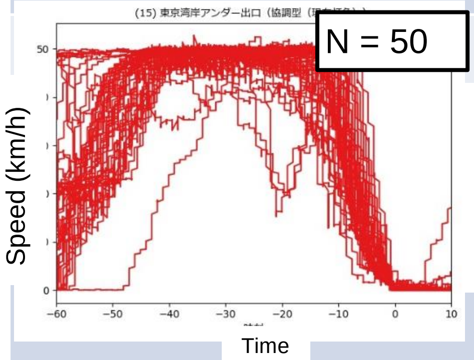
4. Results of the Impact assessment

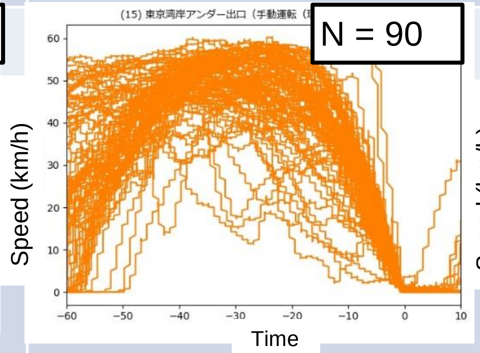
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

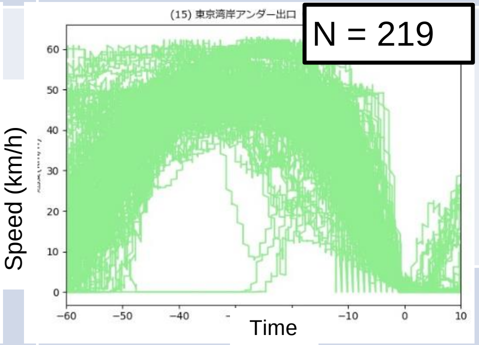
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

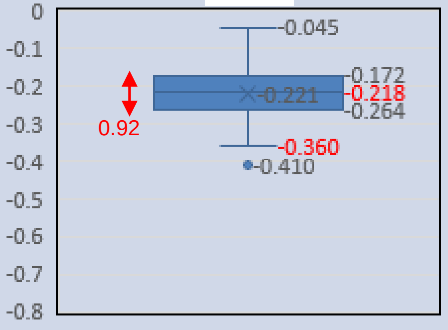
2-2) Results - Target intersection:(15) Tokyo Wangan Underpass Exit **[Current light color information only]**

Automated driving (cooperative)	Manual driving	
Current light color	Current light color	No traffic signal information

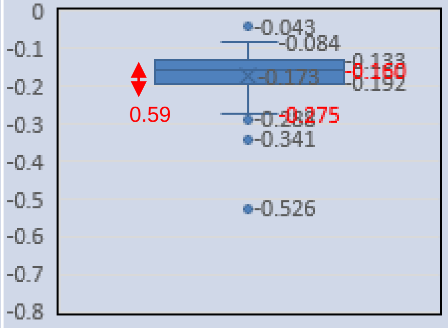




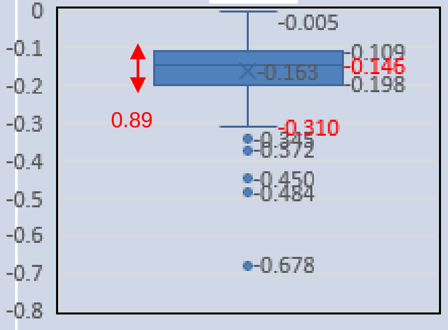




Maximum deceleration (G)



Maximum deceleration (G)



Maximum deceleration (G)

- Cooperative driving (current light color) had the largest average maximum deceleration, largest maximum deceleration, and largest quartile range

→ This indicates that current color information alone may be insufficient for modifying red traffic light deceleration behavior

4. Results of the Impact assessment

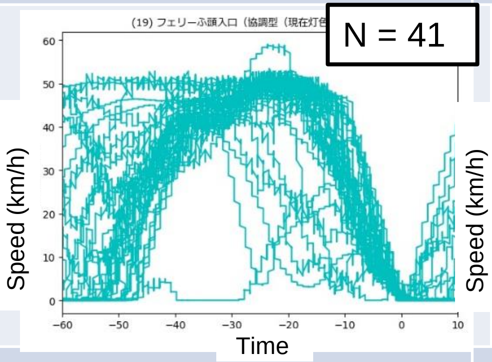
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

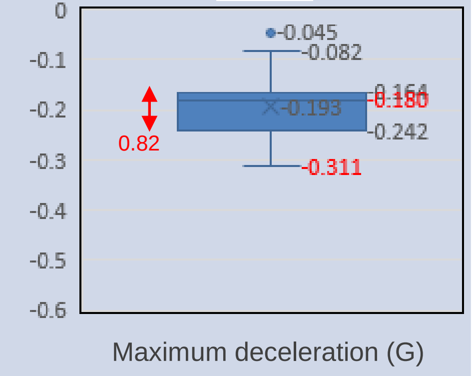
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

2-2) Results - Target intersection:(19) Ferry Terminal Entrance **[Current light color + remaining seconds information (w/ margin)]**

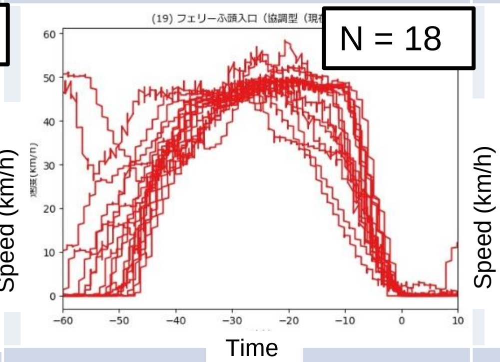
Automated driving (cooperative driving)

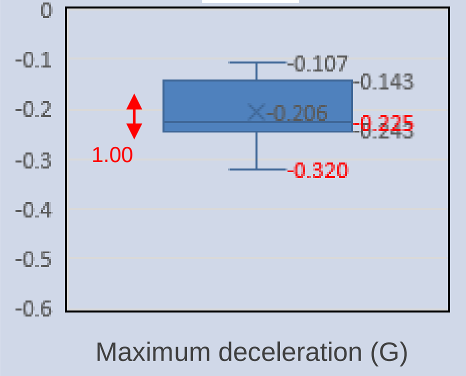
Current light color + remaining seconds





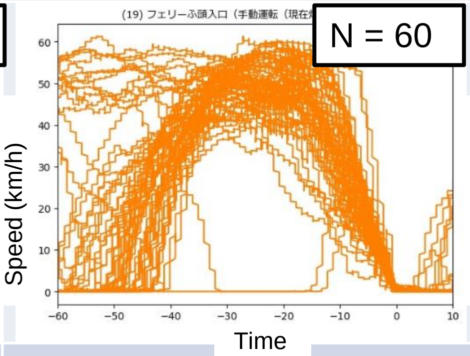
Current light color

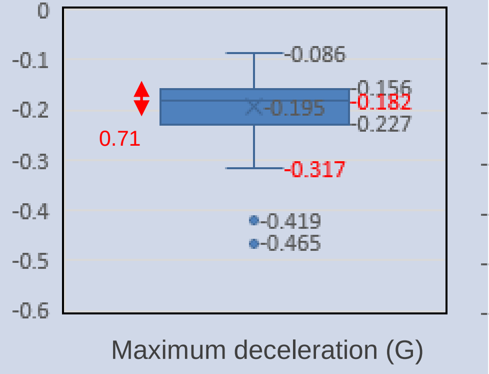




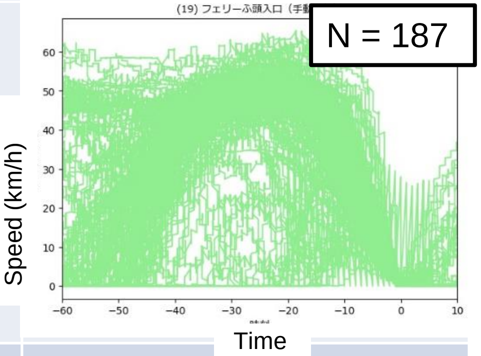
Manual driving

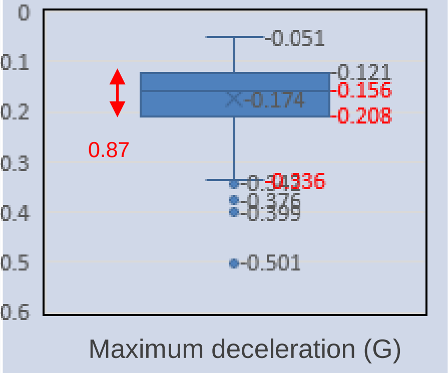
Current light color + remaining seconds





No traffic signal information





* Providing remaining seconds information was somewhat effective in improving the maximum deceleration.
→ Providing remaining seconds information (w/ margin) is believed to have contributed to more stable driving

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

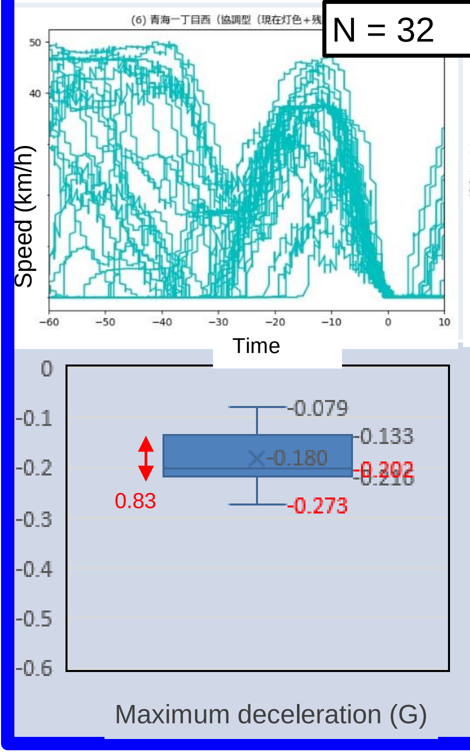
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

2-3) Results - Target intersection: (6) Aomi 1-chome West **[Current light color + remaining seconds information (confirmed)]**

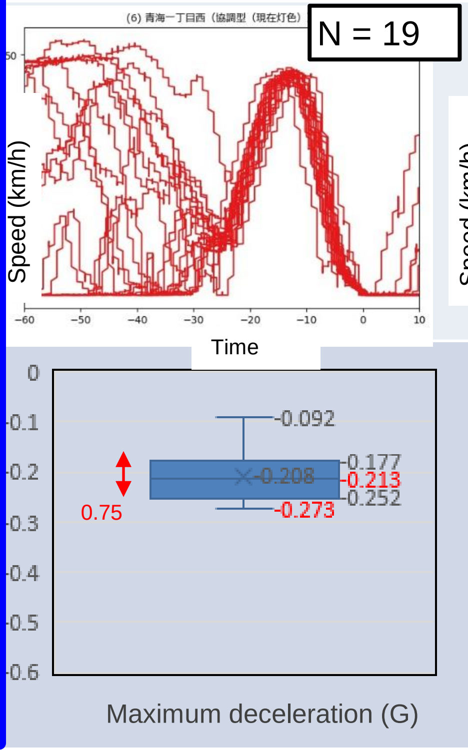
Automated driving (cooperative driving)

Manual driving

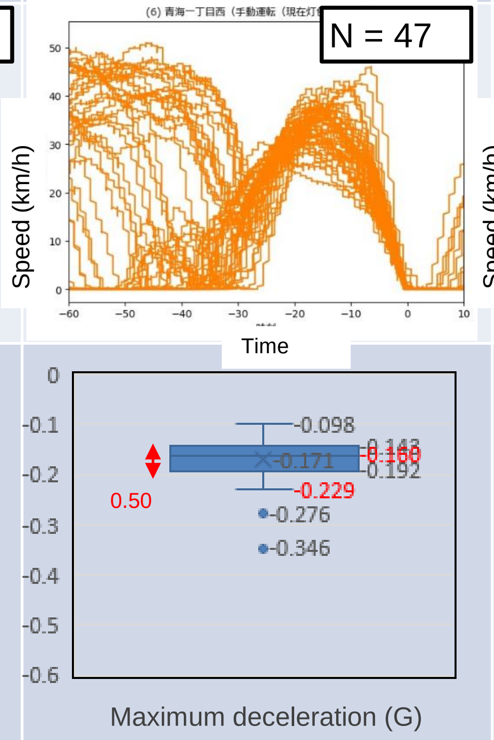
Current light color + remaining seconds



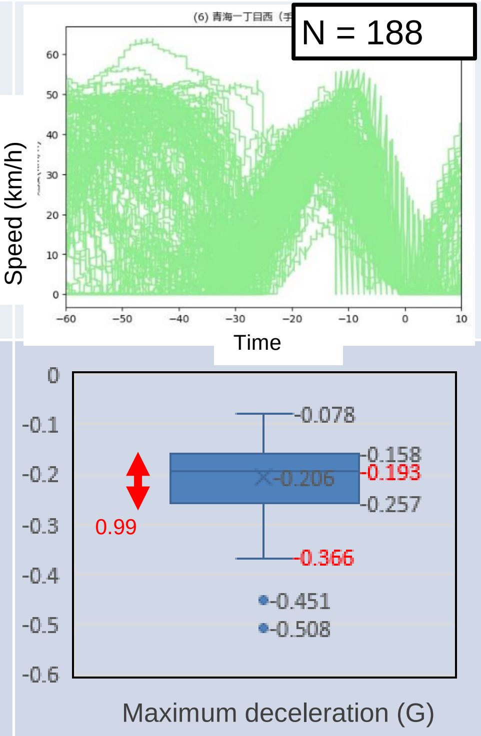
Current light color



Current light color + remaining seconds



No traffic signal information



* The maximum value and quartile range were smallest for cooperative driving (current light color + remaining seconds)
→ Providing confirmed remaining seconds information produced even more stable driving

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

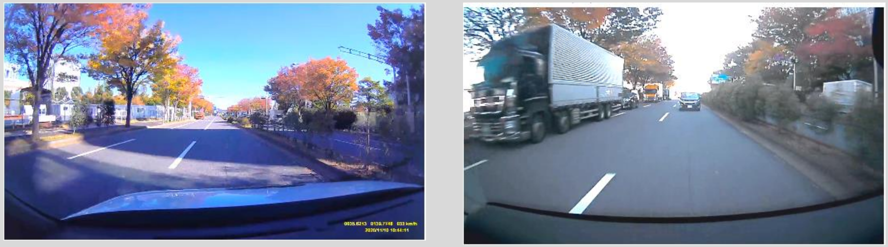
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

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

* Situation when stopping at a red light when driving straight forward.

ID: 31268

The vehicle was driving at 37 km/h.



Immediately after the light turned yellow, the vehicle began decelerating.

The vehicle stopped with some degree of leeway. There was no congestion with following vehicles

Analysis: Confirmation of the effectiveness of infrastructure information (current light color, remaining seconds information)

* There was no congestion with following vehicles.

* The vehicle engaged in safe stopping behavior using the current light color and remaining seconds information (confirmed)

The vehicle used the remaining seconds information and began decelerating immediately after the traffic signal turned yellow

The current light color and remaining seconds information were used to begin deceleration at an early point

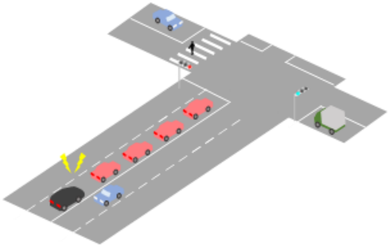
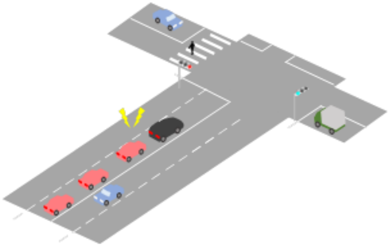
4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

- We evaluated the speed distribution, maximum deceleration, and stop behavior when stopping at red lights
- We focused on differences in the infrastructure information that was provided (whether or not current light color information or remaining seconds information (confirmed/with margin) was provided). We confirmed that when current light color information and remaining seconds information (confirmed) were provided, test vehicles performed preliminary deceleration and drove safely.

1) [In-depth evaluation] Evaluation items: Changes in behavior when stopping at a red light when driving straight
We envisioned the two following types of impact and performed evaluations at (25) Aomi 1-chome and (14) Rainbow Entrance

Impact	Evaluation situation	Target intersection	Evaluation item
Congestion involving preceding vehicles		(25) Aomi 1-chome [Current traffic light color + remaining seconds information (w/ margin)] (Characteristic: High traffic volume)	• Presence/absence of congestion involving preceding vehicles • Did preliminary deceleration using infrastructure information result in gradual deceleration after the detection of preceding vehicles?
Congestion involving following vehicles		(14) Rainbow Entrance [Current traffic light color + remaining seconds information (w/ margin)] (Characteristic: High traffic volume)	• Presence/absence of congestion involving following vehicles (other than accompanying vehicles) • Did preliminary deceleration using infrastructure information result in smooth stopping by following vehicles?

4. Results of the Impact assessment

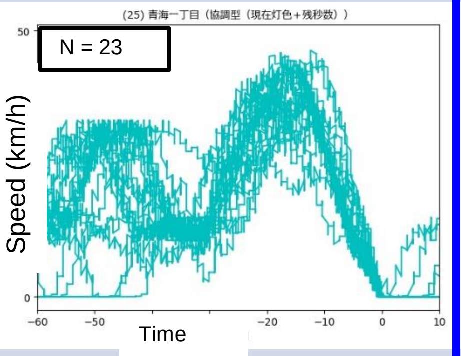
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

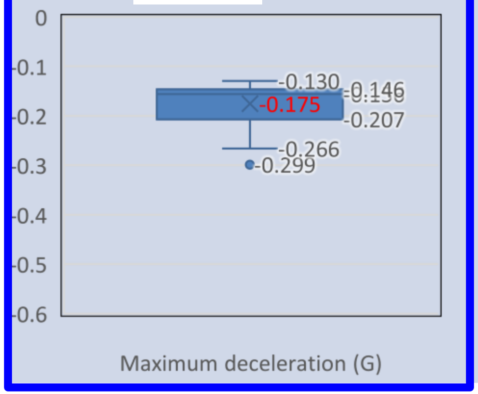
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

2-1) Results (congestion involving preceding vehicles): (25) Aomi 1-chome [Current traffic light color + remaining seconds information

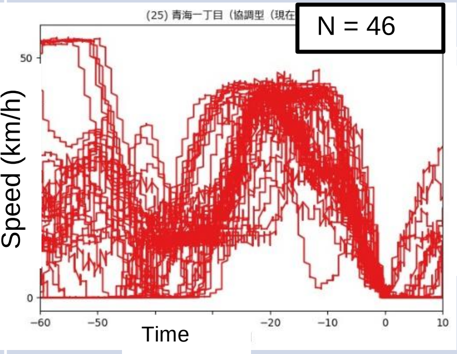
Automated driving (cooperative driving)

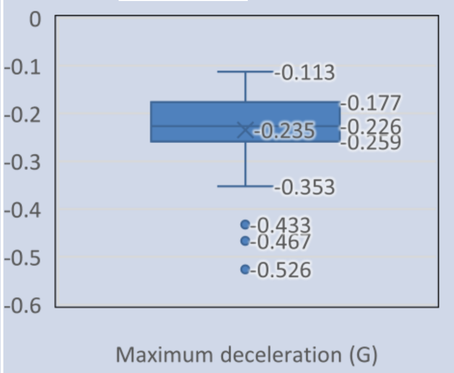
Current traffic light color + remaining seconds information





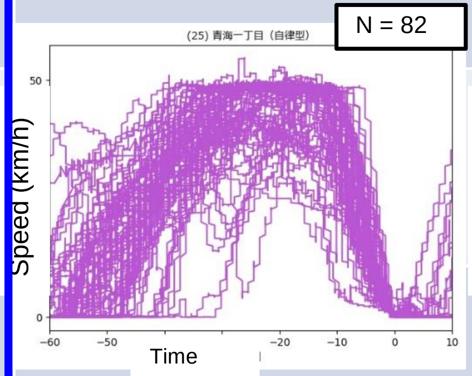
Current traffic light color

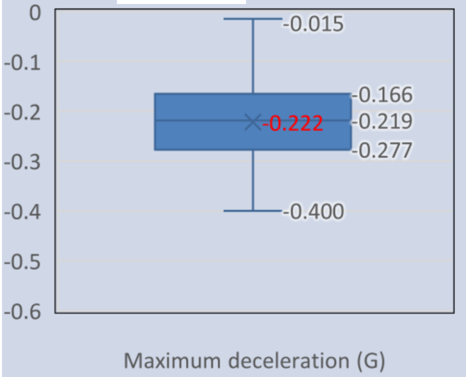




Automated driving (autonomous driving)

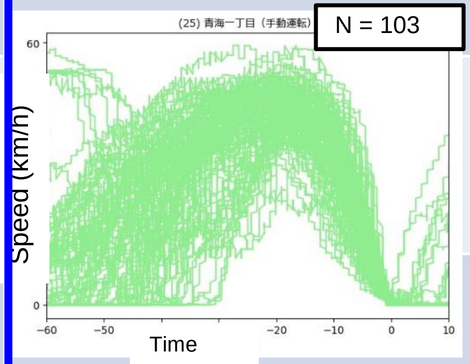
No traffic signal information

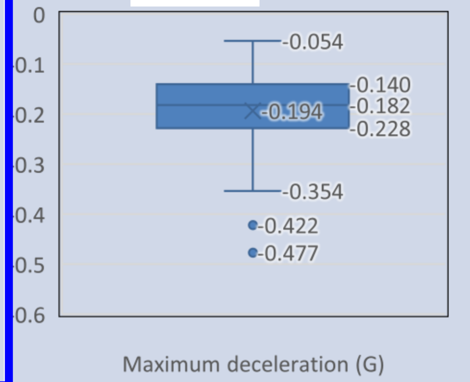




Manual driving

No traffic signal information





*** There was no sudden deceleration during cooperative driving (current traffic light color + remaining seconds information)**

*** We confirmed that there were sudden deceleration situations during autonomous driving**

4. Results of the Impact assessment

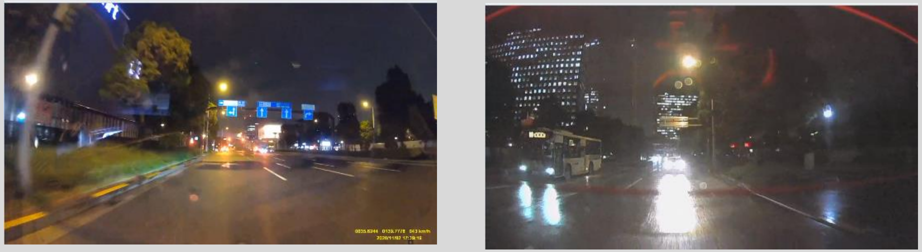
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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**

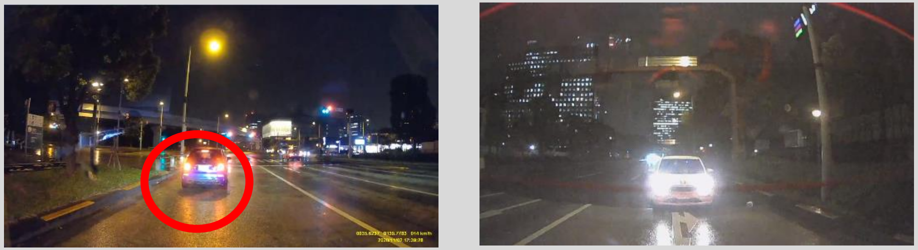
・**[Cooperative (current traffic light color + remaining seconds)]**Situation in which there was preliminary deceleration and a gradual stop

ID: 27105



Infrastructure information was received and the test vehicle began preliminary deceleration in advance (98 meters before reaching the stop line)

The test vehicle detected a vehicle waiting at the intersection, and began further deceleration

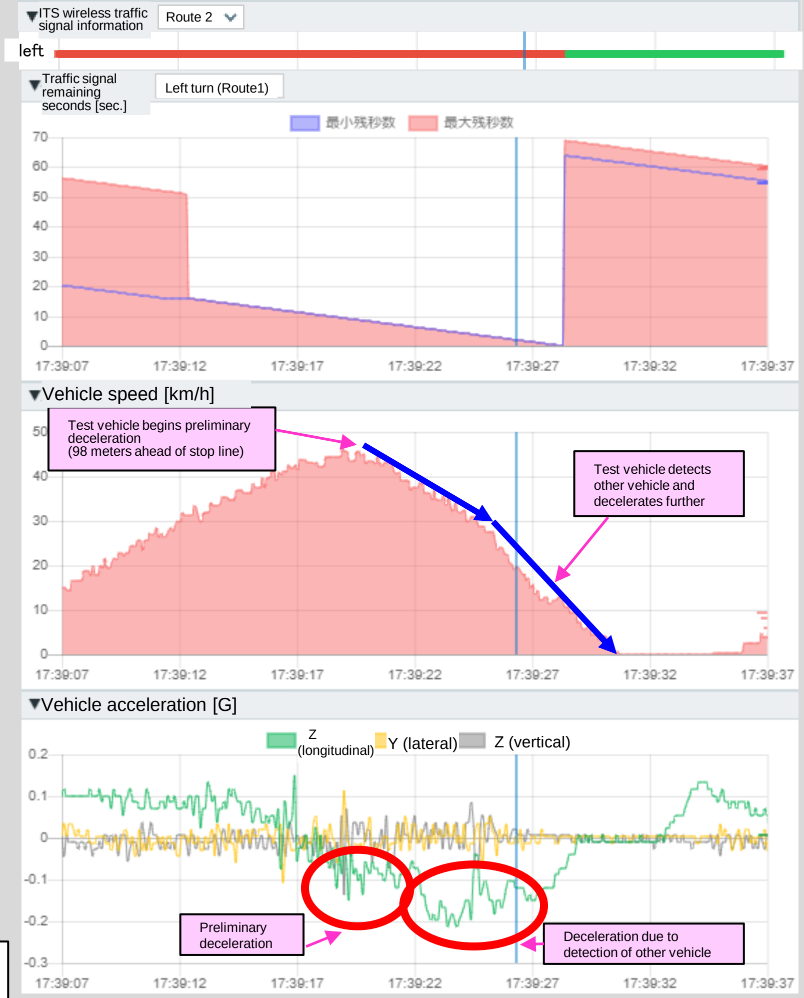


The vehicle stopped. There was no sudden deceleration and no congestion involving the preceding vehicle.

Analysis: Safe stopping behavior was achieved using preliminary deceleration + spatial monitoring

* Infrastructure information (current light color information) was used to perform preliminary deceleration

* Even when a preceding vehicle was encountered, spatial monitoring made safe stopping possible.



Test vehicle begins preliminary deceleration (98 meters ahead of stop line)

Test vehicle detects other vehicle and decelerates further

Preliminary deceleration

Deceleration due to detection of other vehicle

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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**

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

ID: 4226

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)

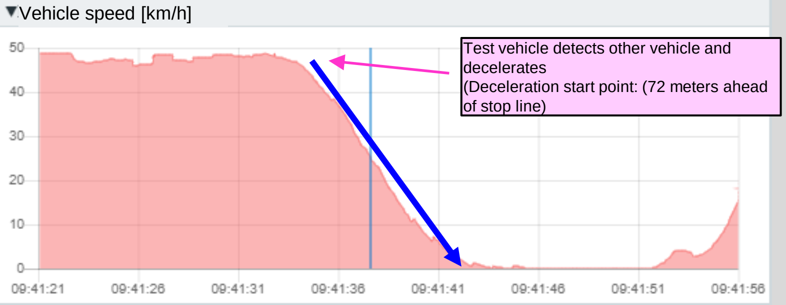
The test vehicle stopped after decelerating suddenly, and there was the potential for congestion involving the preceding vehicle

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

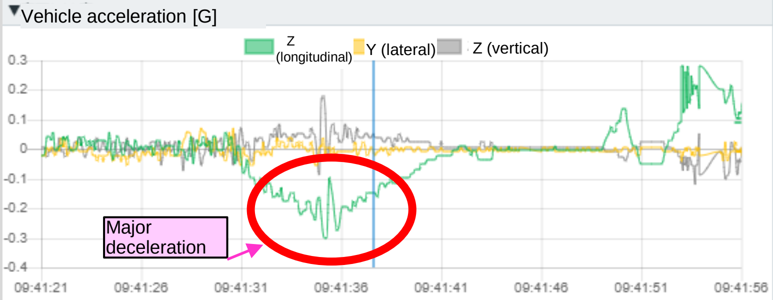
Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure	Image processing

▼Vehicle speed [km/h]



Test vehicle detects other vehicle and decelerates
(Deceleration start point: (72 meters ahead of stop line)

▼Vehicle acceleration [G]



Major deceleration

4. Results of the Impact assessment

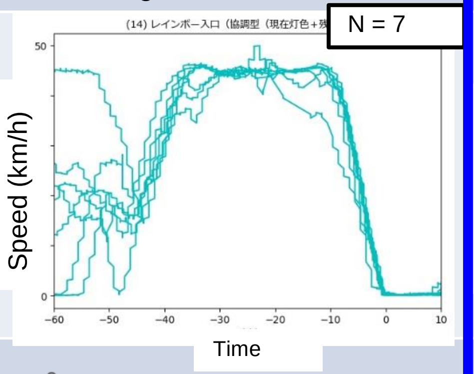
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

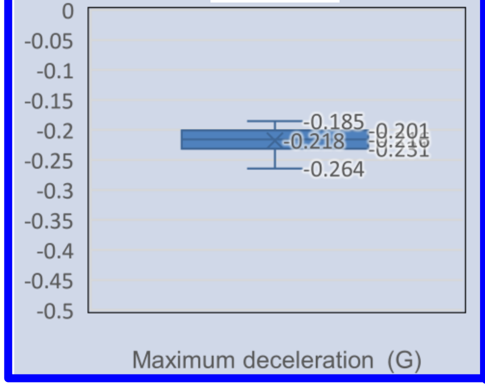
A) Impact on surrounding environment (driving space) (v) Behavior when stopping at a red light when driving straight

2-1) Results (congestion involving following vehicles): (14) Rainbow Entrance [Current traffic light color + remaining seconds information (w/ margin)]

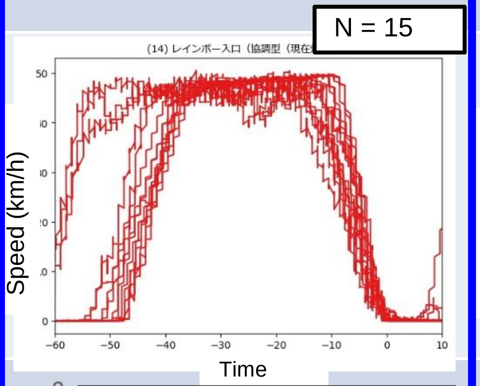
Automated driving (cooperative driving) | **Manual driving**

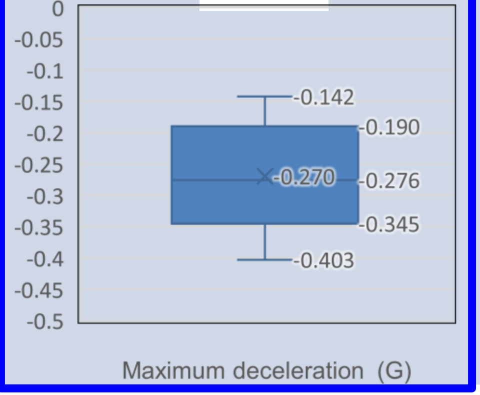
Current traffic light color + remaining seconds information



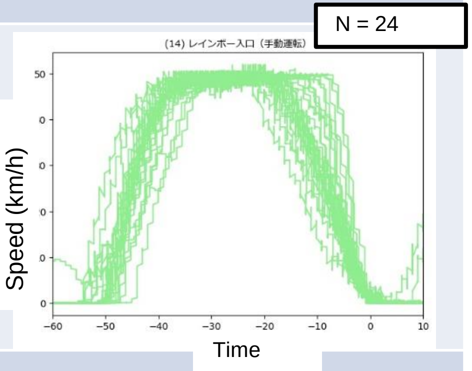


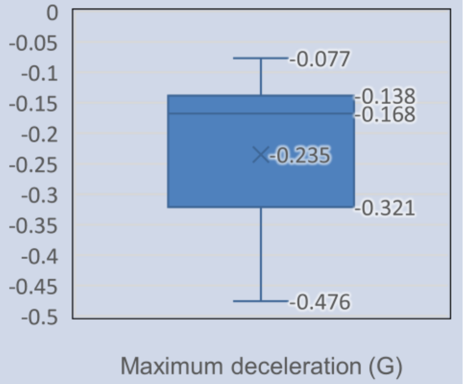
Current traffic light color





No traffic signal information





* There was no congestion involving a following vehicle in the five situations in which there were following vehicles when performing automated driving (current traffic light color + remaining seconds information)
* Of the eight situations in which there were following vehicles when performing automated driving (current traffic light color only), we confirmed one case of congestion involving a following vehicle

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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 [No congestion involving following vehicles]**

ID: 42358

* Current traffic light color + remaining seconds information alone were used to perform deceleration, and there was no congestion involving a following vehicle

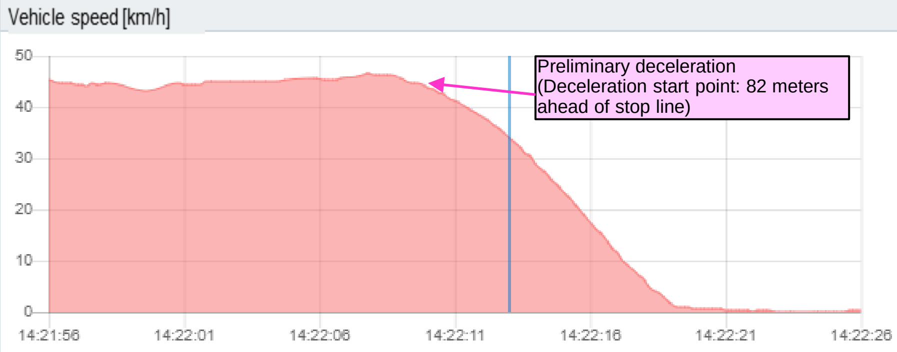
The test vehicle was driving at 45 km/h, and there was a vehicle behind it

The test vehicle decelerated due to a red traffic light (-0.2G) (Deceleration start point: 82 meters ahead of stop line)

There was no congestion involving the vehicle following the test vehicle

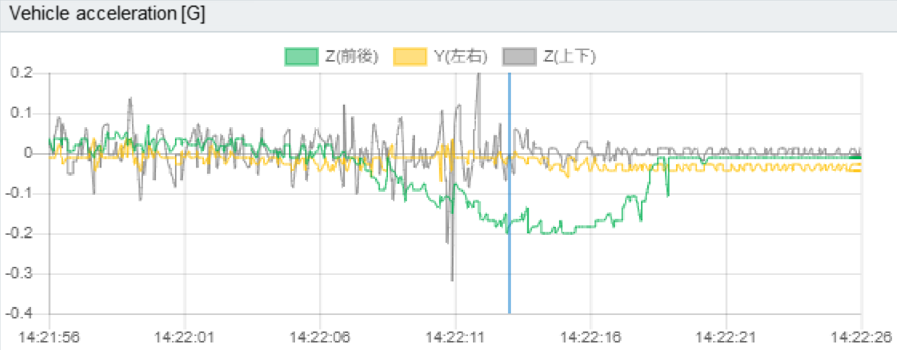
Autonomous vehicle attributes	Passenger vehicle	Cooperative infrastructure used	Image processing

Vehicle speed [km/h]



Preliminary deceleration (Deceleration start point: 82 meters ahead of stop line)

Vehicle acceleration [G]



Analysis: We confirmed the importance of current traffic light color + remaining seconds information

- Infrastructure information was used to perform preliminary deceleration, and there was no congestion involving a following vehicle

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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 [Congestion involving following vehicles]** ID: 38831

* Situation in which deceleration was performed using current light color information alone and there was congestion involving a following vehicle

The test vehicle was driving at 50 km/h, and there was a vehicle behind it

The test vehicle decelerated somewhat suddenly due to a red traffic light (-0.24G) (Deceleration start point: 48 meters ahead of stop line)

There was congestion involving the vehicle following the test vehicle

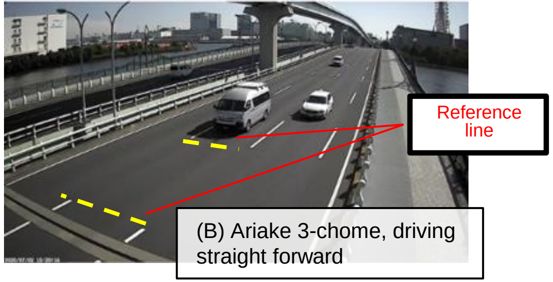
No preliminary deceleration (Deceleration start point: 48 meters ahead of stop line)

Analysis: We confirmed the importance of remaining seconds information

- This situation appears to have occurred because no remaining seconds information was used, so there was no preliminary deceleration and the test vehicle suddenly decelerated

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved
A. Impact on surrounding environment (driving space) (f) Speed deviation when driving straight



(B) Ariake 3-chome, driving straight forward

1) Evaluation items: Changes in speed when driving straight resulting from the inclusion of automated vehicles

- Areas of focus: (a) Does the presence of automated vehicles in traffic affect speeds?
  (b) Were automated vehicles passed or cut in front of?
- Evaluation method: Fixed-point camera video was used to measure when ordinary vehicles passed a reference line. Speeds were then calculated and drive recorder video was confirmed.

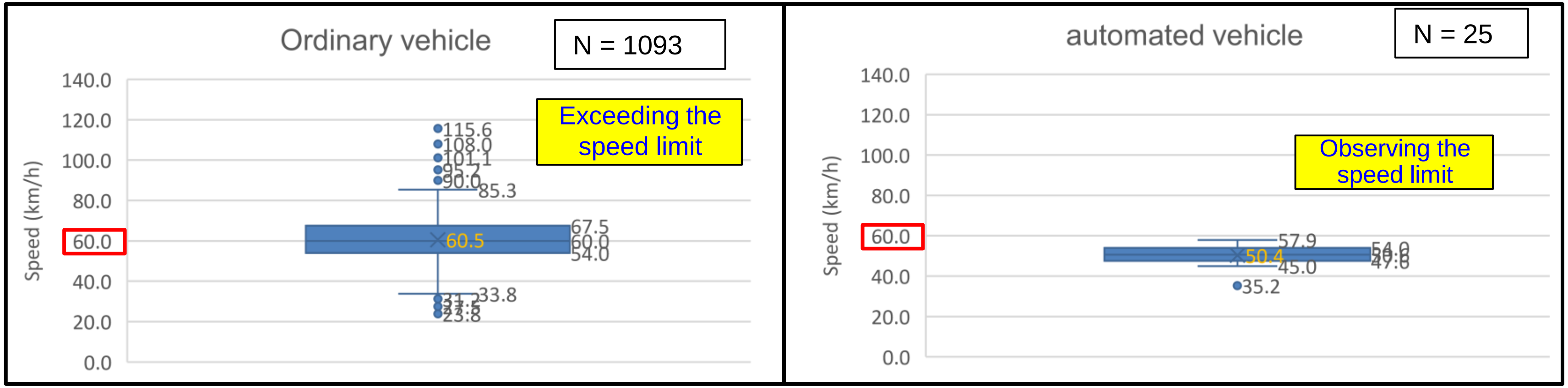
2) Results: Target intersection: (B) Ariake 3-chome, driving straight forward

- Ordinary vehicles had high average speeds (exceeding the speed limit) and large amounts of deviation in their speeds
- Automated vehicles had low average speeds (observing speed limits) and little deviation in their speeds
- Of the 12 samples*1 of automated driving, there were two cases of the test vehicle being passed, but we observed no cases of deceleration or other behavior that affected surrounding vehicles

3) Observations and future prospects

- Our evaluation showed that when automated vehicles are present in traffic, they may produce safer driving environments (which are not influenced by differences in driver characteristics or proficiency)
- Even when passed by a following vehicle, the test vehicles continued to drive stably

*1: Number of samples in which the following vehicle was an ordinary vehicle (not an accompanying vehicle)



Red: Speed limit

Orange: Average

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

■ **Behavior of automated vehicle when driving straight forward**

* In situations in which speed deviations resulted in test vehicles driving straight forward being passed by ordinary vehicles, we observed no cases of test vehicle behavior (such as deceleration) which affected surrounding vehicles

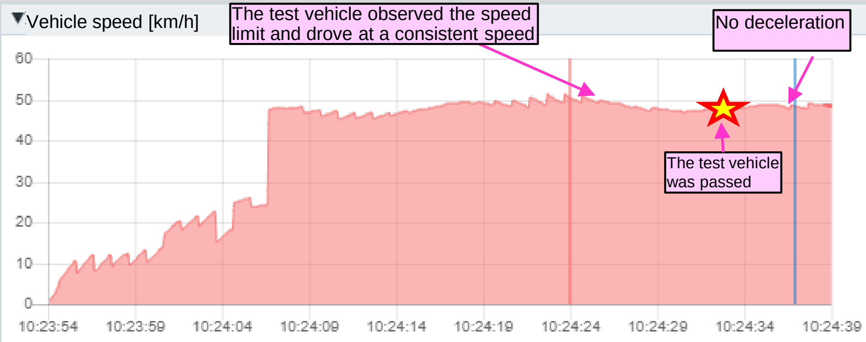
ID: 39016

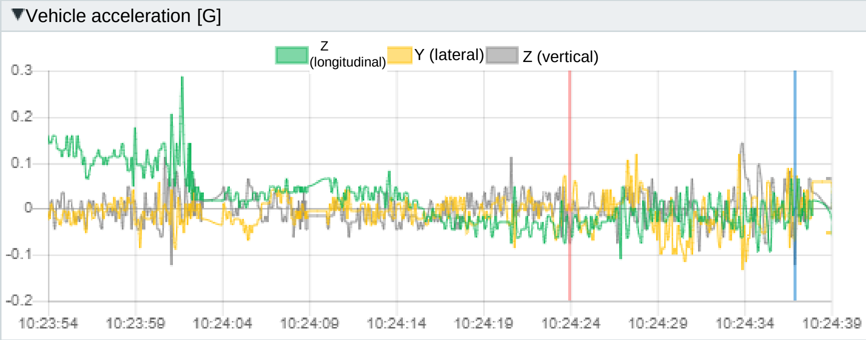
The test vehicle was driving at 50 km/h, observing the speed limit

The following vehicle, circled in red, changed lanes and passed the test vehicle

Even when the test vehicle was passed, it was not observed to engage in any behavior that affected surrounding vehicles, such as deceleration

Autonomous vehicle attributes	Passenger vehicle	Cooperative infrastructure used	Image processing





Analysis: Even when passing occurred, test vehicles were not observed to have an impact on surrounding vehicles

- Even when the test vehicles observed the speed limit and were passed, we observed no impact on surrounding vehicles
- In cases in which test vehicles are cut in front of, and the distance between the vehicles is small, behavior such as deceleration may occur

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

A. Impact on surrounding environment (driving space) (vii) Evaluation of impact on encounters between test vehicles turning right and oncoming cars driving straight

1) Evaluation items: Changes in gap acceptance behavior resulting from the presence of automated vehicles

- What is "gap acceptance behavior"?
  - ➢ Determination of whether a vehicle can turn right in the gap in front of an oncoming vehicles driving straight (headway time (seconds))
  - ➢ Inflow gaps (gaps when turning right) and resignation gaps (gaps when unable to turn right) can be used to identify decisions regarding right turn behavior when encountering oncoming vehicles driving straight forward

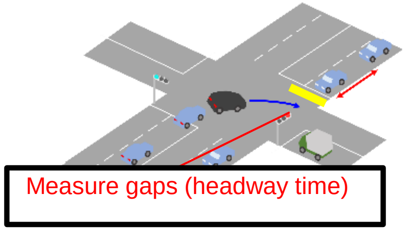
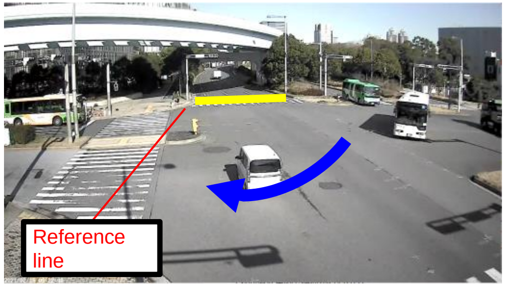

Measure gaps (headway time)

Table Conceptual image of inflow gaps and resignation gaps

Category	Transit time	
Straight-driving vehicle 1	07:34:45.77	Resignation gap: Gap between successive vehicles driving straight which a vehicle wishing to turn right was unable to enter
Straight-driving vehicle 2	07:34:51.24	
Right turn vehicle	07:34:54.74	Inflow gap: Gap between successive vehicles driving straight which a vehicle wishing to turn right entered
Straight-driving vehicle 3	07:35:00.81	


Reference line

(10) Telecom Center-mae, right turn

- Areas of focus: (a) Differences in behavior between automated vehicles and ordinary vehicles

  (b) Is there congestion with following vehicles, etc.?
- Evaluation method: Use fixed-point cameras to capture video of headway and presence of vehicle right turn behavior

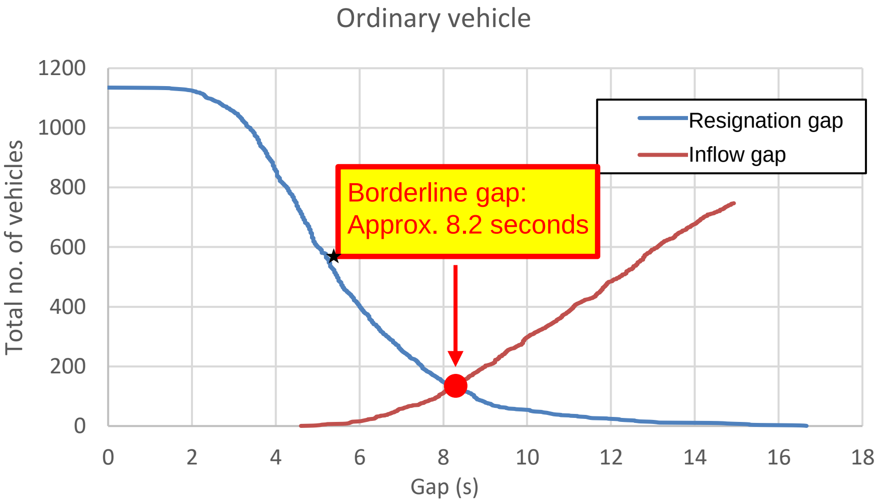
2) Results: Target intersection: (10) Telecom Center-mae, right turn

- No. of inflow gap samples:

(Ordinary vehicles) 747 samples (automated vehicles) 0 samples *1

*1:16 right turn samples were obtained for automated vehicles, but 0 samples involved gaps between oncoming vehicles driving straight forward

- The number of samples acquired for ordinary vehicles was sufficient for performing evaluation
- In the case of automated vehicles, the number of samples acquired was not sufficient for performing evaluation. Evaluating right turn behavior when there are successive oncoming vehicles driving straight forward remains a future challenge.



Borderline gap: Approx. 8.2 seconds

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

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

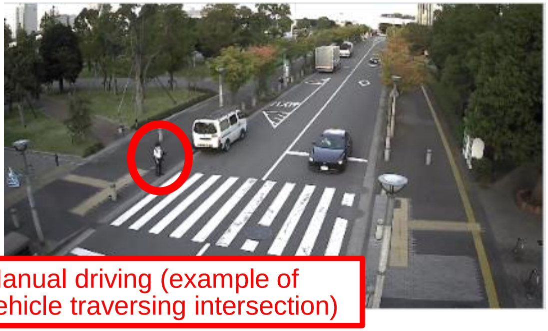
- Areas of focus:
  - ➢ When encountering crosswalk pedestrians, did autonomous vehicles wait for the pedestrians to cross before traverse the intersection?
  - ➢ Did autonomous vehicles that encountered crosswalk pedestrians stop before the stop line?

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, autonomous vehicles always waited for the pedestrians to pass first.

3) Analysis and future prospects

- Autonomous 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 autonomous vehicles when encountering a pedestrian



Manual driving (example of vehicle traversing intersection)

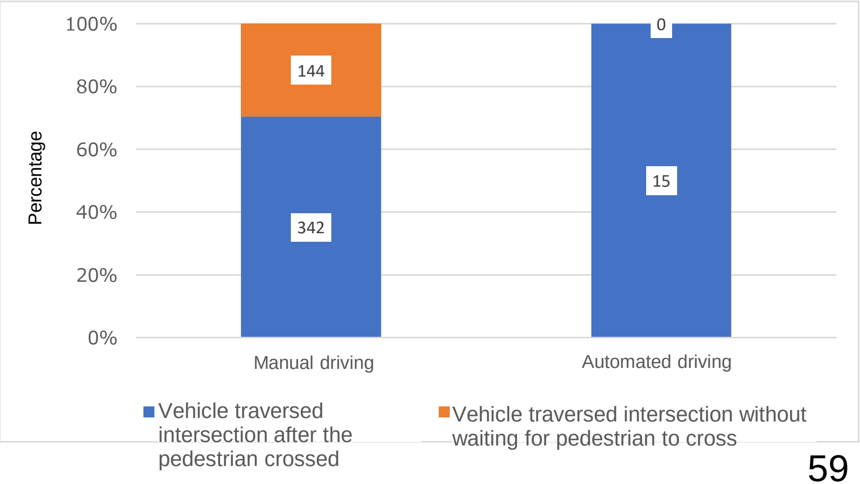
Automated driving (example of vehicle stopping)

■ 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	Autonomous 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. Results of the Impact assessment

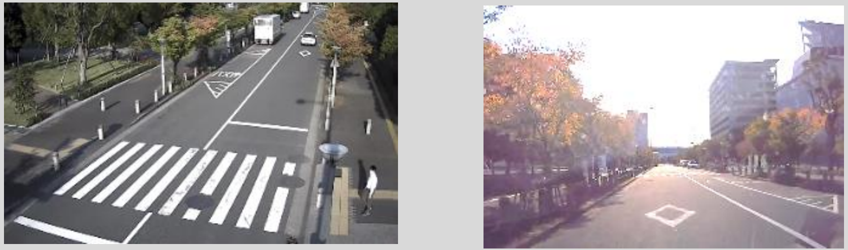
4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

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

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

ID: 16057

* 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.

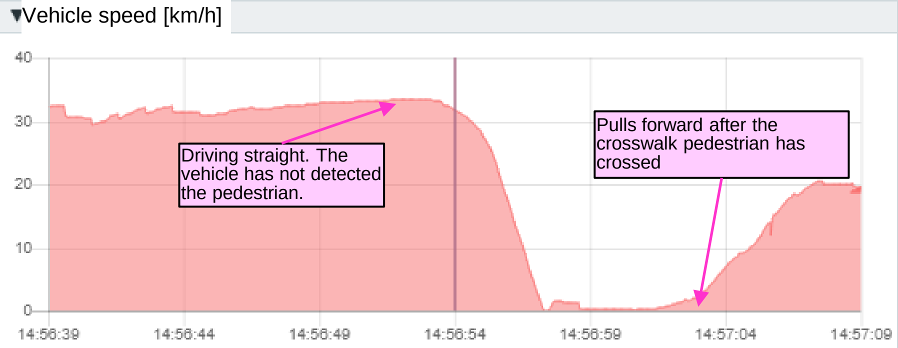


The vehicle approaches the pedestrian crossing. It has not yet detected the presence of the crosswalk pedestrian.

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.

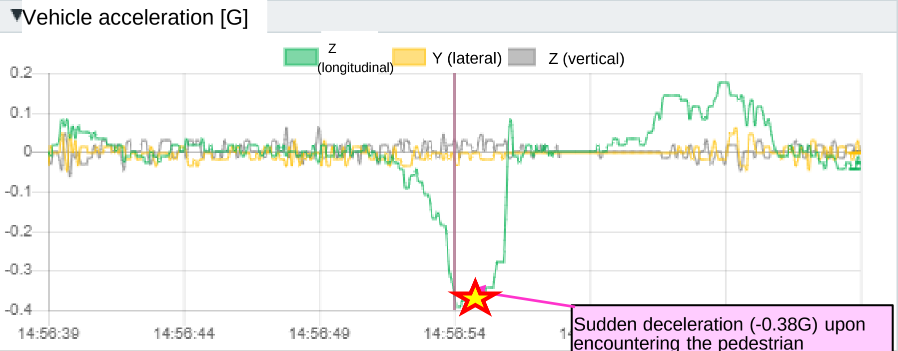
Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing



▼Vehicle speed [km/h]

Driving straight. The vehicle has not detected the pedestrian.

Pulls forward after the crosswalk pedestrian has crossed



▼Vehicle acceleration [G]

Sudden deceleration (-0.38G) upon encountering the pedestrian

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. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved B. Impact on the surrounding environment (pedestrians, etc.) (ii) Crossing pedestrians when turning left or right


(25) Aomi 1-chome - left turn

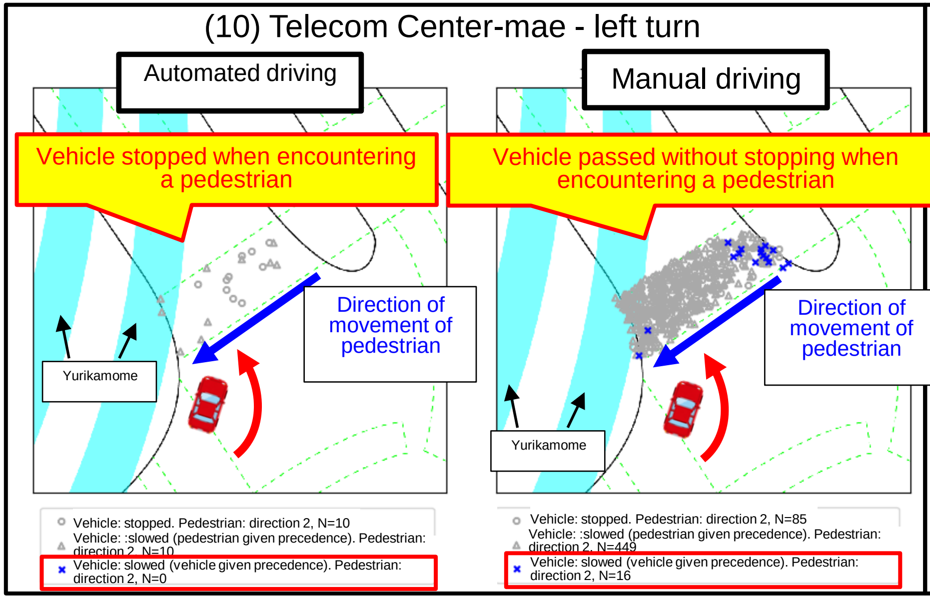
1) Evaluation items: Evaluation of the impact of automated vehicles on crosswalk pedestrians

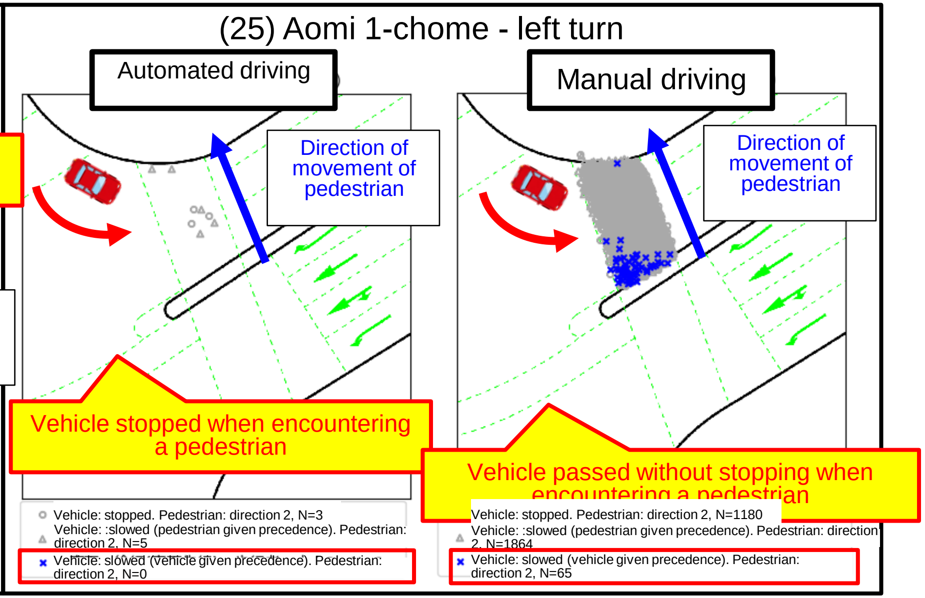
- Areas of focus: What kind of stopping behavior is engaged in with respect to crosswalk pedestrians?
- Evaluation method:
  - ➢ Use fixed-point camera video data to confirm stopping behavior when vehicles encountered crosswalk pedestrians
  - ➢ Plot pedestrian locations, both when stopped and when not stopped, and evaluate collision risk

2) Results Target intersection: (10) Telecom Center-mae - left turn, (25) Aomi 1-chome - left turn

- When encountering pedestrians crossing the street, many of the manually driven vehicles slowed down but kept moving (approaching the pedestrian), but automated vehicles stopped, ensuring pedestrian safety.

3) Analysis and future prospects: automated vehicles were confirmed to behave in a way that involved little risk of collision with crosswalk pedestrians.


(10) Telecom Center-mae - left turn


(25) Aomi 1-chome - left turn

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved
B. Impact on the surrounding environment (pedestrians, etc.) (iii) Impact on bicycles and motorcycles

1) Evaluation items: Evaluation of the impact of autonomous vehicles on bicycles

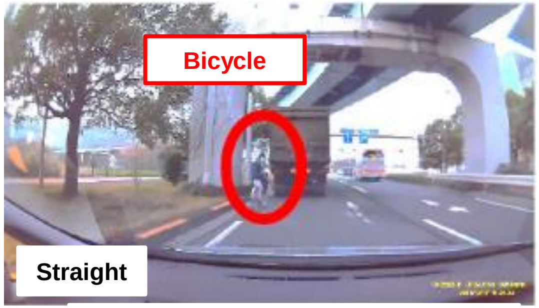
- Areas of focus: What kind of behavior do autonomous vehicles engage in with respect to bicycles?
- Evaluation method:
  - ➢ Use the visualization system to confirm how autonomous vehicles behave when encountering bicycles

2) Results

- It was confirmed that when autonomous vehicles encounter bicycles, after the bicycles detect the autonomous vehicles, they drive smoothly.

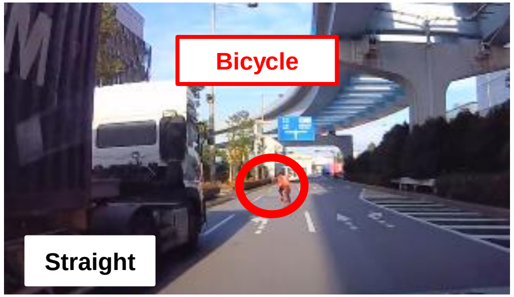
3) Analysis and future prospects

- As of the present, we have not confirmed any situations in which autonomous vehicle had a major impact on bicycles.
- However, we have seen scattered cases of bicycle and motorcycle behavior affecting autonomous vehicles. There were cases of sudden deceleration during encounters, and we have confirmed actual cases of this presenting the risk of affecting following vehicles, etc.



(25) Near Aomi 1-chome intersection

(10) Telecom Center-mae intersection



(10) Near Telecom Center-mae intersection

4. Results of the Impact assessment

4-1 Assessment of impact of autonomous vehicle driving on traffic flow and the factors involved

B. Impact on the surrounding environment (pedestrians, etc.) (iii) Impact on bicycles and motorcycles

■ **Case of sudden stopping**

ID: 15645

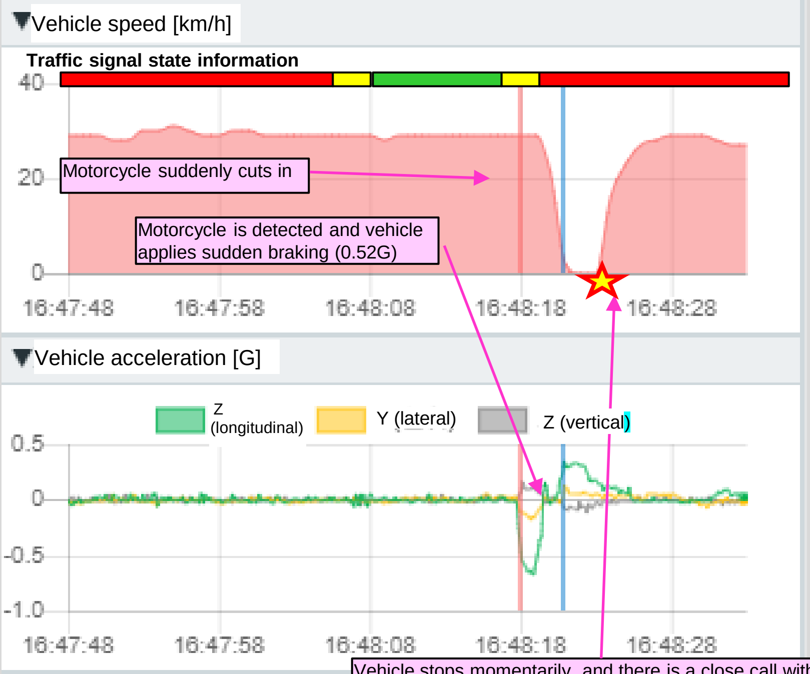
* While driving at low speed (30km/h), **a motorcycle cut in** from the passing lane. The autonomous vehicle detected this, applied sudden braking, and stopped momentarily. Because this occurred in a basic road section, the following vehicle approached and there was a rear-end collision close call.

The vehicle was driving slowly (approx. 30km/h) in the second cruising lane (the speed limit was 50km/h)

A motorcycle passed from the rear right and cut in. The vehicle detected this and applied sudden braking.

After sudden braking, the vehicle stopped momentarily. This surprised the following vehicle, which applied sudden braking (close call).

Autonomous vehicle attributes	Passenger vehicle	No cooperative infrastructure use	Image processing



Motorcycle suddenly cuts in

Motorcycle is detected and vehicle applies sudden braking (0.52G)

Vehicle stops momentarily, and there is a close call with the following vehicle

Analysis: The autonomous vehicle was passed and cut in by a motorcycle behind it, partly due to its driving at slow speed. This caused sudden braking and resulted in a close call.

* This behavior consisted of sudden braking and stopping on a basic road section, so its impact must be addressed. We confirmed that when driving slower than surrounding traffic, there is a risk of the vehicle being passed by or cut in by nearby vehicles.

4. Results of the Impact assessment

4-1 Assessment of impact of automated vehicle driving on traffic flow and the factors involved

B. Impact on the surrounding environment (pedestrians, etc.) (iii) Impact on bicycles and motorcycles (2)

- **Being passed from behind when driving straight at the legal speed**

ID:16059

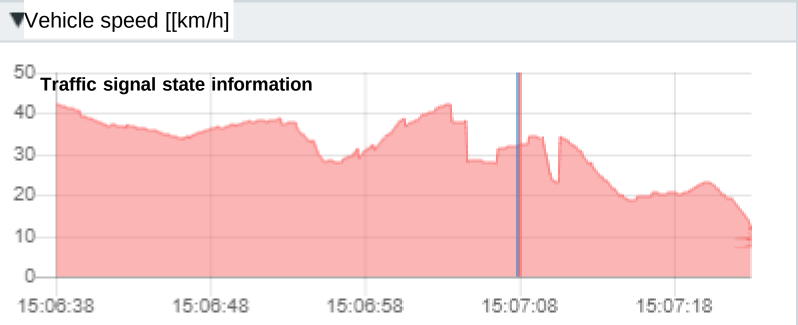
* While driving in the second cruising lane, the test vehicle encountered a bicycle and applied sudden braking. No impact on the following vehicle was observed.

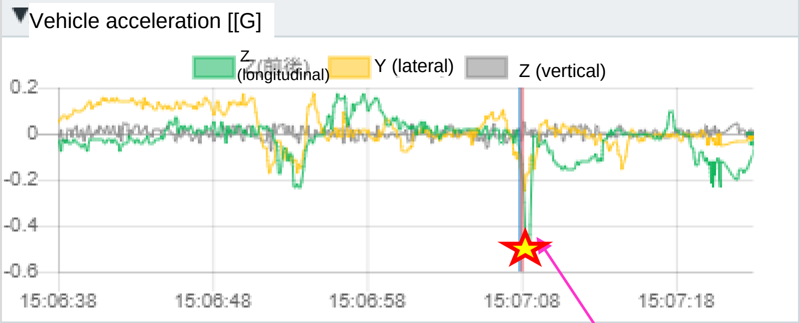
Autonomous vehicle attributes | Passenger vehicle | No cooperative infrastructure use | Image processing

The vehicle was driving in the second cruising lane.

It detected a sports-type bicycle in front and applied sudden braking (approx. -0.44G).

There was no impact on the following vehicle.





The test vehicle detected a sports bicycle and applied sudden braking

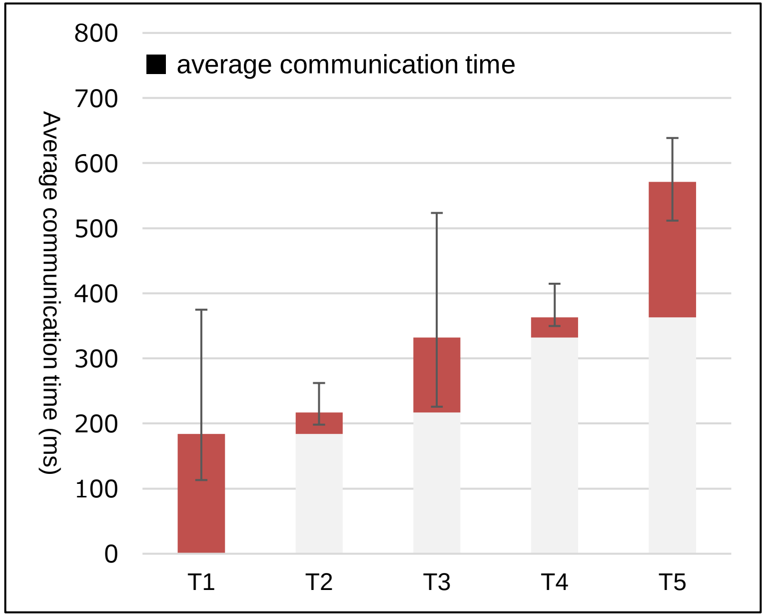
Analysis: When detecting a bicycle and applying sudden braking, the impact on following vehicles must be given sufficient consideration

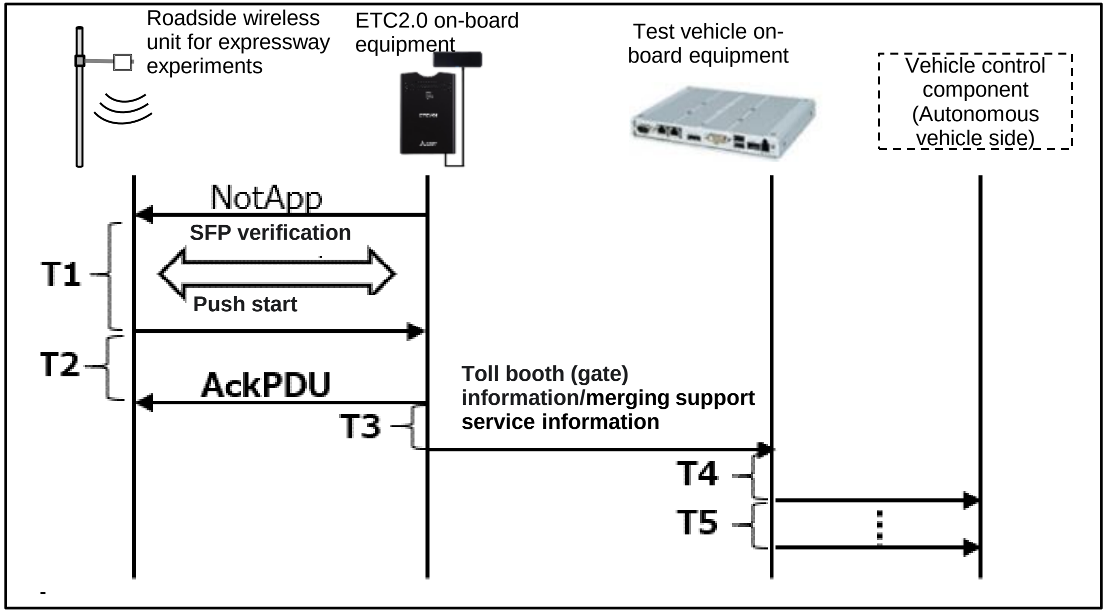
5. Results of the FOTs on the Metropolitan Expressway

5-1 Appropriateness of operation of cooperative infrastructure system

(b) Measurement of transmission time between roadside wireless units for expressway experiments and test vehicle on-board equipment

- The average communication time for ETC gate passing was roughly 600 ms from starting processing to completing output.





Transmission time	Average	Maximum	Minimum
T1	184	219	178
T2	33	52	18
T3	115	300	2
T4	31	78	14
T5	208	236	156

Fig.: ETC gate passing average communication time (N=27 drives)

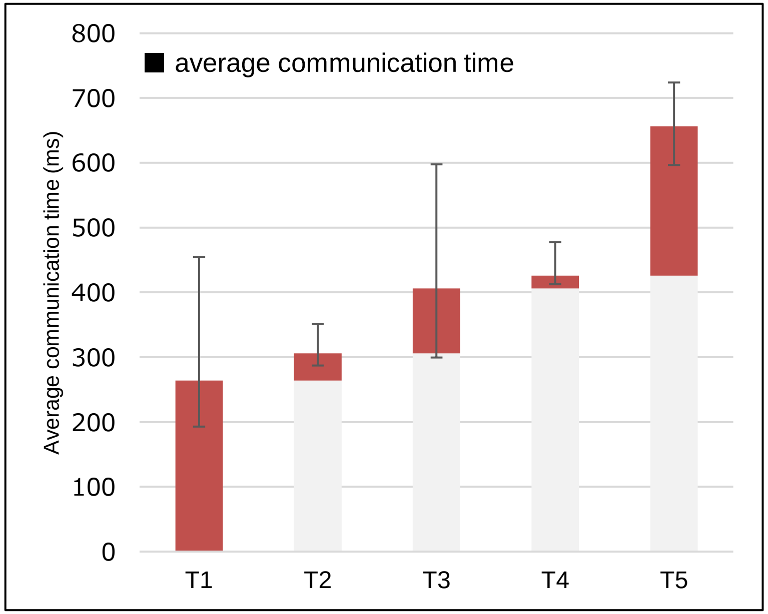
- T1: Time difference between NotApp* reception and PushOperation* transmission times
- T2: Time difference between PushOperation transmission and AckPDU* reception times
- T3: Time difference between AckPDU reception and toll booth (gate) information/merging support service information reception times
- T4: Time difference between toll booth (gate) information/merging support service information reception times and time immediately before test vehicle on-board equipment transmission
- T5: Time difference between time immediately before test vehicle on-board equipment transmission and completion of CAN transmission

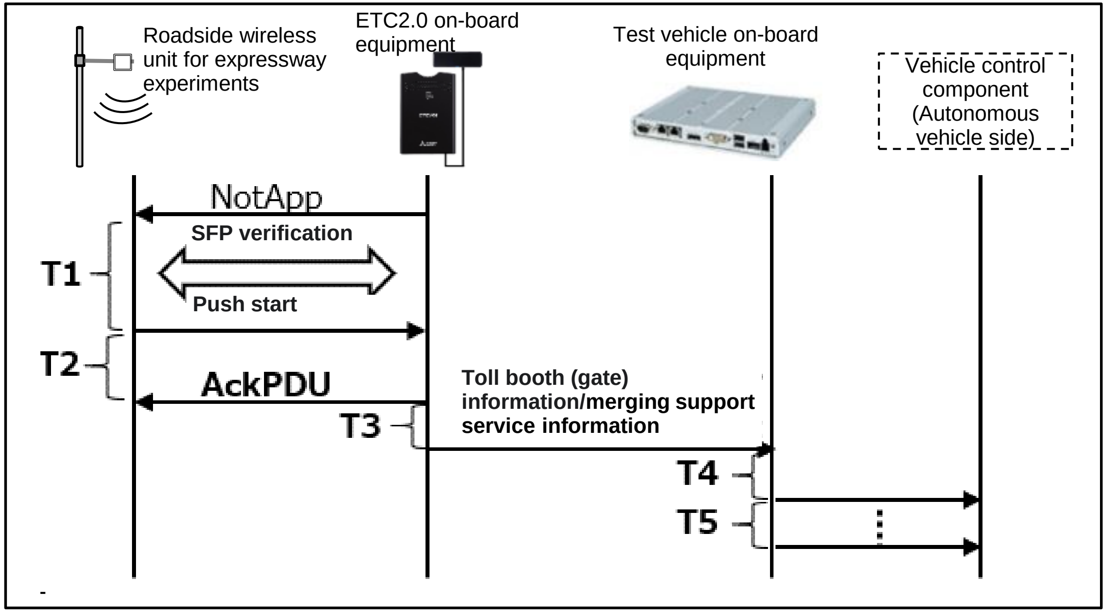
5. Results of the FOTs on the Metropolitan Expressway

5-2 Appropriateness of operation of cooperative infrastructure system

(b) Measurement of transmission time between roadside wireless units for expressway experiments and test vehicle on-board equipment

- The average communication time for cruising line merging was roughly 650 ms from starting processing to completing output.





Transmission time	Average	Maximum	Minimum
T1	264	409	147
T2	42	82	19
T3	100	264	2
T4	20	44	13
T5	230	283	204

Fig.: Cruising line merging average communication time (N=23 drives)

- T1: Time difference between NotApp* reception and PushOperation* transmission times
- T2: Time difference between PushOperation transmission and AckPDU* reception times
- T3: Time difference between AckPDU reception and toll booth (gate) information/merging support service information reception times
- T4: Time difference between toll booth (gate) information/merging support service information reception times and time immediately before test vehicle on-board equipment transmission
- T5: Time difference between time immediately before test vehicle on-board equipment transmission and completion of CAN transmission

5. Results of the FOTs on the Metropolitan Expressway

5-2 Effectiveness of support information provided to autonomous vehicles, etc.

Correction section traffic flow diagram

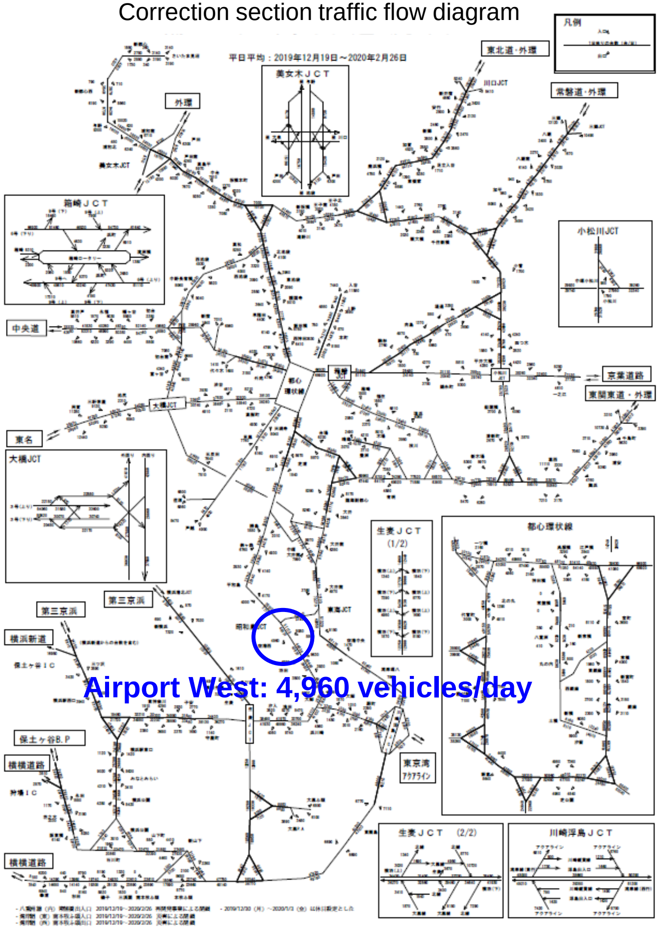


Table: Inflow volume by Metropolitan Expressway entrance/exit (top 10 entrances/exits)

Entrance Name	Inflow Volume (vehicles/day)
Kasumigaseki Entrance/Exit	16,090
Shibakoen Entrance/Exit	12,340
Shibaura Entrance/Exit	8,750
Haneda Entrance/Exit	8,510
Oi Entrance/Exit	8,260
Ginza Entrance/Exit	6,810
Suzugamori Entrance/Exit	6,760
Shiodome Entrance/Exit	6,080
Takaracho Entrance/Exit	5,110
Airport West Entrance/Exit	4,960

Source: Metropolitan Expressway traffic flow diagram (Dec. 2019 to Feb. 2020, weekday average)

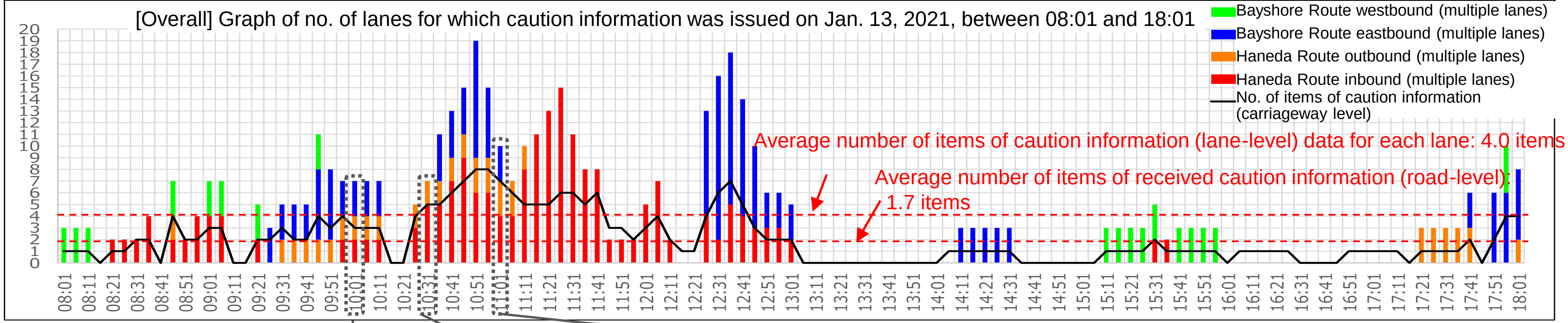
5. Results of the FOTs on the Metropolitan Expressway

5-3 Lane-specific traffic information transmission testing: Field advance confirmation

Online delivery (evaluated at factory)
(advance confirmation, Jan. 13, 2021, 8:01 to 18:01)

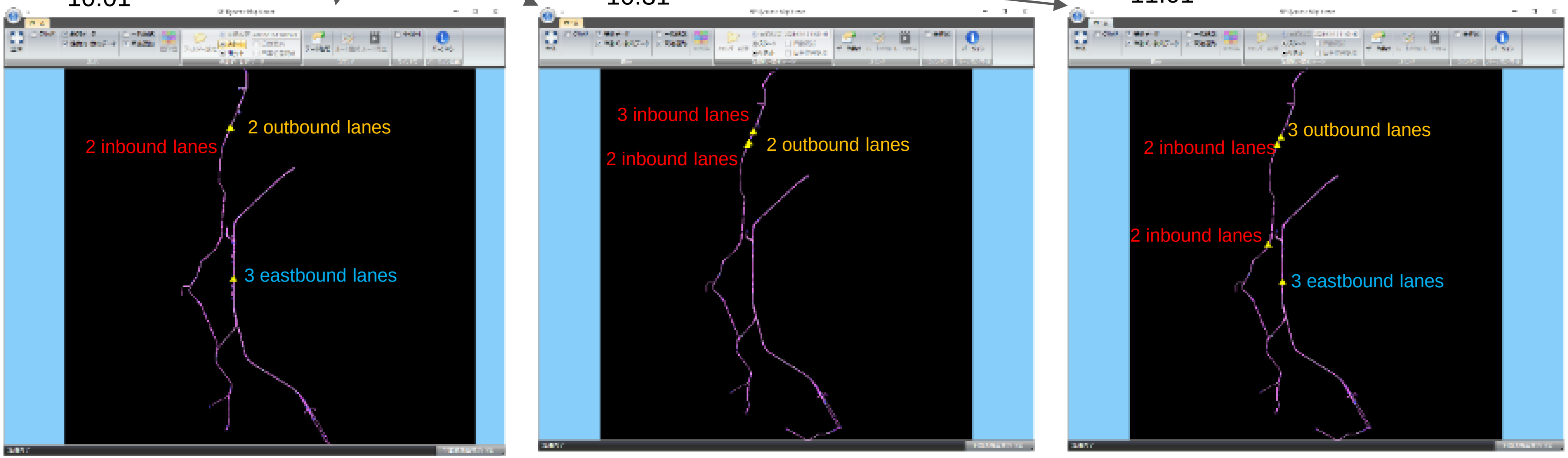
Caution information for each lane for the Metropolitan Expressway Haneda Route and Bayshore Route for use in viewer display and vehicle output

Caution information = generated by collecting probe information from vehicles driving on said expressways at said times


[Overall] Graph of no. of lanes for which caution information was issued on Jan. 13, 2021, between 08:01 and 18:01

Average number of items of caution information (lane-level) data for each lane: 4.0 items

Average number of items of received caution information (road-level): 1.7 items

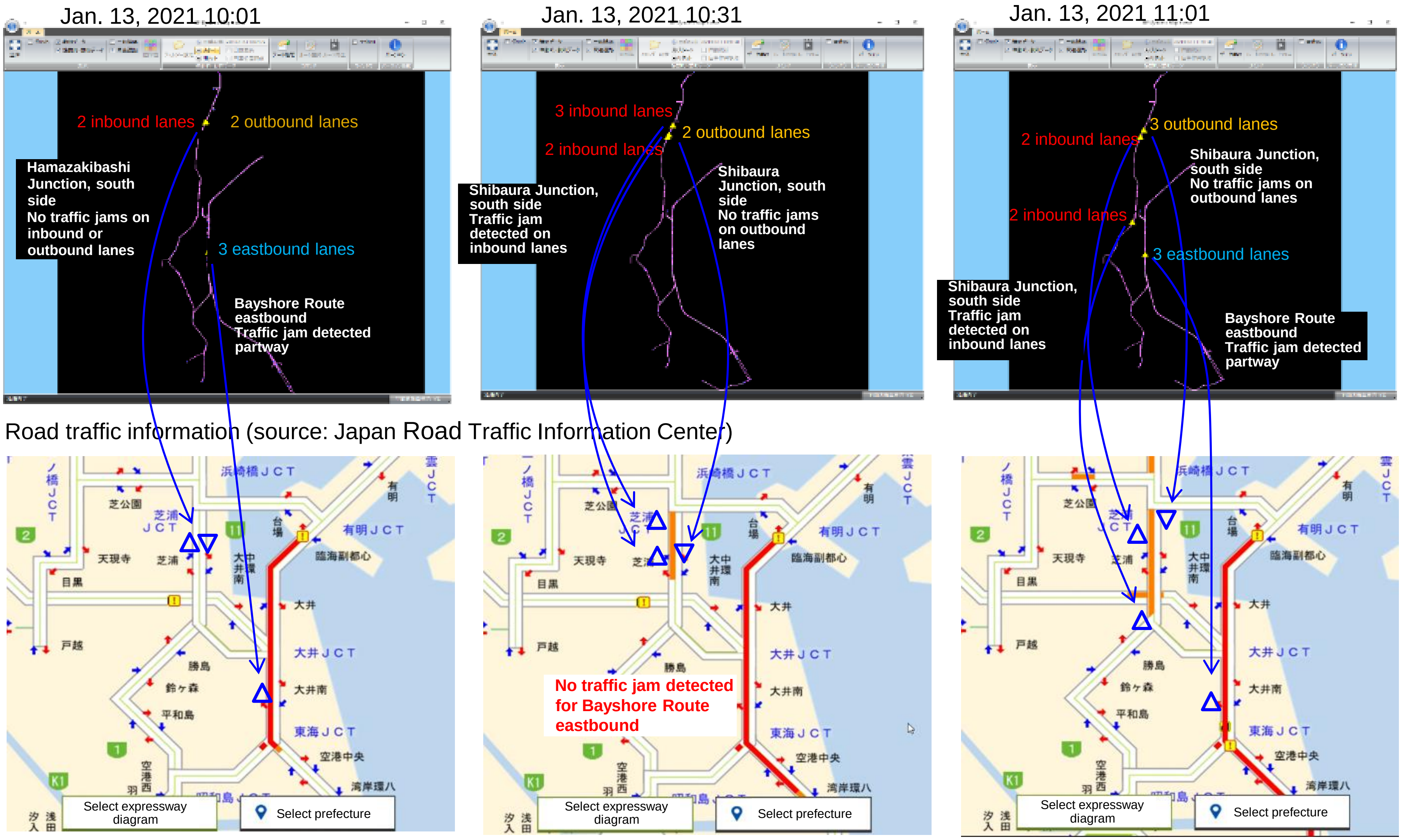


10:01 10:31 11:01

Viewer display example

5. Results of the FOTs on the Metropolitan Expressway

5-3 Lane-specific traffic information transmission testing: Field advance confirmation (Comparison with JARTIC information (factory evaluation))



Jan. 13, 2021 10:01

2 inbound lanes

2 outbound lanes

Hamazakibashi Junction, south side
No traffic jams on inbound or outbound lanes

3 eastbound lanes

Bayshore Route eastbound
Traffic jam detected partway

Jan. 13, 2021 10:31

3 inbound lanes

2 outbound lanes

2 inbound lanes

Shibaura Junction, south side
Traffic jam detected on inbound lanes

Shibaura Junction, south side
No traffic jams on outbound lanes

Jan. 13, 2021 11:01

3 outbound lanes

2 inbound lanes

Shibaura Junction, south side
No traffic jams on outbound lanes

2 inbound lanes

3 eastbound lanes

Shibaura Junction, south side
Traffic jam detected on inbound lanes

Bayshore Route eastbound
Traffic jam detected partway

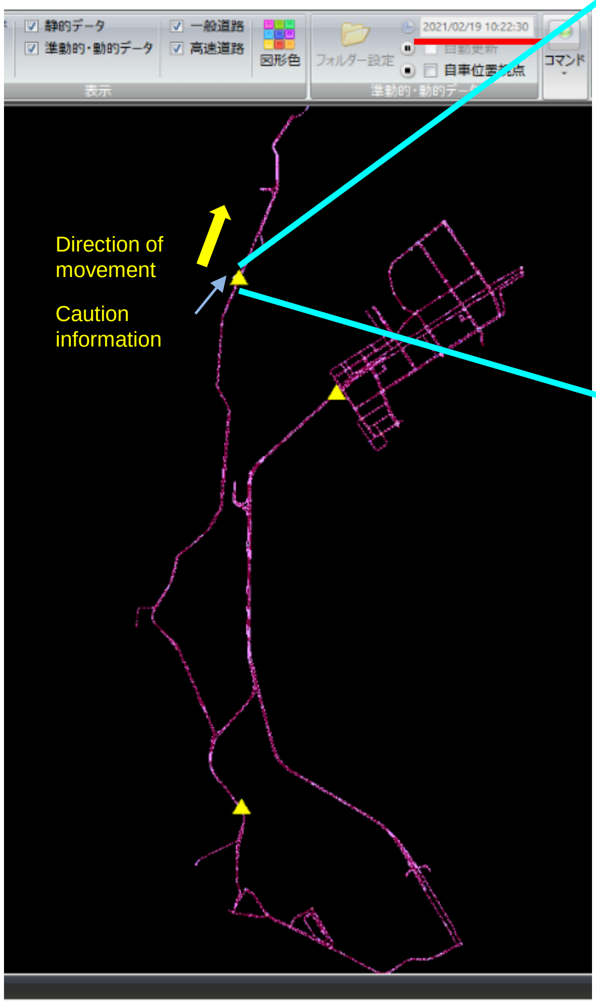
Road traffic information (source: Japan Road Traffic Information Center)

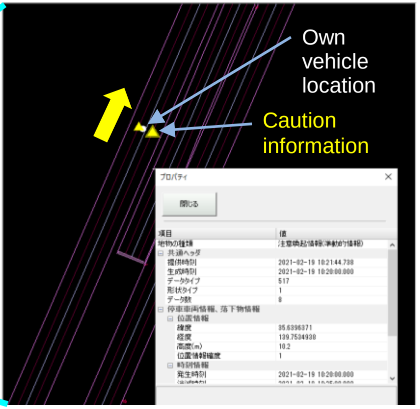
No traffic jam detected for Bayshore Route eastbound

5. Results of the FOTs on the Metropolitan Expressway

5-3 Lane-specific traffic information transmission testing:
Field verification (2) Feb. 19, 2021. approx. 10:22:30 (evaluated through on-site driving)

The tail end of the traffic jam was further back than the location indicated in the caution information





項目	値
地物の種類	注意喚起情報(準動的情報)
⊟ 共通ヘッダ	
提供時刻	2021-02-19 10:21:44.738
生成時刻	2021-02-19 10:20:00.000
データタイプ	517
形状タイプ	1
データ数	8
⊟ 停車車両情報、落下物情報	
⊟ 位置情報	
緯度	35.6396371
経度	139.7534938
高度(m)	10.2
位置情報確度	1
⊟ 時刻情報	
発生時刻	2021-02-19 10:20:00.000

Japan Road Traffic Information Center website screen
Feb. 19, 10:20 a.m.

There was already a traffic jam at the data location.
Approx. 10:22:30 Speed: 23 km/h

The speed of the traffic slowed (to 30 km/h or less) approximately 4 1/2 minutes earlier (approx. 1.3 km ahead of the location in the caution information. 10:17:55 Speed: 30 km/h or less The right lane slowed approximately 10 seconds earlier.

The traffic jam was growing, so the situation is believed to have occurred because of the time lag between when the data was generated and when the location was reached.

6. Results of the FOTs in the Haneda Airport area

6-1 Effectiveness of cooperative infrastructure in regularly scheduled transport

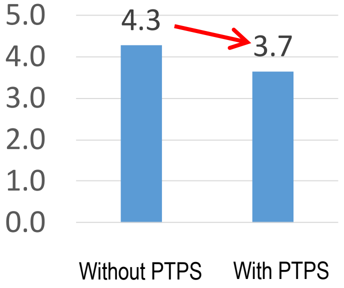
(a) Confirm effectiveness of PTPS in improving arrival speed and punctuality

◆ We confirmed that, as expected, when using PTPS the number of red light stops per route decreased

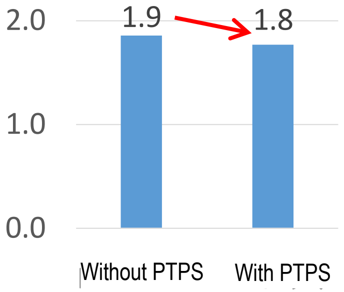
[Analysis results] * When PTPS was used, the number of route drives with few red light stops increased and the average number of red light stops per route drive decreased.

→ **The decrease in red light stops is believed to have been linked to reduced average required times through the use of PTPS.**

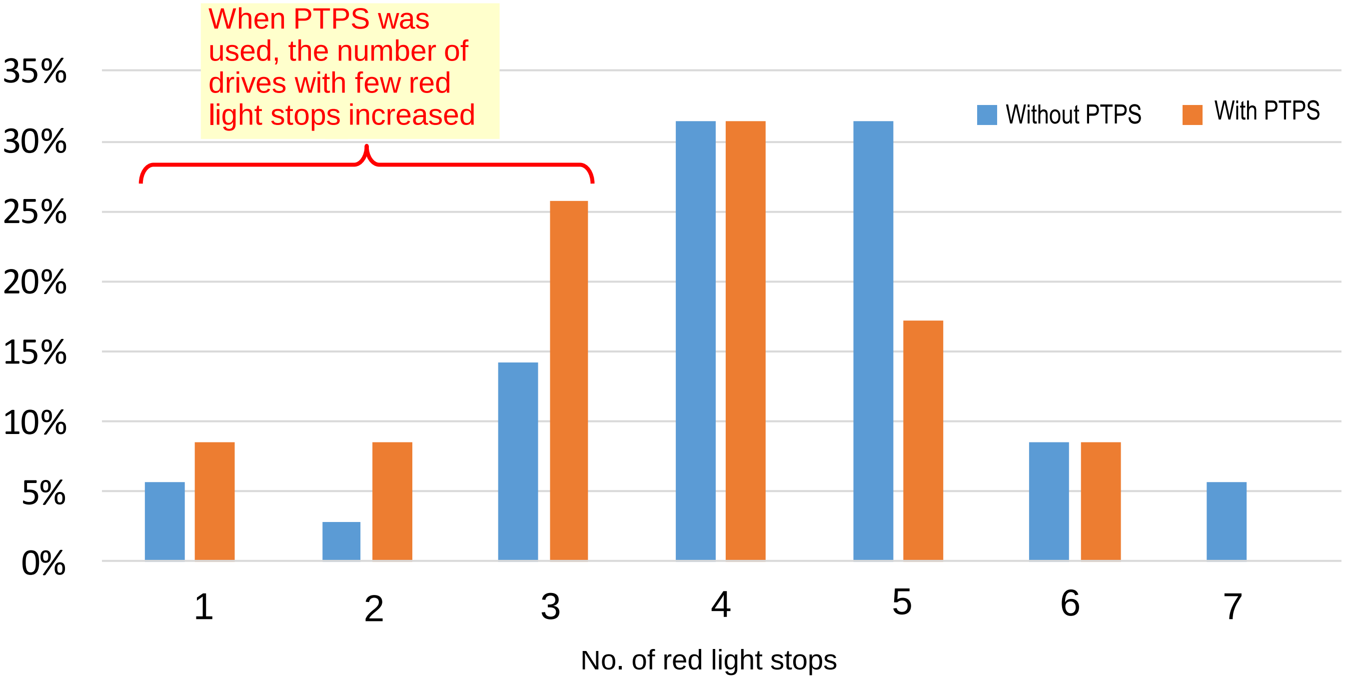
Average number of red light stops per route



Standard deviation of red light stops per route



Distribution of no. of drives by number of red light stops per route (with/without PTPS)
: for drives by Company C


When PTPS was used, the number of drives with few red light stops increased

6. Results of the FOTs in the Haneda Airport area

6-1 Effectiveness of cooperative infrastructure in regularly scheduled transport

(a) Confirm effectiveness of PTPS in improving arrival speed and punctuality

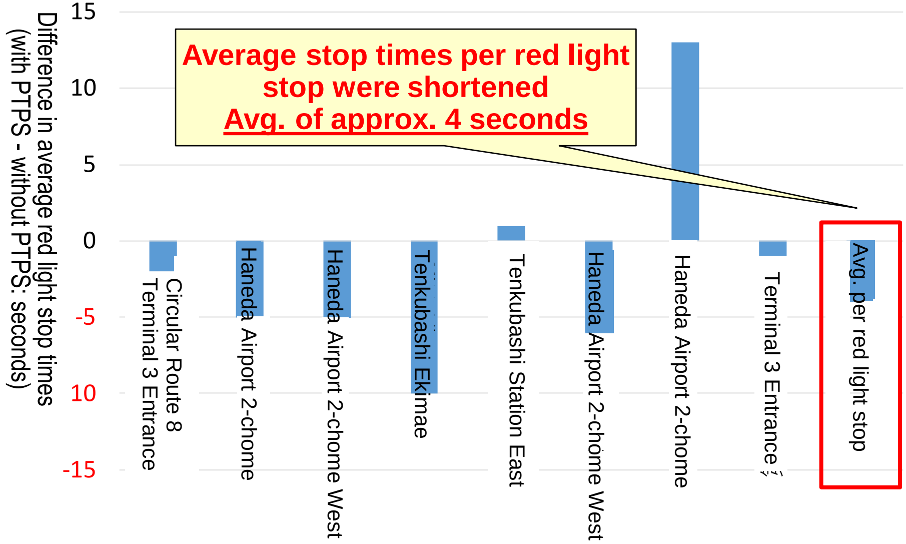
◆ We confirmed that, as expected, when using PTPS the amount of time spent stopped at red lights decreased

[Analysis results]

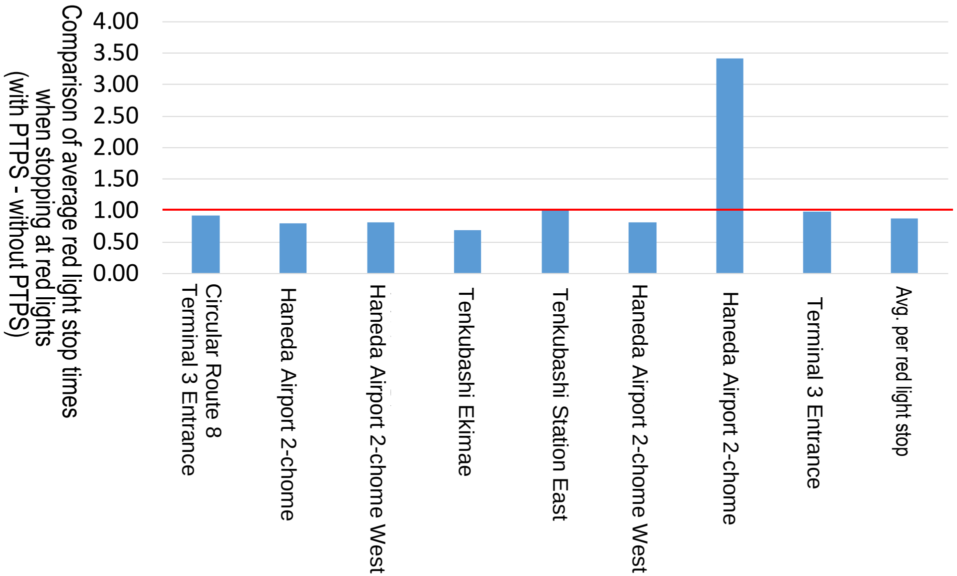
* Comparison of drives with and without PTPS showed that red light stop times were shorter for many intersections when using PTPS. The average stop time per red light was shortened.

→ **We also confirmed that the average required time was reduced by the reduction in average stop times at red lights.**

Differences in average red light stop times *
(with PTPS - without PTPS) : for drives by Company C



Comparison of average red light stop times when stopping at red lights*
(with/without PTPS) : for drives by Company C



* Average red light stop times = total red light stop time for all intersections ÷ number of red light stops

6. Results of the FOTs in the Haneda Airport area

6-1 Effectiveness of cooperative infrastructure in regularly scheduled transport

(b) Confirm impact on driving in situations involving signal recognition difficulty

◆ Assess impact of situations involving signal recognition difficulty on autonomous bus driving

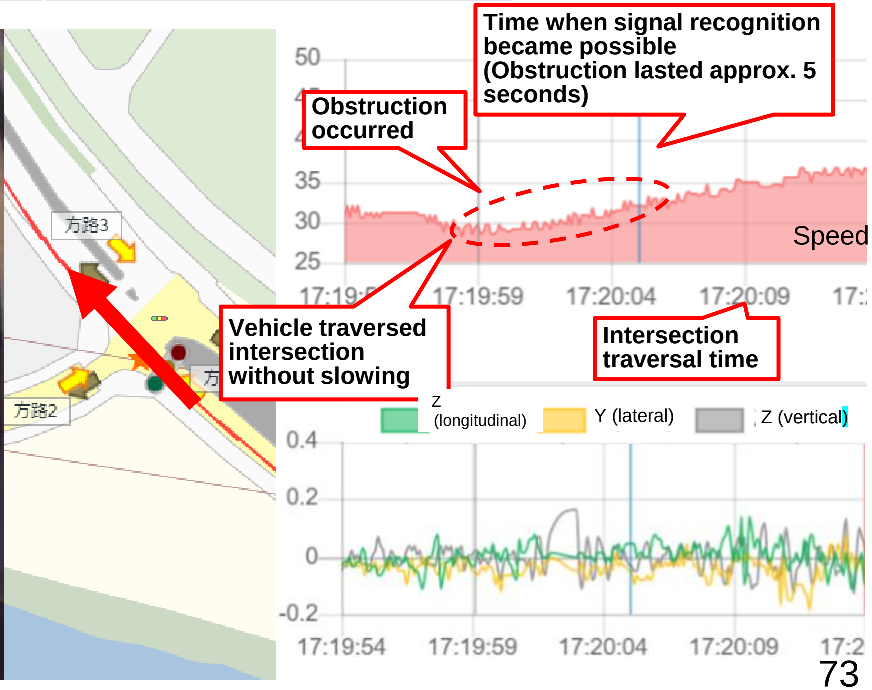
[Analysis results]

Even when driving on roads with good visibility, the traffic signal color was obstructed by a large vehicle immediately in front of the intersection.

Company A: August 17, 2020, 17:19:59

Identification of situations involving signal recognition difficulty

Name of intersection	Speed when obstruction occurred	Speed when traversing intersection	Issue
Haneda Airport 2-chome West	32 km/h	36 km/h	Obstruction of traffic signal by large vehicle


Time when signal recognition became possible (Obstruction lasted approx. 5 seconds)

Obstruction occurred

Vehicle traversed intersection without slowing

Intersection traversal time

6. Results of the FOTs in the Haneda Airport area

6-1 Effectiveness of cooperative infrastructure in regularly scheduled transport

(c) GNSS measurement deviation during automated driving

* The reference line is the magnetic marker line connecting locations where magnetic markers are buried

[Analysis results]

* Near Terminal 3, where there are overhead obstructions, there is a large amount of deviation between current locations estimated by GNSS on-board equipment and reference lines* → The installation of magnetic markers is effective in locations with a high level of GNSS measurement deviation

[[2]Analysis method] Measure the distance between GNSS measurement values and magnetic marker lines

(a) Measure the perpendicular distance between GNSS measurement values (for five route drives)Note 1) and magnetic marker lines during RTK-GNSS drivingNote 2)

(b) Using the data from (a), calculate the average values and standard deviations for each road structure

Note 1) Latitude and longitude data in 0.01 second increments

Note 2) Magnetic marker driving is performed near Terminal 3

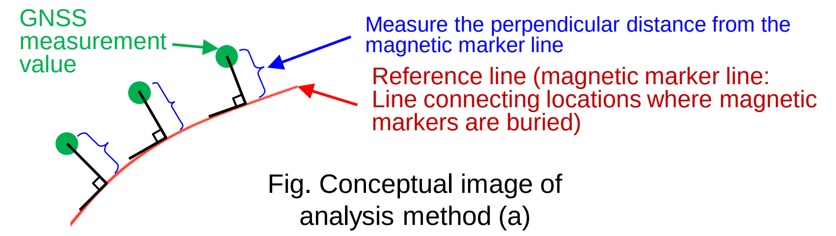
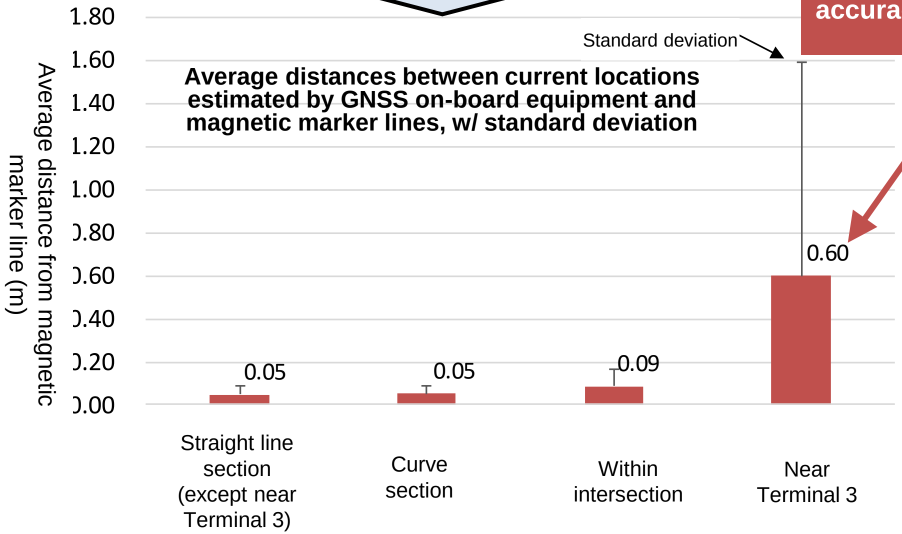
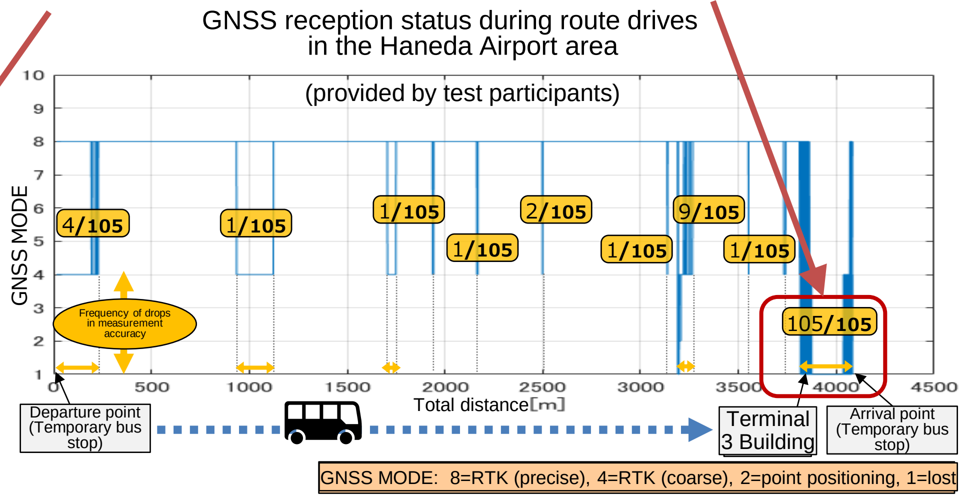


Fig. Conceptual image of analysis method (a)

Near Terminal 3, GNSS measurement mode for all drives is performed in low accuracy mode, and the accuracy of current location estimation by the GNSS on-board equipment is low





* Analysis is performed using data from five RTK-GNSS route drives

* Excludes drives in Zone 1, which has a large number of vehicles parked on the street

n=105 No. of the 105 drives in which GNSS MODE fell to a low accuracy of 4 or below

6. Results of the FOTs in the Haneda Airport area

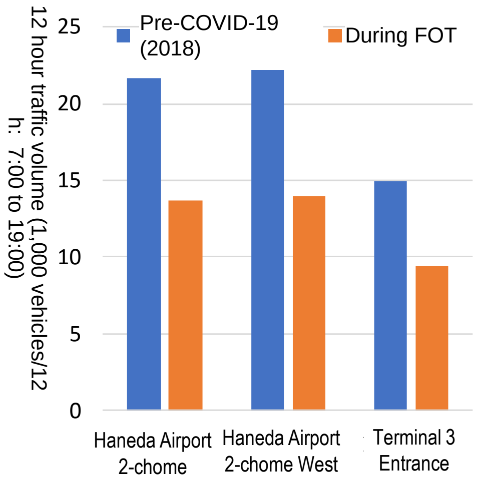
6-2 Assessment of impact of autonomous vehicle driving on traffic flow, and factors causing this impact

(a)Changes in traffic jam conditions resulting from the installation of a bus-only lane

[Evaluation results]

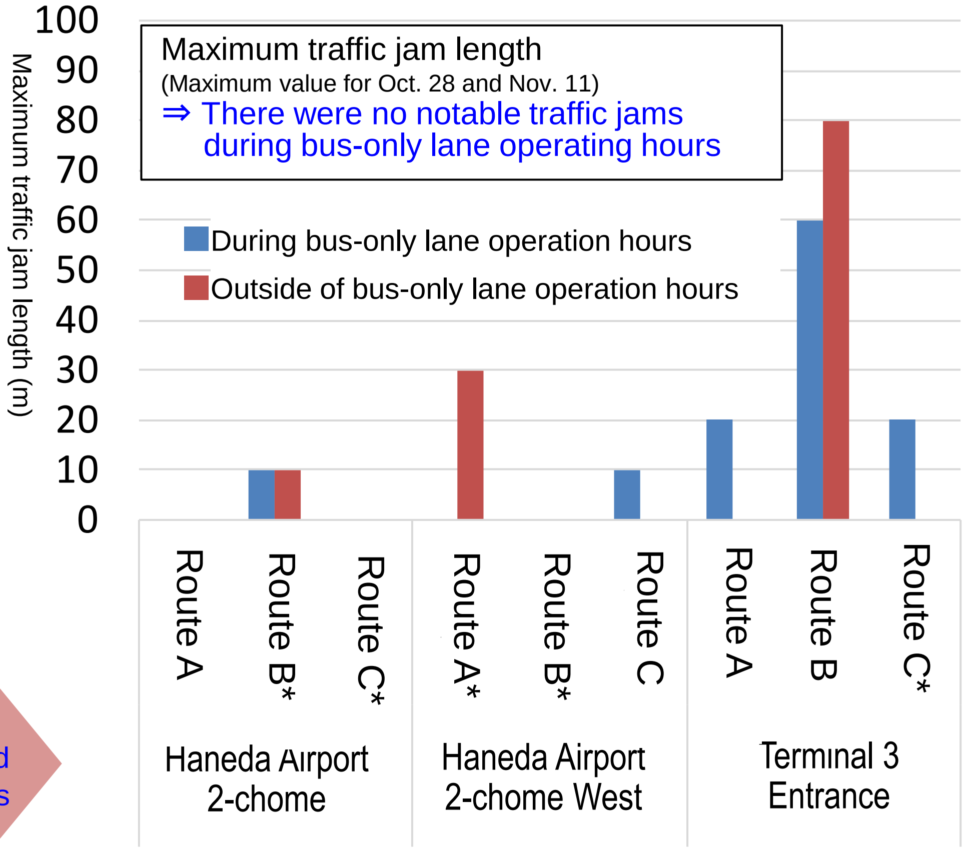
- The amount of traffic volume was roughly 60% of the normal amount of traffic volume pre-COVID-19.
- No increases in traffic jam length were observed during bus-only lane operating hours.

Traffic volume: 37% decrease



Traffic volume fell by roughly 60% compared to pre-COVID-19 levels

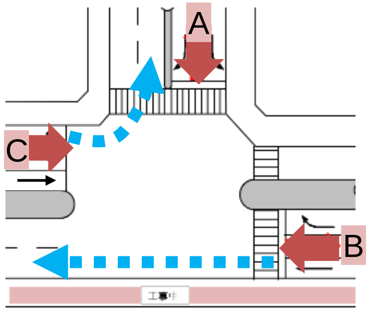
Maximum traffic jam length by intersection and route



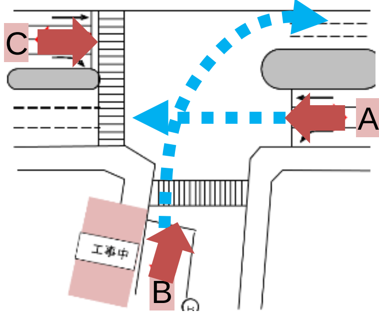
Maximum traffic jam length
(Maximum value for Oct. 28 and Nov. 11)
⇒ There were no notable traffic jams during bus-only lane operating hours

Note) Routes indicated with a (*) are routes that were driven by autonomous vehicles

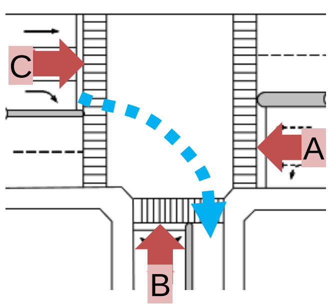
Haneda Airport 2-chome



Haneda Airport 2-chome West



Terminal 3 Entrance



6. Results of the FOTs in the Haneda Airport area

6-2 Assessment of impact of autonomous vehicle driving on traffic flow, and factors causing this impact

(b)Autonomous bus and ordinary bus processing times

◆ Autonomous bus and ordinary bus processing times were observed and the differences between them were used to infer the influence of the presence of autonomous buses on traffic flow

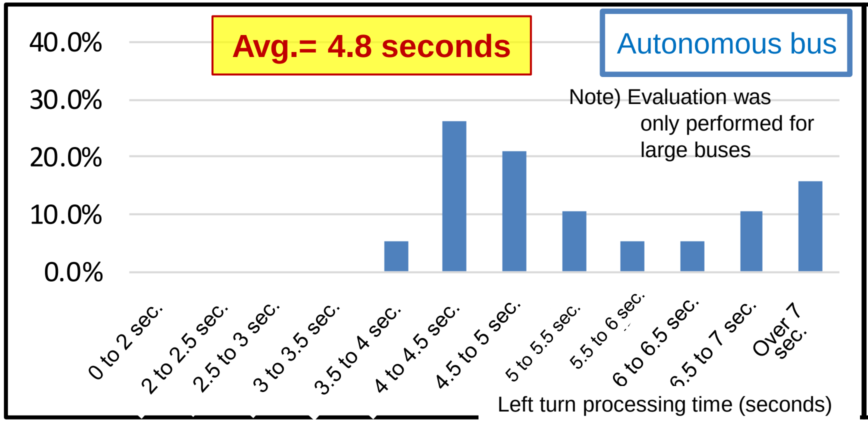
[Analysis results]

- For both left and right turns, the average processing times for autonomous buses were roughly 1 second longer than for ordinary buses.

→ **If all buses switch to autonomous buses, processing traffic volumes are estimated to fall by roughly 4% to 8%.**

Left turn

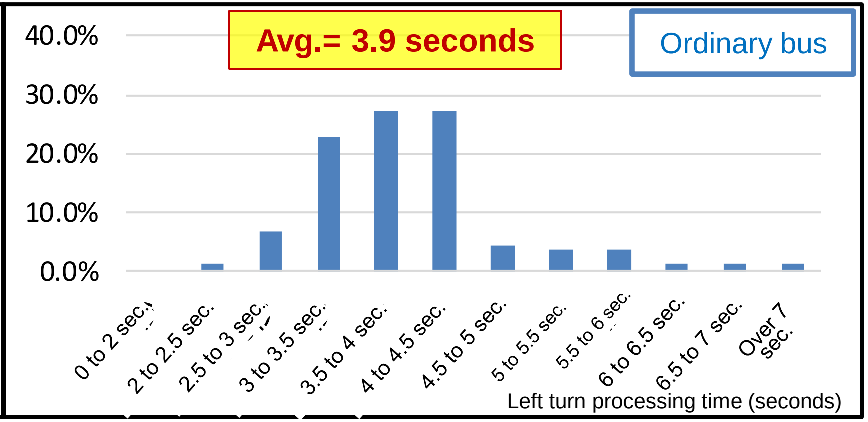
Haneda
Airport
2-chome



Avg.= 4.8 seconds

Autonomous bus

Note) Evaluation was only performed for large buses



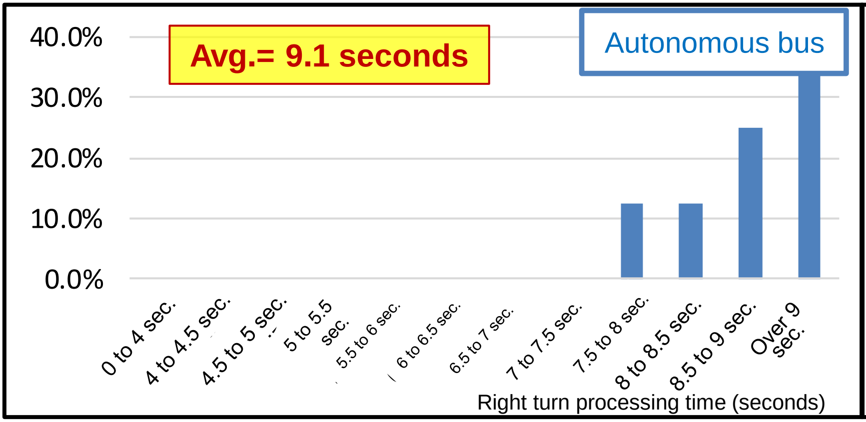
Avg.= 3.9 seconds

Ordinary bus

Right turn

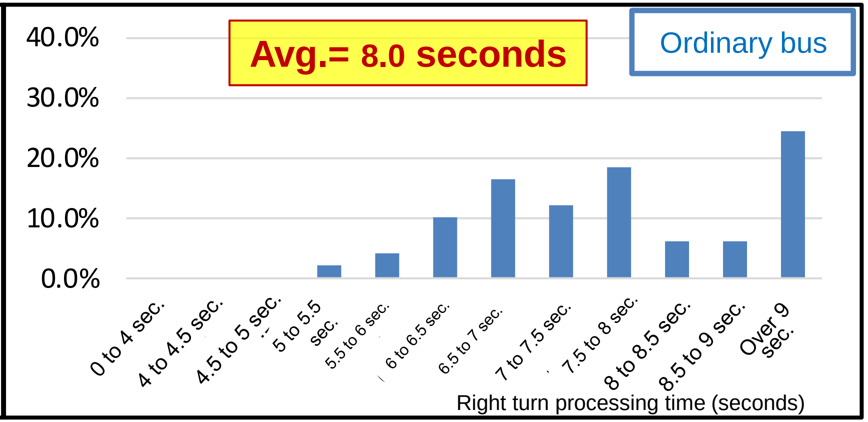
Terminal 3
Entrance

* When right turns are possible, the traffic signal turns red for oncoming vehicles, so oncoming vehicles do not have any impact on right turn times



Avg.= 9.1 seconds

Autonomous bus



Avg.= 8.0 seconds

Ordinary bus

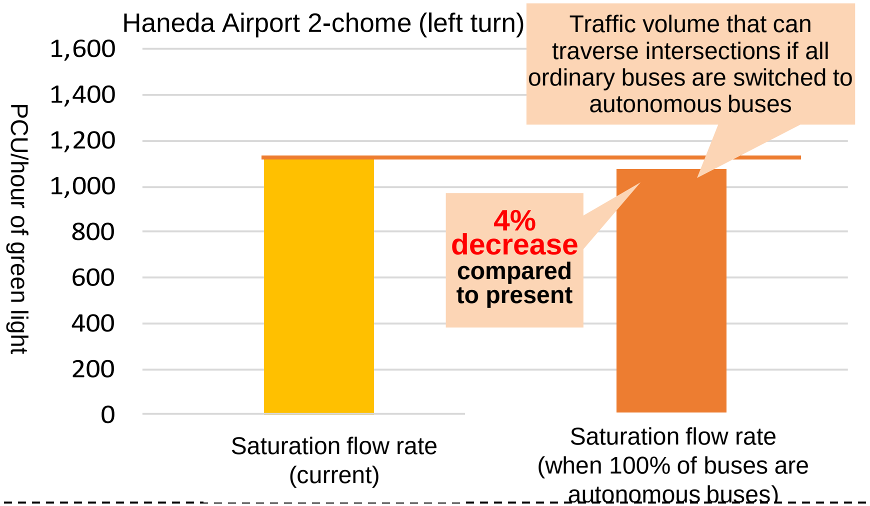
Note) When vehicles were affected by crosswalk pedestrians when traversing intersections, the corresponding data was excluded from the evaluation scope.

6. Results of the FOTs in the Haneda Airport area

(b) Autonomous bus and ordinary bus processing times: Maximum change in processed traffic volume due to presence of autonomous buses

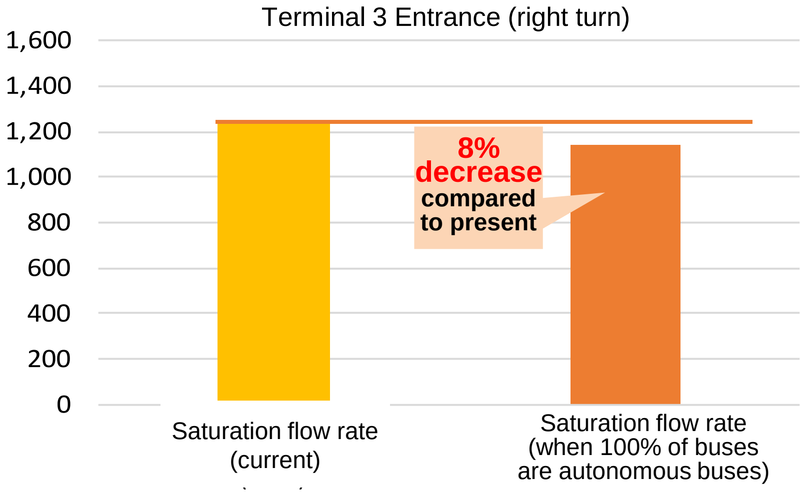
◆ The maximum change in processed traffic volume due to presence of autonomous buses was tentatively calculated based on the difference in processing times between autonomous buses and ordinary buses

[Analysis results] If all buses switch to automated buses, processing traffic volumes are estimated to fall by roughly 4% to 8%.



Traffic volume that can traverse intersections if all ordinary buses are switched to autonomous buses

4% decrease compared to present



8% decrease compared to present

[Calculation procedure]

(1) The average headway was measured for the lanes in the evaluation scope and the saturation flow rate was calculated based on the average headway (*1) (=saturation flow rate (current))

(2) Assuming that headway increases proportionally with the percentage of buses that drive on the lanes within the evaluation scope, the decrease in saturation flow rate was tentatively calculated (=saturation flow rate (when 100% of buses are autonomous buses))

*1) Saturation flow rate (PCU/hr green)1)
=3,600/average headway(calculation of average headway of vehicles in queue)

PCU: Passenger car unit (traffic volume figure that takes into consideration how many passenger vehicles a large vehicle is equivalent to)

The volume of traffic processed per hour of green light was calculated by reducing it by the average processing time increase rate calculated on the previous page

Ref.) Ratio of average processing time for autonomous buses to average processing time for ordinary buses

	Haneda Airport 2-chome (left turn)	Terminal 3 Entrance (right turn)
Average processing time for autonomous buses/average processing time for ordinary buses	1.23	1.14

6. Results of the FOTs in the Haneda Airport area

6-2Assessment of impact of automated vehicle driving on traffic flow, and factors causing this impact

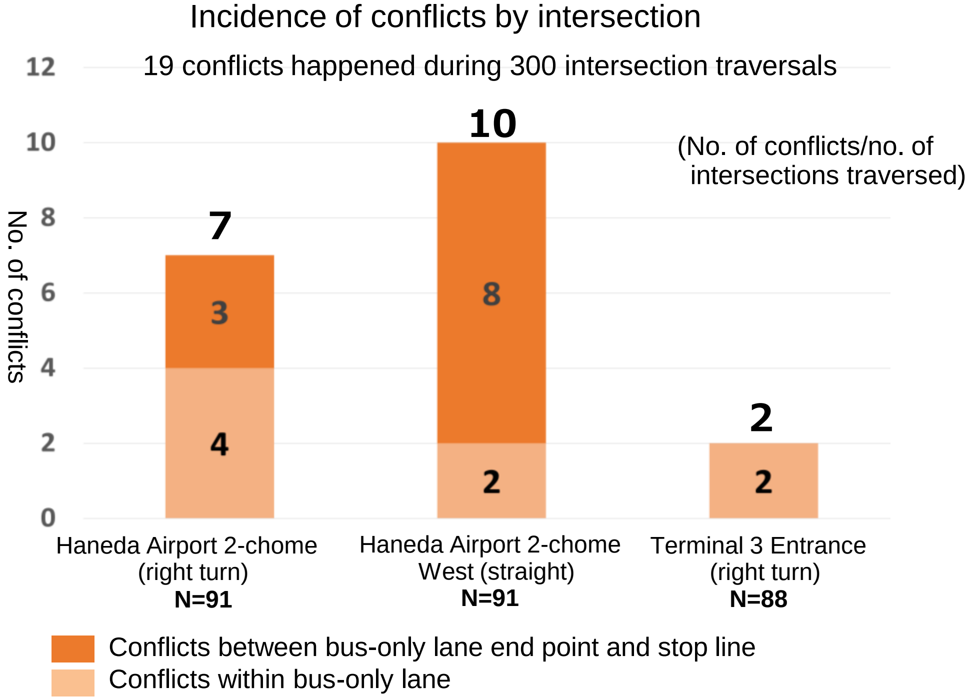
(c)Conflict occurrence related to autonomous buses

Definition of “conflict”:
Situations in which the distance between ordinary vehicles and autonomous buses narrows due to ordinary vehicle lane changes, etc., affecting the behavior (speed/acceleration) of either of the vehicles

[Analysis results]

・There were 19 conflicts in 300 intersection traversals, including conflicts in bus-only lanes.
→ It is also 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.

* Signs placed at bus-only lane start points and end points

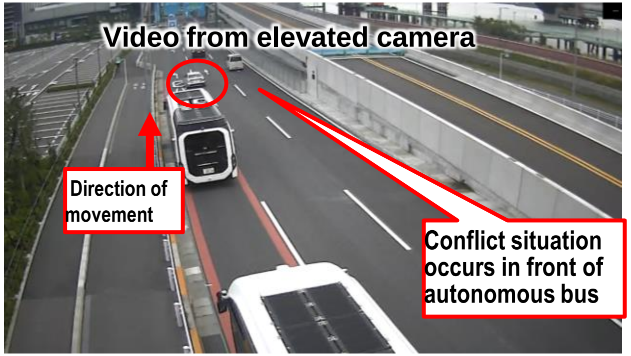

Incidence of conflicts by intersection

19 conflicts happened during 300 intersection traversals

(No. of conflicts/no. of intersections traversed)

	Haneda Airport 2-chome (right turn) N=91	Haneda Airport 2-chome West (straight) N=91	Terminal 3 Entrance (right turn) N=88
Conflicts between bus-only lane end point and stop line	3	8	
Conflicts within bus-only lane	4	2	2
Total	7	10	2

🟧 Conflicts between bus-only lane end point and stop line
🟧 Conflicts within bus-only lane


Video from elevated camera


Video from on-board camera

6. Results of the FOTs in the Haneda Airport area

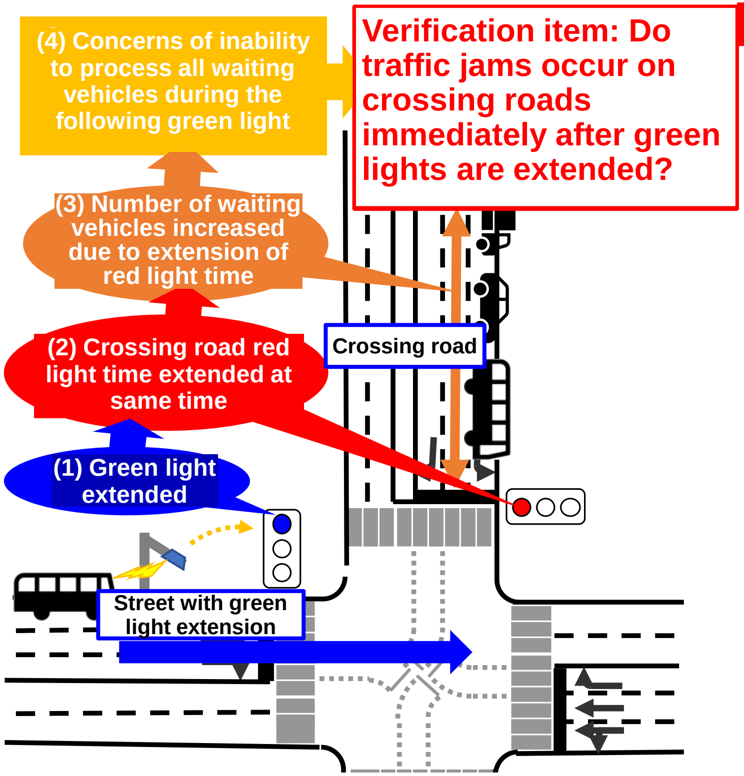
6-2 Assessment of impact of automated vehicle driving on traffic flow, and factors causing this impact

(d)Impact on crossing road traffic when using PTPS to change traffic light cycles

◆ We confirmed the state of incidence of traffic jams on crossing roads when using PTPS to extend green lights and shorten red lights

[Analysis results]

- No crossing road traffic jams were caused by using PTPS to extend green lights and shorten red lights.



Verification item: Do traffic jams occur on crossing roads immediately after green lights are extended?

(4) Concerns of inability to process all waiting vehicles during the following green light

(3) Number of waiting vehicles increased due to extension of red light time

(2) Crossing road red light time extended at same time

(1) Green light extended

Name of intersection	Green light duration extensions	Red light duration reductions	Traffic jams occurring on crossing roads immediately afterwards*1)
Circular Route 8 Terminal 3 Entrance	0	20 (5 seconds)	0
Haneda Airport 2-chome	4 (6 to 12 seconds)	0	0
Haneda Airport 2-chome West	5 (3 to 7 seconds)	0	0
Terminal 3 Entrance	1 (10 seconds)	0	0

- Study of number of cases of PTPS control on October 28 and 29
- Numbers in parentheses indicate duration of green light extension/reduction of red light time

*1 We confirmed the status of incidence of traffic jams in the cycles immediately following the extension of green lights or the shortening of red lights