Cross-ministerial Strategic Innovation Promotion Program

TF3-19-245 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" – 2019 Results Reporting Overview –

FOTs in the Tokyo Waterfront Area Consortium

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Nippon Koei Co., Ltd.
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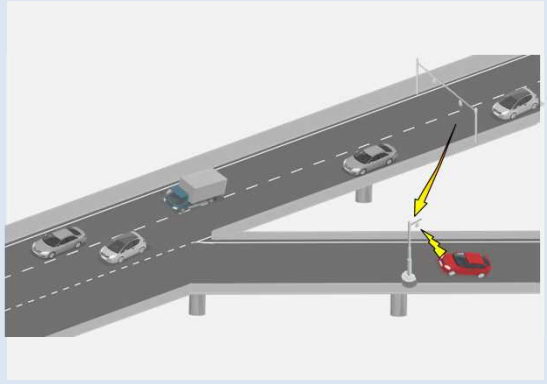
1. Background and Purposes of the FOTs in the Tokyo Waterfront Area

[Implementation contents and testing areas]

Transmitting traffic signal information via ITS wireless to **implement advanced automated driving on ordinary roads**

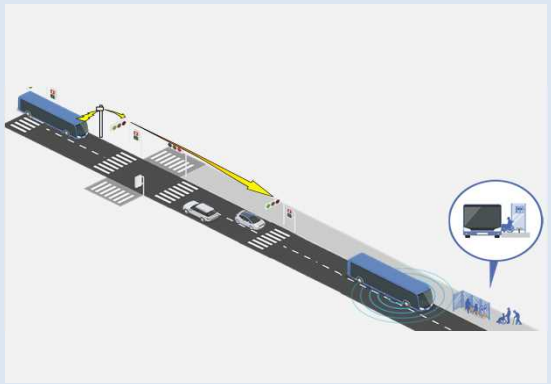
① Waterfront City Area
③ Haneda Airport area

Transmitting driving support information and lane-level traffic environment information using via ETC2.0 to **implement advanced automated driving on highways**



②Expressway routes connecting Haneda Airport and the Waterfront City, etc.

Defining ODDs and using infrastructure facilities such as advanced PTPS in mixed traffic environments to **implement ART using automated driving technology**



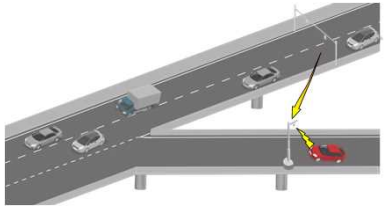
③Haneda Airport area

1. Background and Purposes of the FOTs in the Tokyo Waterfront Area

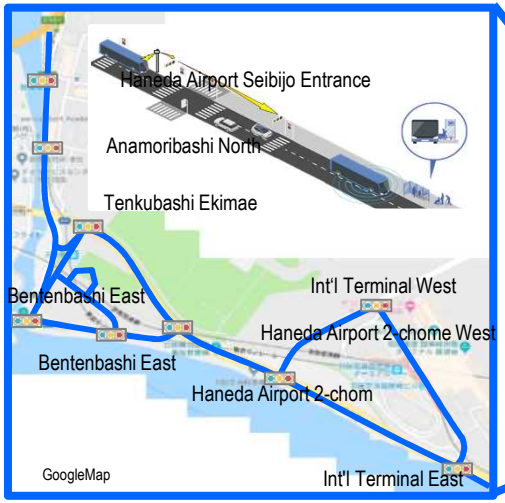
[Implementation contents and testing areas]

②Expressway routes connecting Haneda Airport and the Waterfront City, etc.

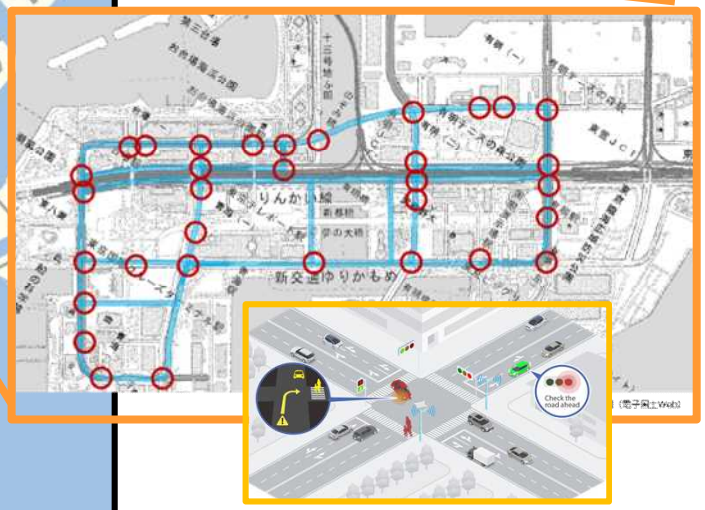
Providing gate and merging support information through ETC2.0 road-to-vehicle communication（FY2019 – FY2020）



③Haneda Airport area (ordinary roads)



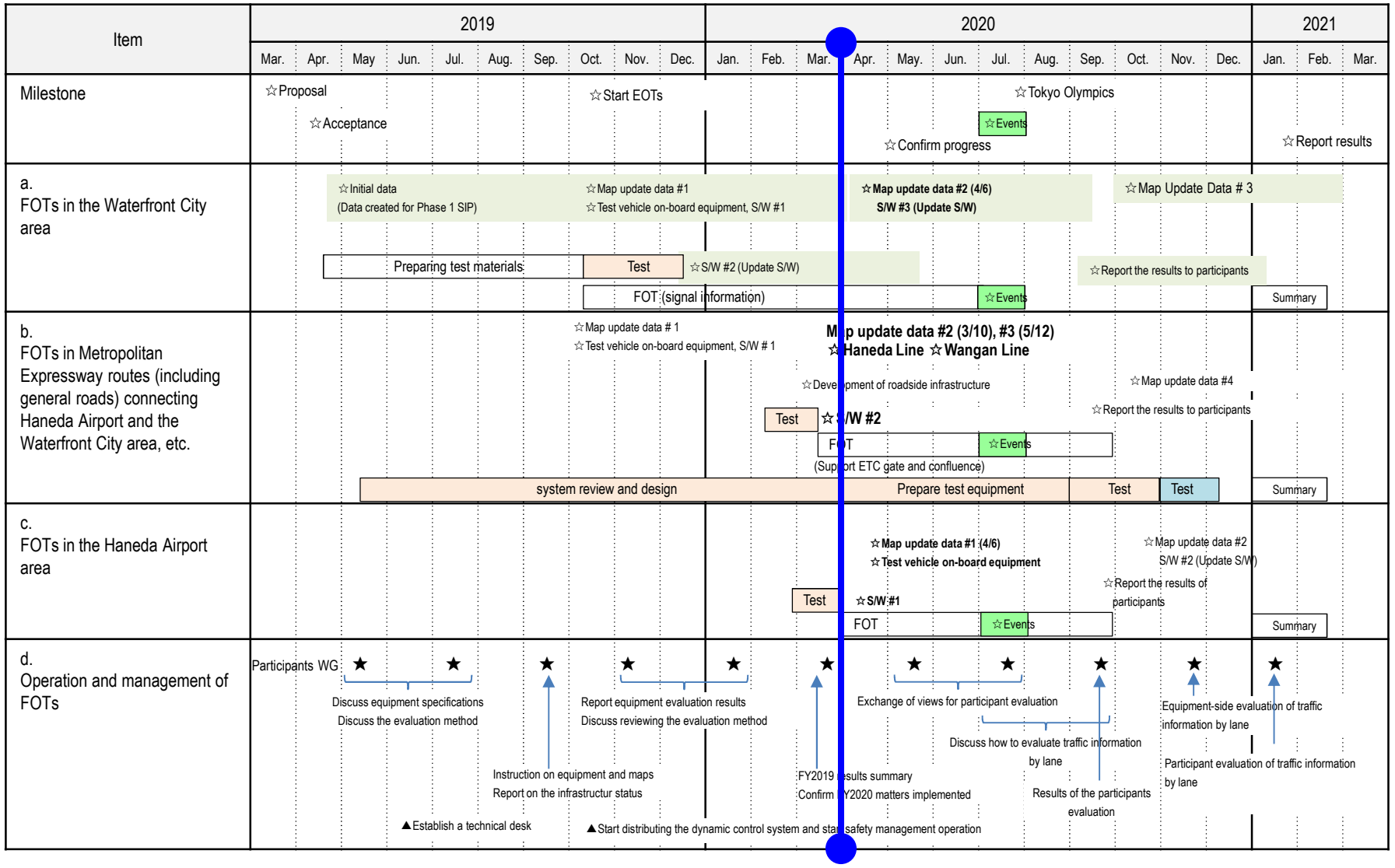
①Waterfront City Area (ordinary roads)



・Realize highly automated driving on ordinary roads by supplying traffic signal information via ITS wireless communication(750Mhz) (FY2019 - FY2020)

Realize ART (autonomous bus) in mixed transportation environments by utilizing infrastructure equipment such as magnetic markers and PTPS (FY2020)

2. FOTs in the Tokyo Waterfront area schedule



3. Contents of tests performed in each area

3.1 Waterfront City area

(1) Overview

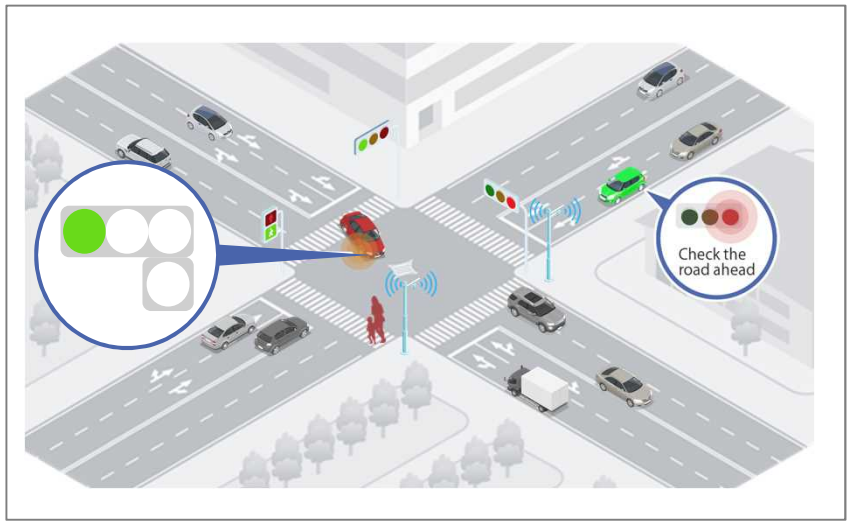
Issues

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

* Timing when it is not possible to pass the stop line when the light is yellow, but it is also not possible to stop without braking suddenly

Verification items

- **Infrastructure information effectiveness and conditions** for traffic signal intersections
- **Assessment of impact** of autonomous vehicle driving **on traffic flow, and factors causing this impact**



Hypotheses regarding effectiveness of cooperative infrastructure technologies

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

Target

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

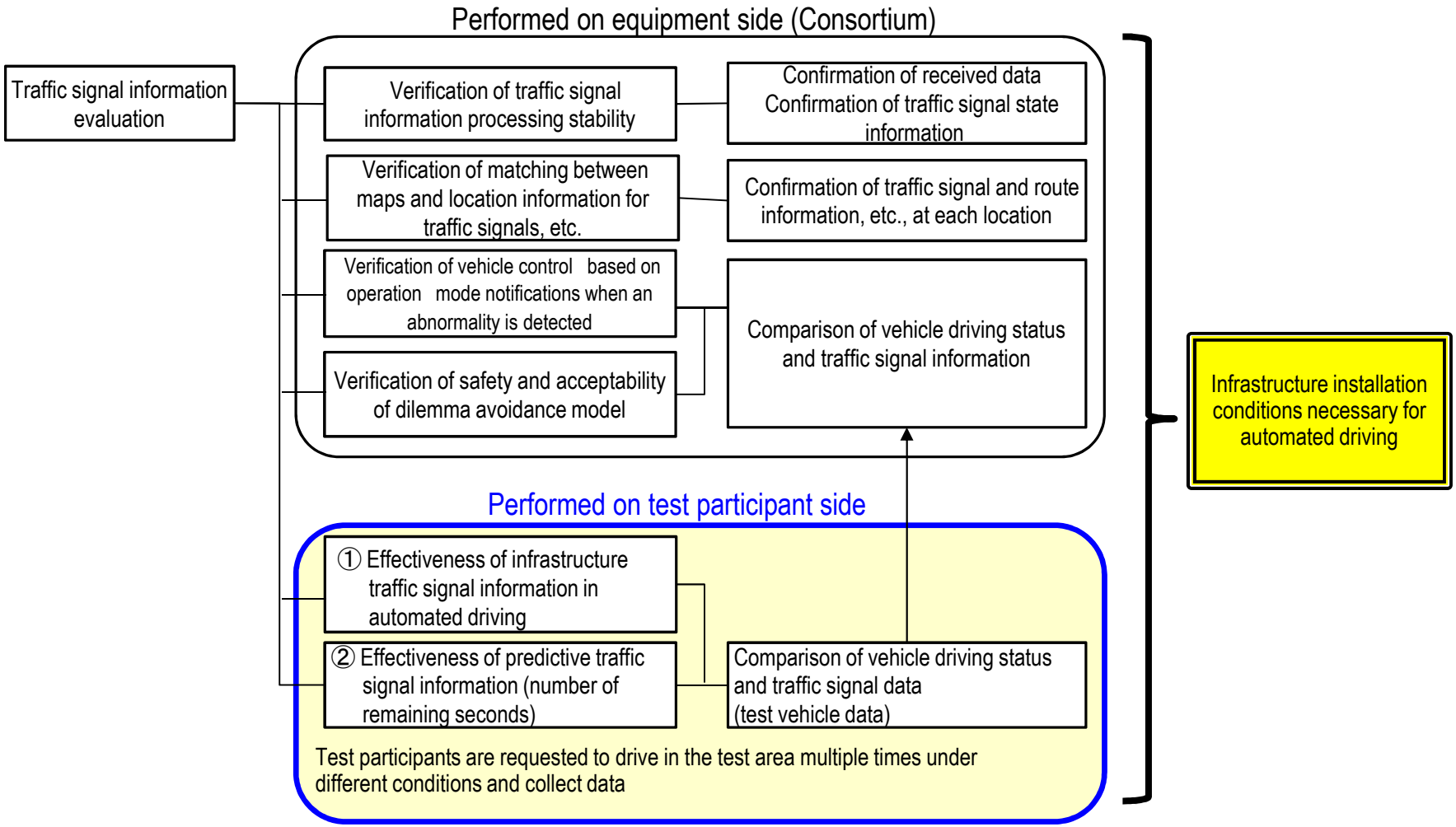
Items to be provided by SIP

Infrastructure	On-board test equipment
• ITS wireless roadside devices for supplying traffic signal information • High-accuracy 3D map	• On-board ITS wireless device • High-accuracy 3D map and distributed information overlap display viewer • Output function to vehicle control • Data logger (movement management)

3. Contents of tests performed in each area

3.1 Waterfront City area

(2) Traffic signal information evaluation concept



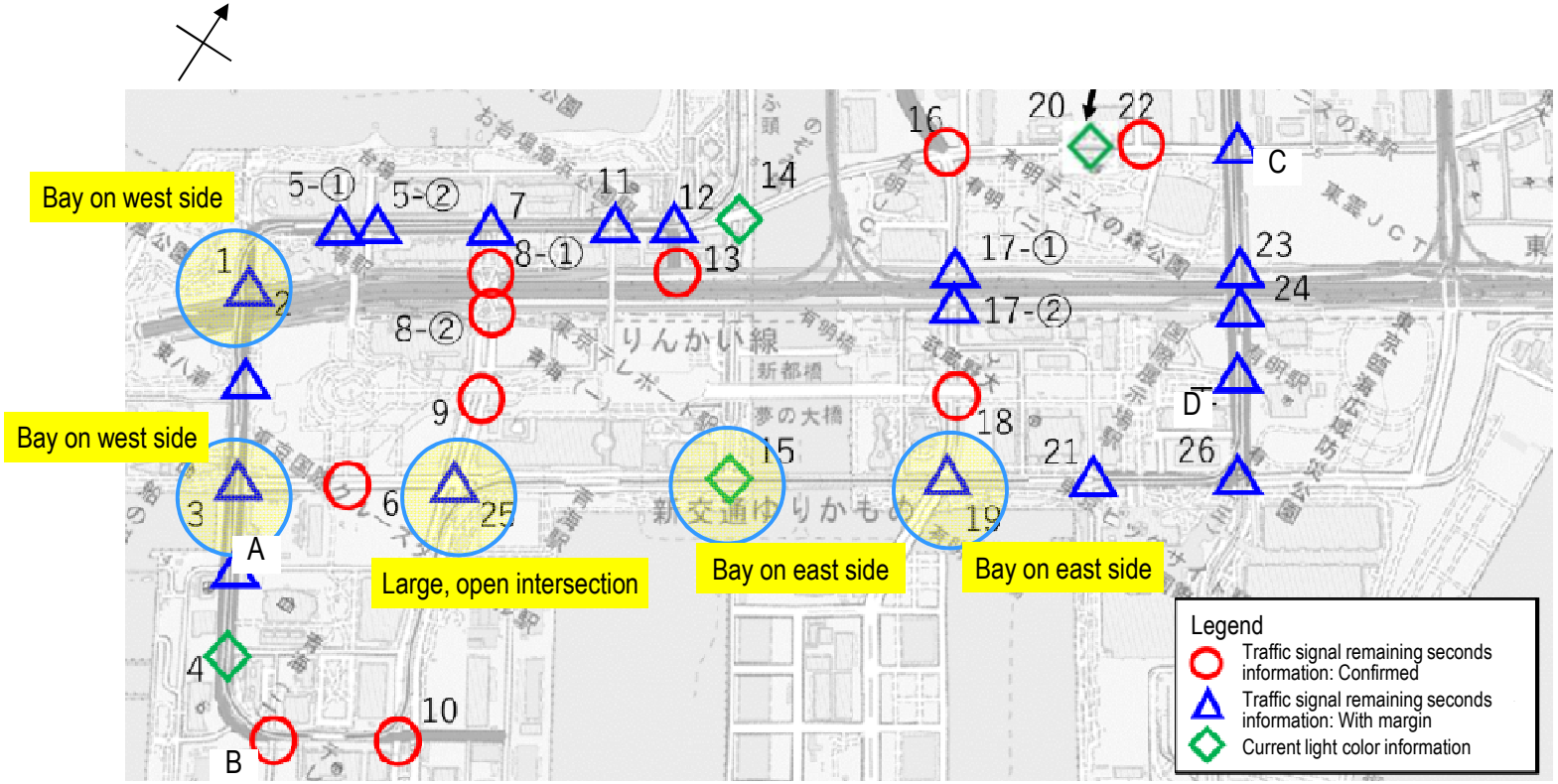
3. Contents of tests performed in each area

3.1 Waterfront City area

(3) Evaluation patterns

① Confirmation of impact on automated driving for intersections/routes for which traffic signal color determination is difficult due to morning sun, evening sun, headlights of oncoming vehicles, etc.

* Please drive and perform testing during the early morning, in the evening, and at night



Intersections in the Waterfront City area where traffic signal current color determination is difficult due to morning or evening sunlight, etc., and intersections with few nearby buildings

Potential evaluation locations

3. Contents of tests performed in each area

3.1 Waterfront City area

(3) Evaluation patterns

① Confirmation of impact on automated driving for intersections/routes for which traffic signal color determination is difficult due to morning sun, evening sun, headlights of oncoming vehicles, etc.

* Please drive and perform testing during the early morning, in the evening, and at night

Backlight（Evening sun）

Backlight（Morning sun）

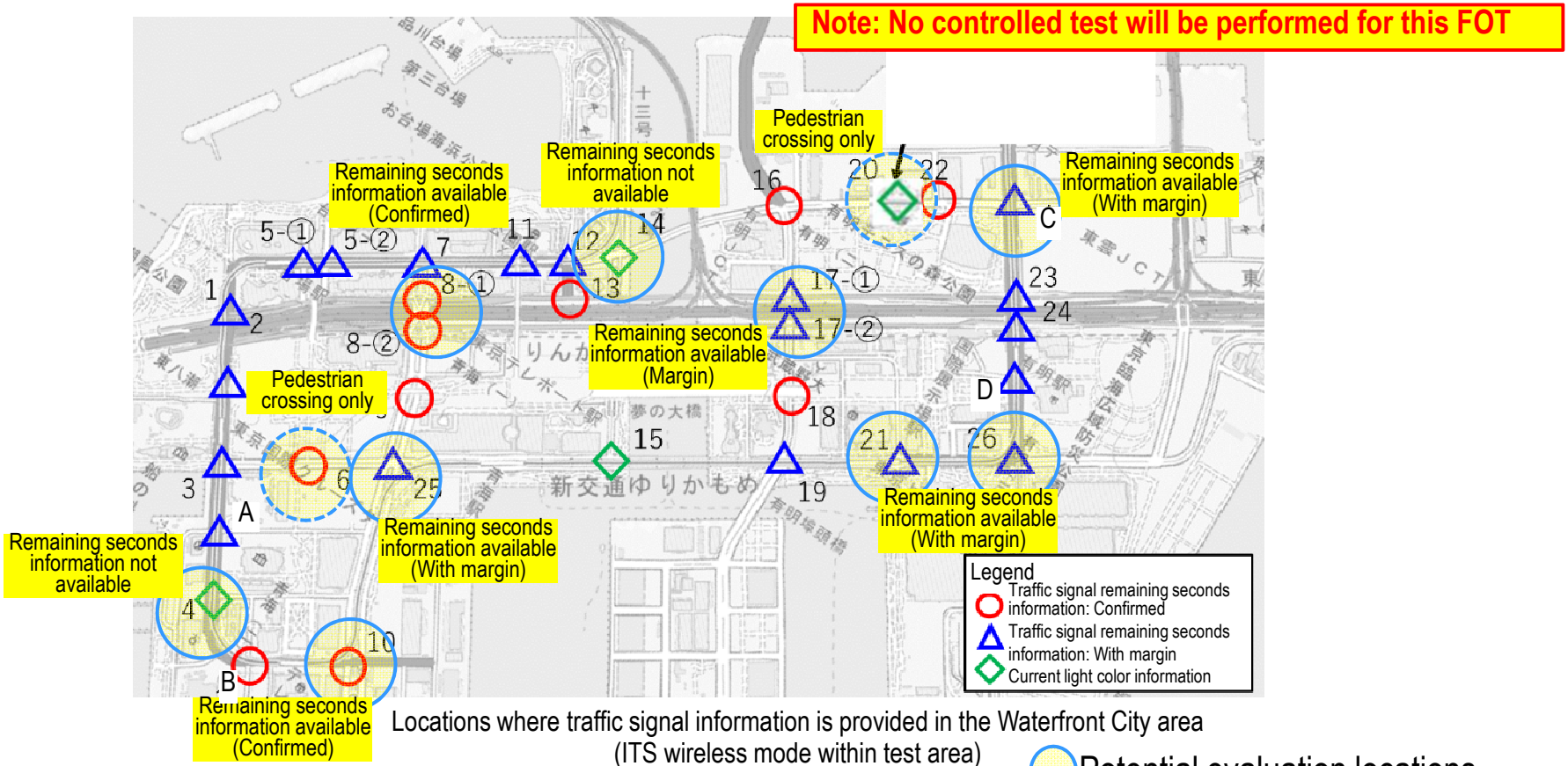
3. Contents of tests performed in each area

3.1 Waterfront City area

(3) Evaluation patterns

② Effectiveness of predictive traffic signal information (number of remaining seconds) (Confirmation of impact of the presence or absence of traffic signal remaining seconds information on automated driving)

Note: No controlled test will be performed for this FOT



Locations where traffic signal information is provided in the Waterfront City area (ITS wireless mode within test area)

Potential evaluation locations

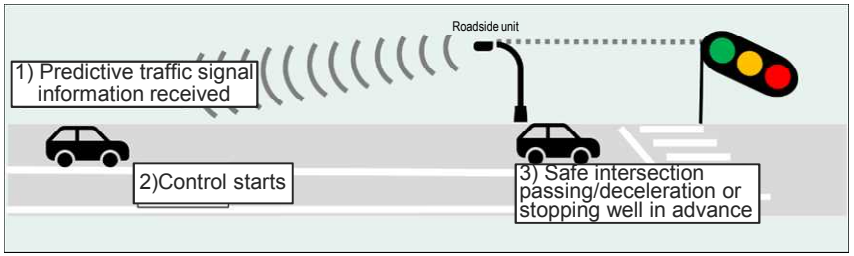
3. Contents of tests performed in each area

3.1 Waterfront City area

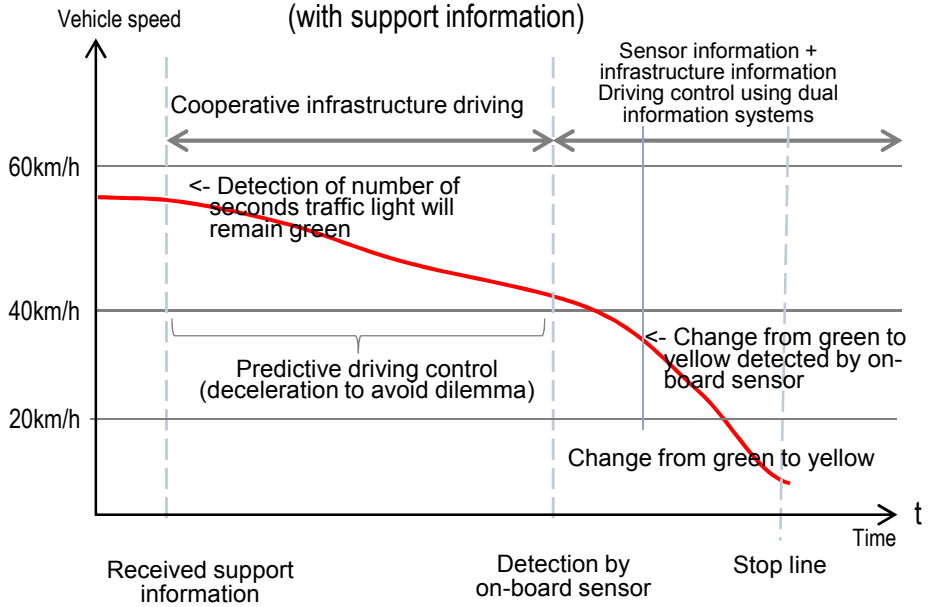
(3) Evaluation patterns

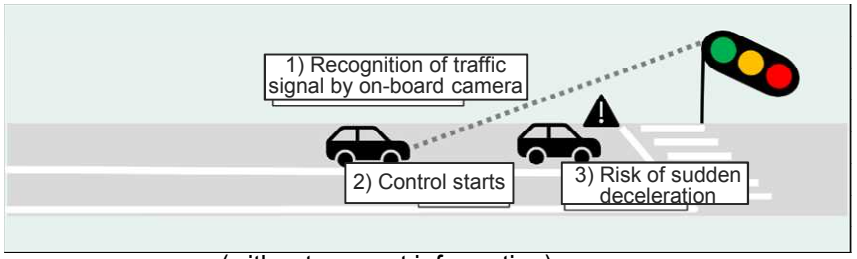
② Effectiveness of predictive traffic signal information (number of remaining seconds)

(Confirmation of impact of the presence or absence of traffic signal remaining seconds information on automated driving)

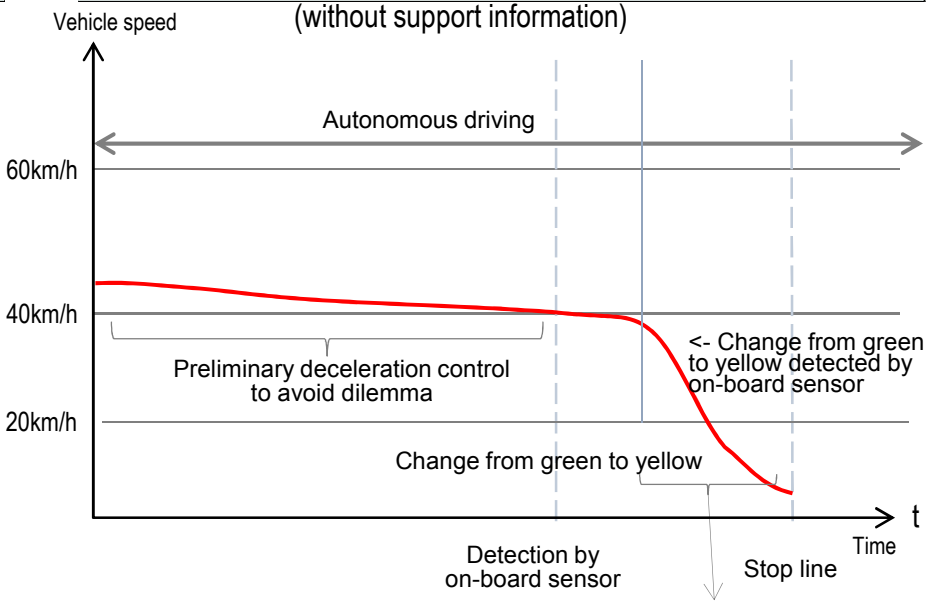


(with support information)





(without support information)



3. Contents of tests performed in each area

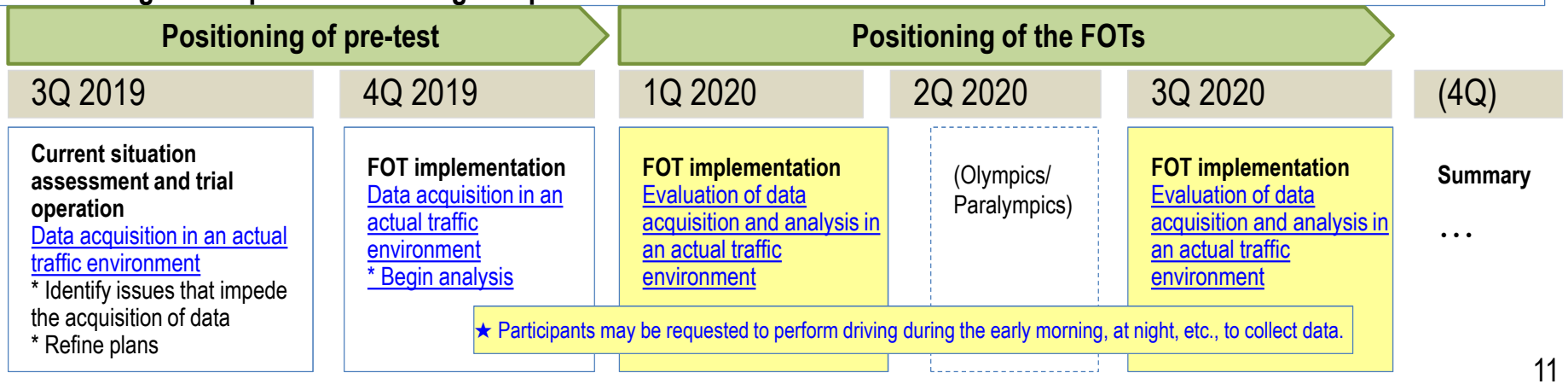
3.1 Waterfront City area

(3) Evaluation patterns

③ Impact assessment

* The impact assessment will consist of evaluation of the impact autonomous vehicles have on their surrounding environment when realizing safe driving in actual traffic environments. This includes their impact on ordinary vehicles driving nearby, crosswalk pedestrians, and the like.
* Study and analysis will be performed using data from test participants, data from movement management systems, and roadside camera video, etc.

- **There are various obstacles and risks that affect automated driving itself in actual traffic environments.**
  - E.g.) In routes with many vehicles parked on the street, automated driving systems may have difficulty making left turns in accordance with Road Traffic Law Articles 18 and 20
  - E.g.) There are many trailers in Odaiba, which can present impediments to automated driving E.g.) Traffic jams may result from observing speed limits, etc.
- **The fourth quarter of 2019 and the first through the third quarters of 2020 are positioned as the FOT evaluation period, and testing will be performed during this period.**



3. Contents of tests performed in each area

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

(1) Overview

Issues

- Smooth ETC gate pass support
- Main roadway merging support based on actual main roadway vehicle speeds

Hypotheses regarding effectiveness of cooperative infrastructure technologies

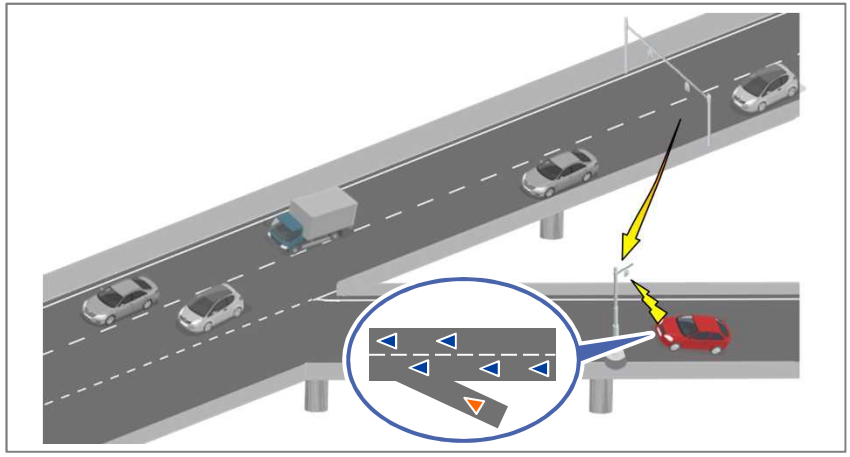
- Support gate selection and passing by providing information
- Support adjustment of vehicles speeds in order to merge into main roadways by providing information

Verification items

- **Appropriateness of operation** of cooperative infrastructure system
- **Effectiveness** of provision of support information to autonomous vehicles, etc.
- Impact on ordinary vehicles (assessment)
- Verification of infrastructure installation conditions

Target

- Consider infrastructure specification improvements
- **Identify infrastructure installation conditions** for airport west exit/entrance
- **Clarify issues** in order to define specifications based on FOT
- Identify infrastructure need and **prioritization requirements**



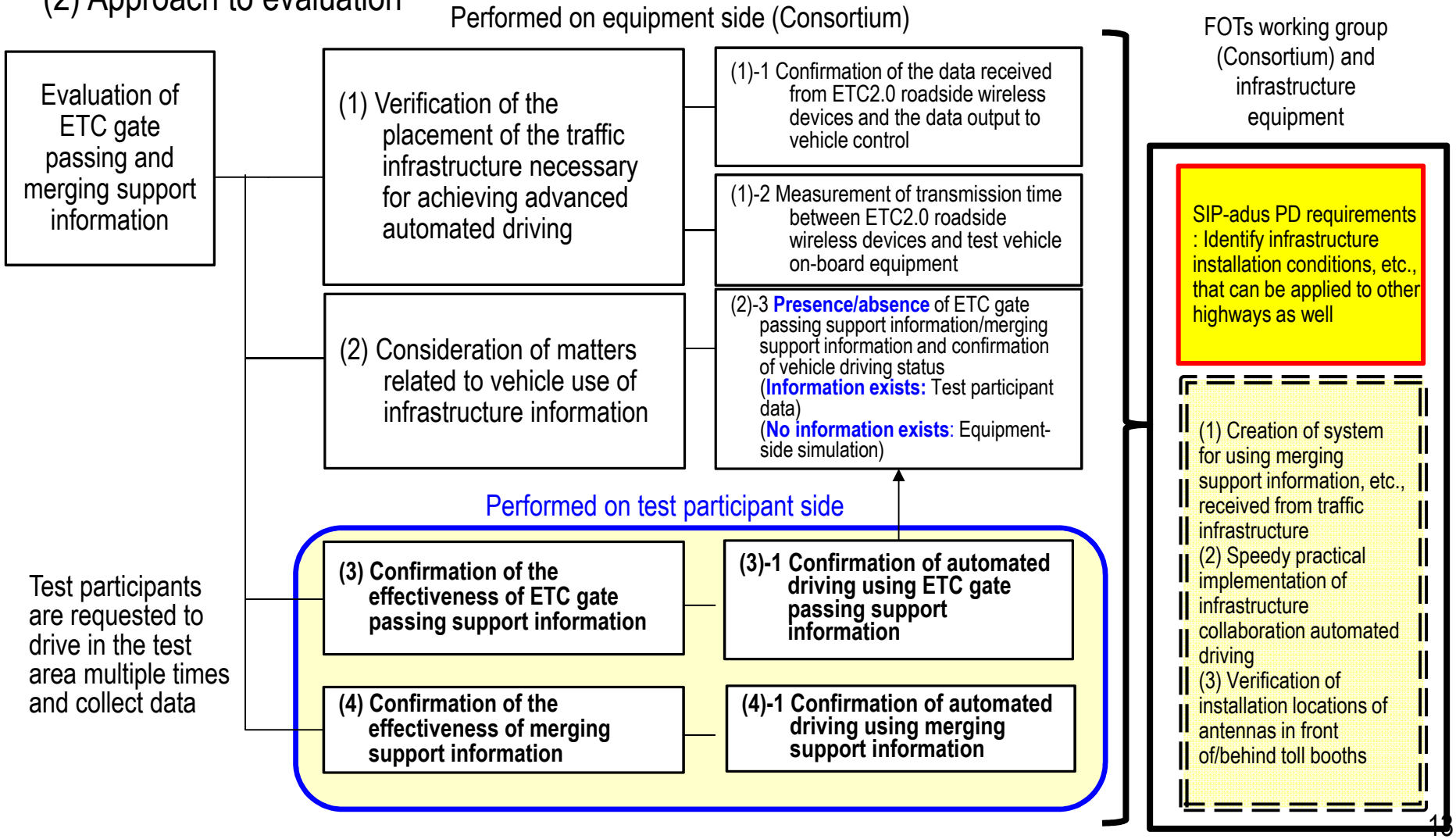
Items to be provided by SIP

Infrastructure	On-board test equipment
• ETC2.0 road-side devices (provision of merging support information and ETC gate pass support information) • High-accuracy 3D map	• ETC2.0 vehicle-mounted device • High-accuracy 3D map and distributed information overlap display viewer • Output function to vehicle control • Data logger (movement management) • Drive recorder

3. Contents of tests performed in each area

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

(2) Approach to evaluation



3. Contents of tests performed in each area

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

(3) Evaluation patterns

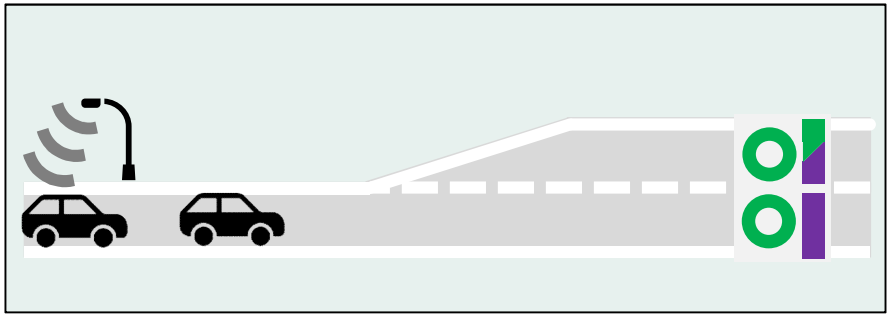
① ETC gate passing support

Application design approach:

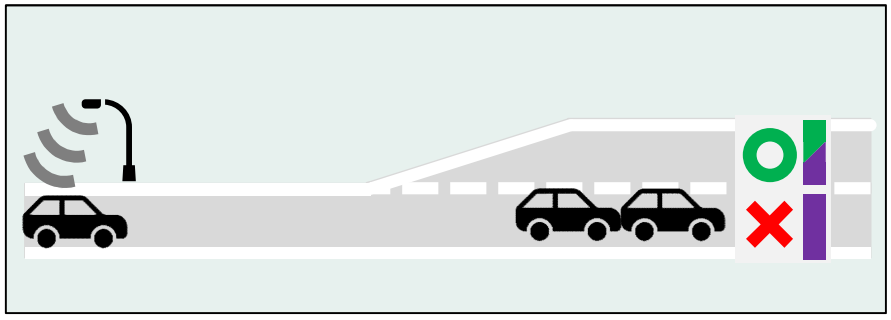
- Vehicles that receive information drive towards appropriate ETC gates without suddenly accelerating, decelerating, or turning, reduce their speed to a safe speed for passing through the ETC gate (20km/h), and pass through the gate

Key evaluation points:

- Confirm whether vehicle control functions in accordance with the driving profile envisioned when designing the system
  Check if differences in driving environments (tracking driving, ETC gate congestion, etc.) have an impact



When tracking driving



When there is congestion near the ETC gate

3. Contents of tests performed in each area

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

(3) Evaluation patterns

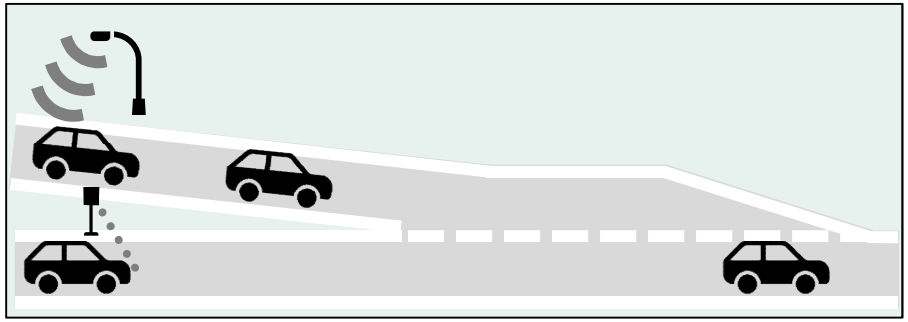
② Merging support

Application design approach:

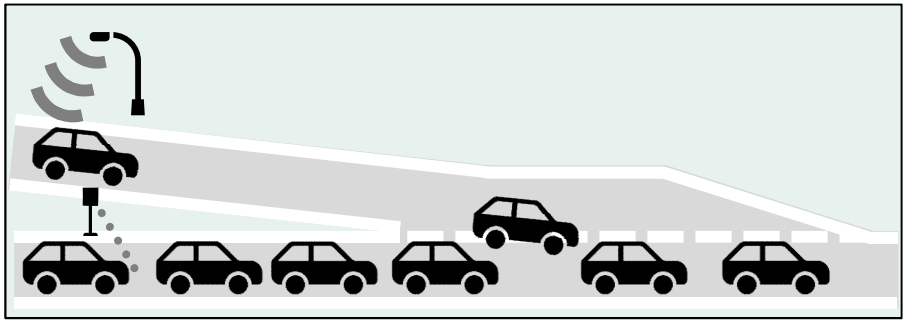
- Vehicles that receive information drive towards the main roadway while accelerating, striving to maintain an appropriate time gap between themselves and the vehicles in front of them, without suddenly accelerating, decelerating, or turning.

Key evaluation points:

- Confirm whether vehicle control functions in accordance with the driving profile envisioned when designing the system
  Check if differences in driving environments (tracking driving, main roadway congestion, etc.) have an impact



When Tracking driving



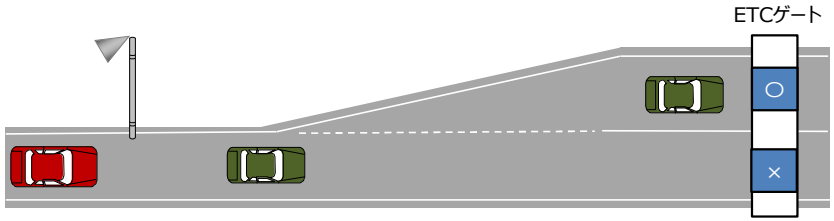
When the main line is congestion

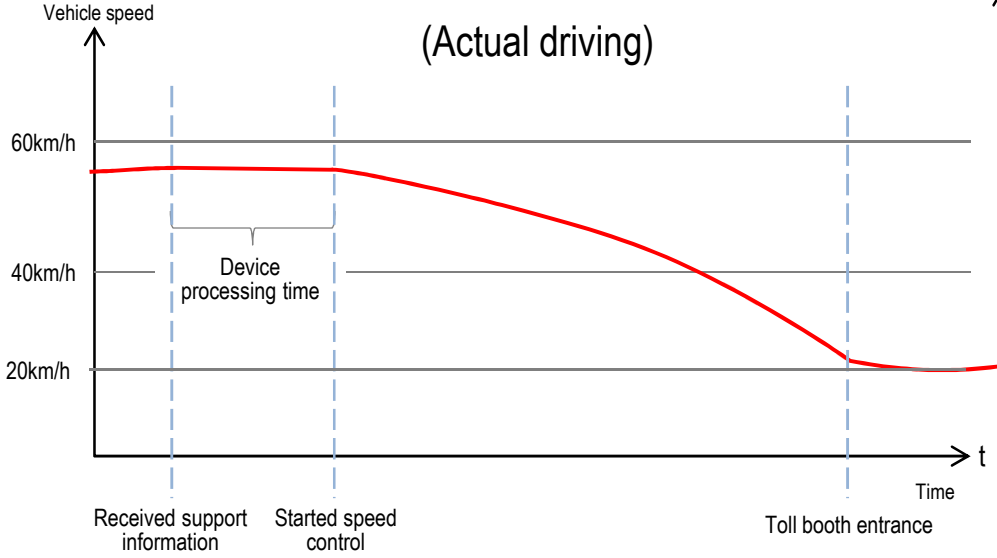
3. Contents of tests performed in each area

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

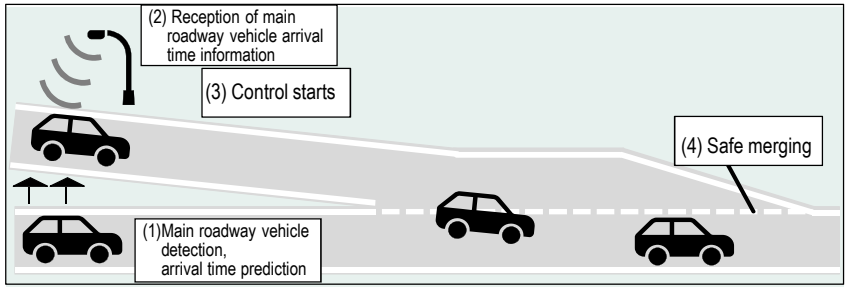
(3) Evaluation patterns

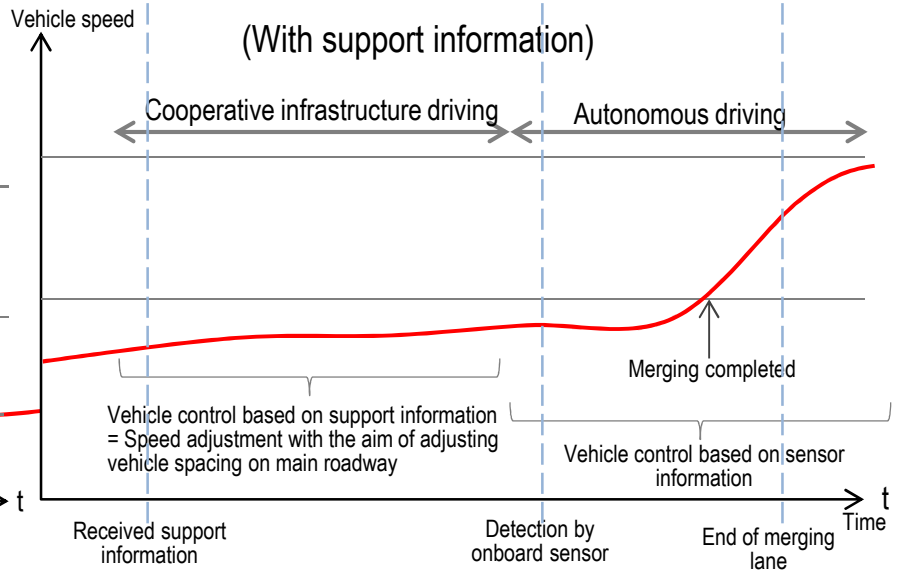
① ETC gate passing support





② Merging support





3. Contents of tests performed in each area

3.3 Haneda Airport area

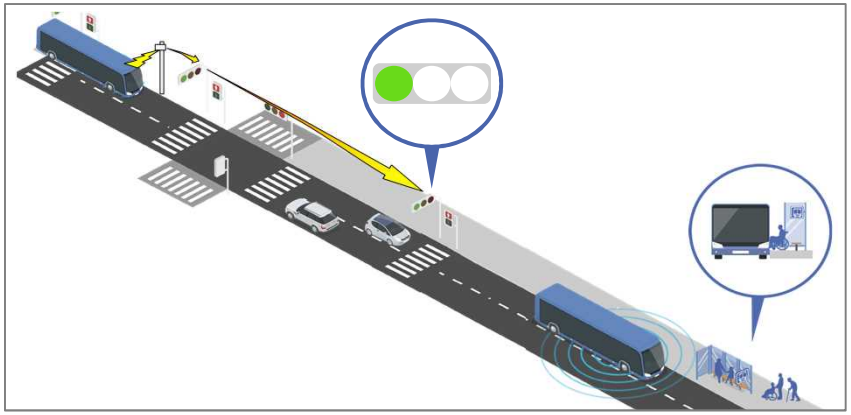
(1) Overview

Issues

- Clarification of environment conditions required for practical implementation of level 4 ART in mixed transportation environments

Verification items

- **Analysis of factors necessitating driver involvement** in mixed transportation environments
- **Effectiveness of cooperative infrastructure** in regularly scheduled transport
- **Comfort** when boarding/exiting
- **Assessment of impact** of autonomous vehicle driving **on traffic flow, and factors causing this impact**



Hypotheses regarding effectiveness of cooperative infrastructure technologies

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

Target

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

Items to be provided by SIP

Infrastructure	On-board test equipment
• ITS wireless roadside device (supporting PTPS) • Bus-only lane • Track induction magnetic markers • Curb docking bus stop • High-accuracy 3D map	• ITS wireless/optical beacon receiver (supporting PTPS) • Data logger (movement management)

3. Contents of tests performed in each area

3.3 Haneda Airport area

(2) Evaluation approach

[Infrastructure evaluation perspectives]

	Perspective	Examples of indices
Evaluation of effectiveness of infrastructure coordination	1. Contribution to the realization of automated driving	The number of times manual intervention was performed, automated driving distance, reliability of infrastructure information acquisition, reliability of driving based on infrastructure information, etc.
	2. Improvements to punctuality, comfort, etc.	Route times, disparities in route times, vehicle behavior (forward/backward acceleration, lateral acceleration, etc.), etc.
Impact assessment	3. Impact on surrounding traffic	Storage lengths, number of vehicles processed, intersection passing time, etc.

[Relationship between infrastructure and affected perspectives]

	1. Contribution to the realization of automated driving	2. Improvements to punctuality, comfort, etc.	3. Impact on surrounding traffic
Own location identification infrastructure (magnetic markers, etc.)	○		
Traffic light information	○		
Dedicated lane	○	○	○
PTPS		○	○

3. Contents of tests performed in each area

3.3 Haneda Airport area

(3) Evaluation patterns

(1) Magnetic marker usage

<Evaluation methods (example)>

(Envisioned results)
* In sections with installed magnetic markers, there was no manual intervention except for when necessary due to external factors
* Gap distances between bus stops and bus boarding/exiting points were smaller than for ordinary airport buses

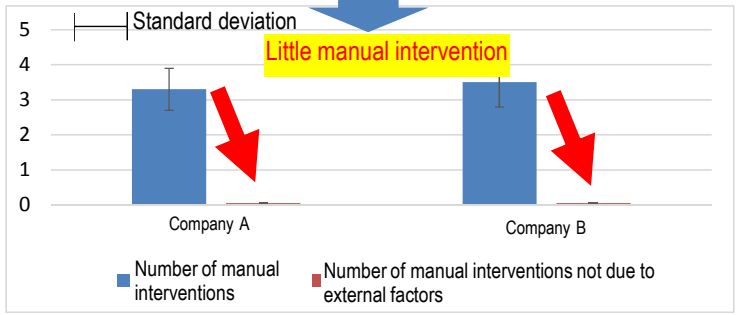
Number of manual interventions, automated driving distance

=> The number of manual interventions is tabulated by pressing the tally counter key, and the automated driving distance is determined from drive recorder data.

Time/ Punched key	Start test 1	Automated driving ON: 2	Automated driving OFF: 3	End test 4	Event 5
1:30:30	1				
1:30:31		1			
…					
1:31:33			1		
…					
1:31:40		1			1
1:31:45			1		
1:31:49		1			
…					

Count the number of manual interventions

Video is confirmed to assess the causes of manual interventions (lane cutting by ordinary vehicles, avoidance of vehicles parked on the street, etc.)



❷ Distances between bus stops and vehicles

=> Magnetic markers are used to determine the distance between the bus stop platform and the position of the stopped bus, and standard deviation information, etc., is compared. Results are compared against ordinary airport buses.

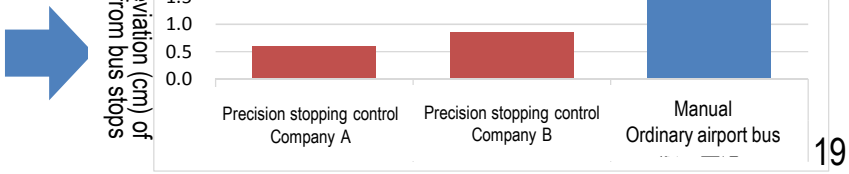
[Precision stopping control]

	Distance between stop and vehicle
Drive 1	X cm
Drive 2	Y cm
:	
Drive N	

Comparison

[Ordinary airport bus]

	Distance between bus stop and vehicle
Drive 1	AA cm
Drive 2	BB cm
:	
Drive N	



3. Contents of tests performed in each area

3.3 Haneda Airport area

(3) Evaluation patterns

(2) PTPS

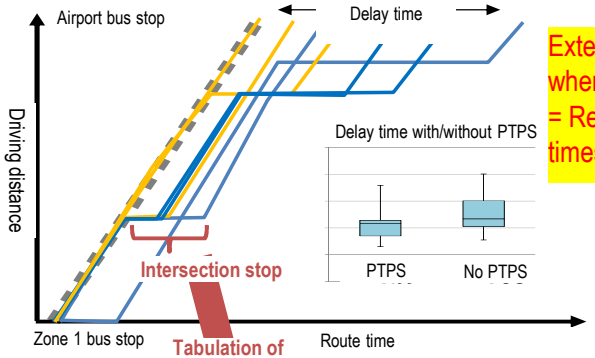
<Evaluation methods (example)>

❶ Route times and delay times per route drive

(Envisioned results)
* Fewer stops at red lights when driving using PTPS
* Reduced route times

=> Latitude and longitude information measured by GNSS receivers and drive recorders, etc., is used to determine the average route time. Delay times resulting from stopping or not stopping at intersections with traffic lights, and the presence/absence of PTPS, are compared.

Time	Latitude	Longitude	X acceleration	Y acceleration
…	…	…	…	…
120531	35.545547	139.760188	0.03	0.05
120531	35.545214	139.761126	0.02	0.11
…	…	…	…	…
121128	35.544041	139.768703		



Extended green light time when driving using PTPS = Reduction in average route times and delay times

❷ No. of red traffic light stops per route drive

⇒ Latitude and longitude information from GNSS receivers, drive recorders, etc., are used to compare the number of intersection stops per route drive.

Tabulation of number of stops

Few stops per route drive

3. Contents of tests performed in each area

3.3 Haneda Airport area

(3) Evaluation patterns

(3) Dedicated lanes

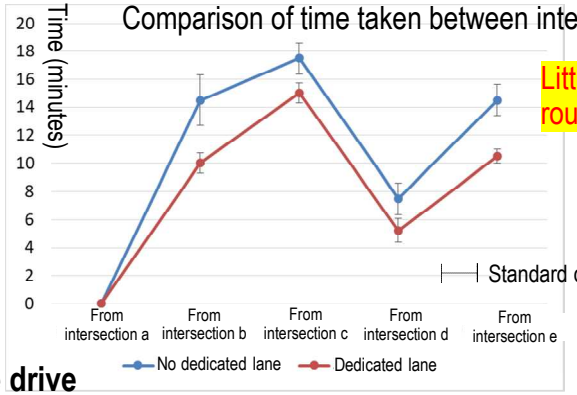
<Evaluation methods (example)>

(Envisioned results)
* When driving in bus-only lanes, average route times are low and there is little disparity in route times

❶ Route times and disparities in route times per route drive

=> The amount of time taken to drive the entire route, and the amounts of time taken to drive between intersections, are acquired and used to determine the average route time and standard deviation, etc.

Time	Latitude	Longitude	X acceleration	Y acceleration
…	…	…	…	…
120531	35.545547	139.760188	0.03	0.05
120531	35.545214	139.761126	0.02	0.11
…	…	…	…	…
121128	35.544041	139.768703		

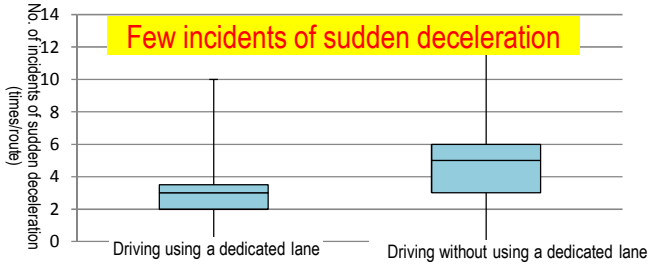


❷ Number of sudden actions, stops, and manual interventions per route drive

=> The number of sudden decelerations at intersections (e.g. deceleration of over 0.3G) is counted, the results are used to calculate averages, medians, 25th percentiles, 75th percentiles, etc., and the data when infrastructure is used is compared against the data when infrastructure is not used.

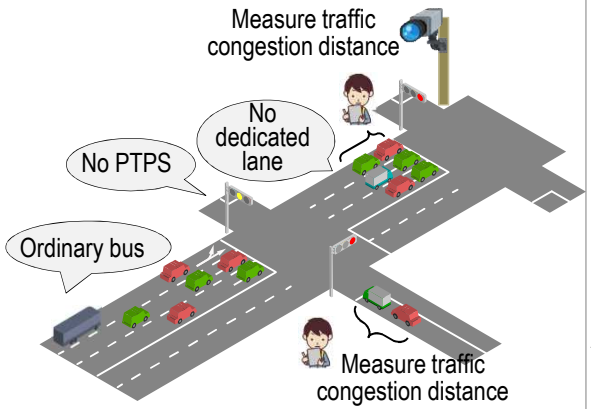
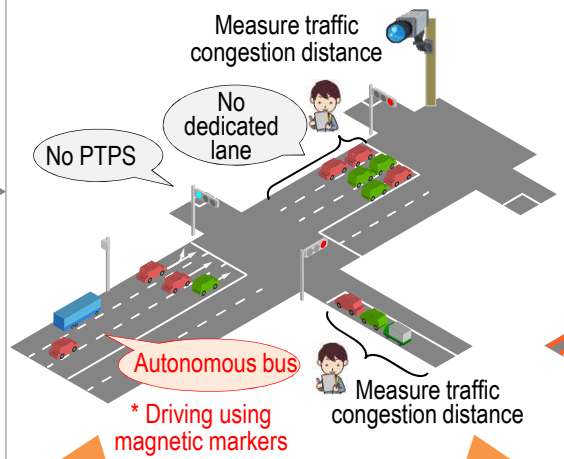
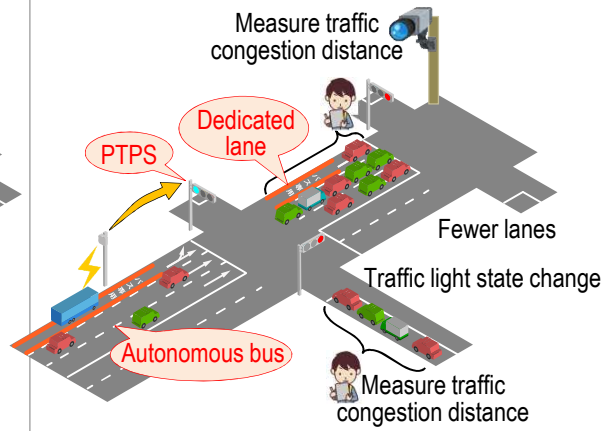
The number of times per route that the Y acceleration equaled or exceeded a certain level is acquired

	Dedicated lane use	No. of incidents of sudden deceleration
Drive 1	Yes	XX times
Drive 2	No	YY times
:	‥	
Drive N	No	



3. Contents of tests performed in each area

3.3 Haneda Airport area (4) Impact assessment

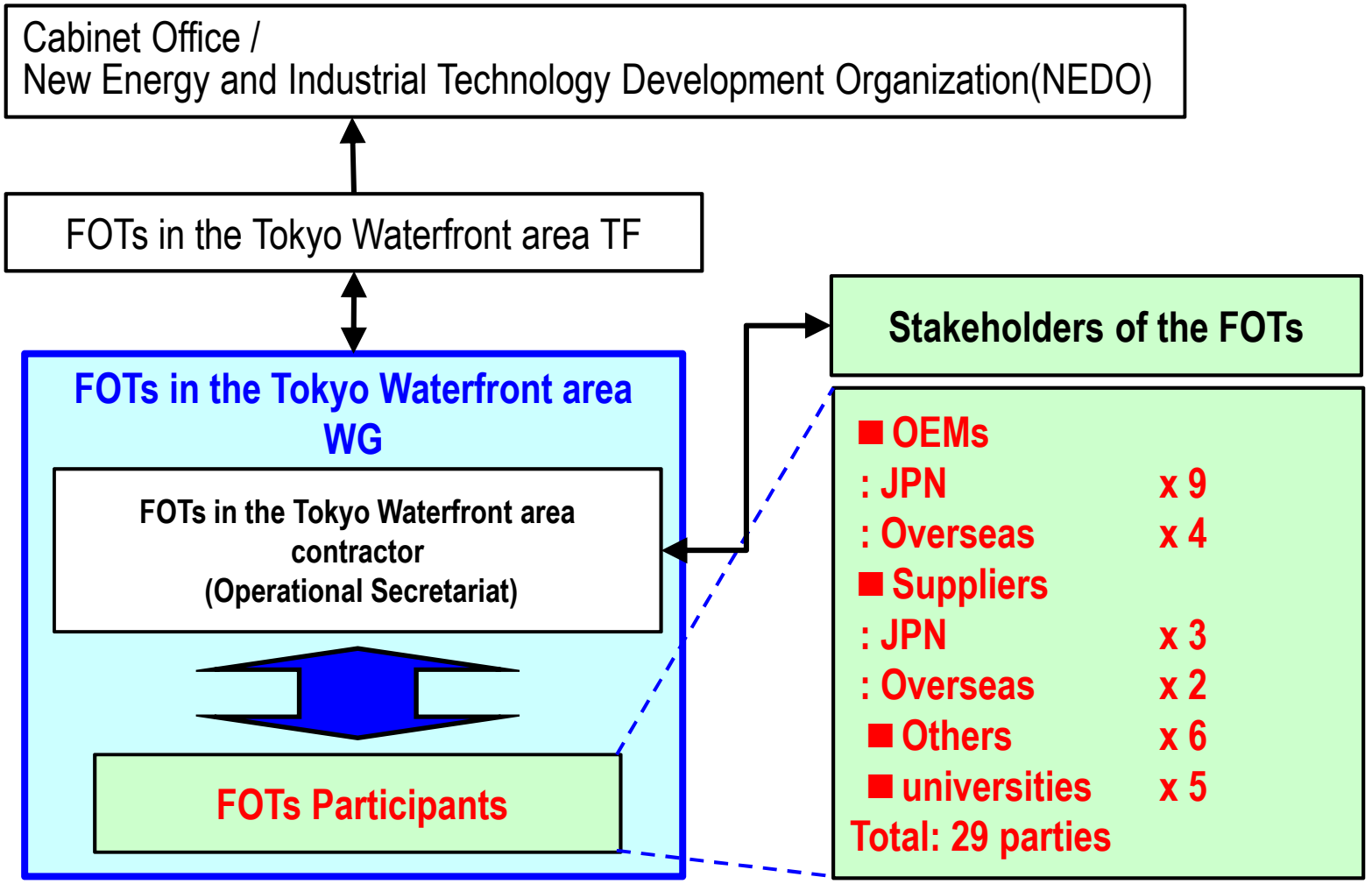
	Stage 1) No autonomous vehicles or infrastructure equipment (no dedicated lanes or PTPS + no autonomous buses)	Stage 2) Autonomous vehicles, but no infrastructure equipment. (autonomous buses + no dedicated lanes or PTPS)	Stage 3) Autonomous vehicles and infrastructure equipment (autonomous buses + dedicated lanes or PTPS)
Conceptual image			
Observation goals	Assess impact of traffic including autonomous buses	Assessment of impact of PTPS/dedicated lane	* "infrastructure," in the context of impact assessment, refers to bus-only lanes and PTPS "Automated driving" refers to automated driving using magnetic markers
Observation period	Late March 2020 (observation during times when bus-only lanes are not in operation following the lifting of Circular Route 8 traffic restrictions related to the Haneda connection road) * No driving by participants	May to September or October 2020 (observation outside bus-only lane operation hours) * Driving by participants	May to September 2020 (observation outside bus-only lane operation hours) * Driving by participants

* Bus-only lane operation hours are scheduled for 10:00 a.m. to 5:00 p.m. from April to September 2020, excluding period when the Olympics are held

4. FOTs preparation

4.1 Design of FOTs system

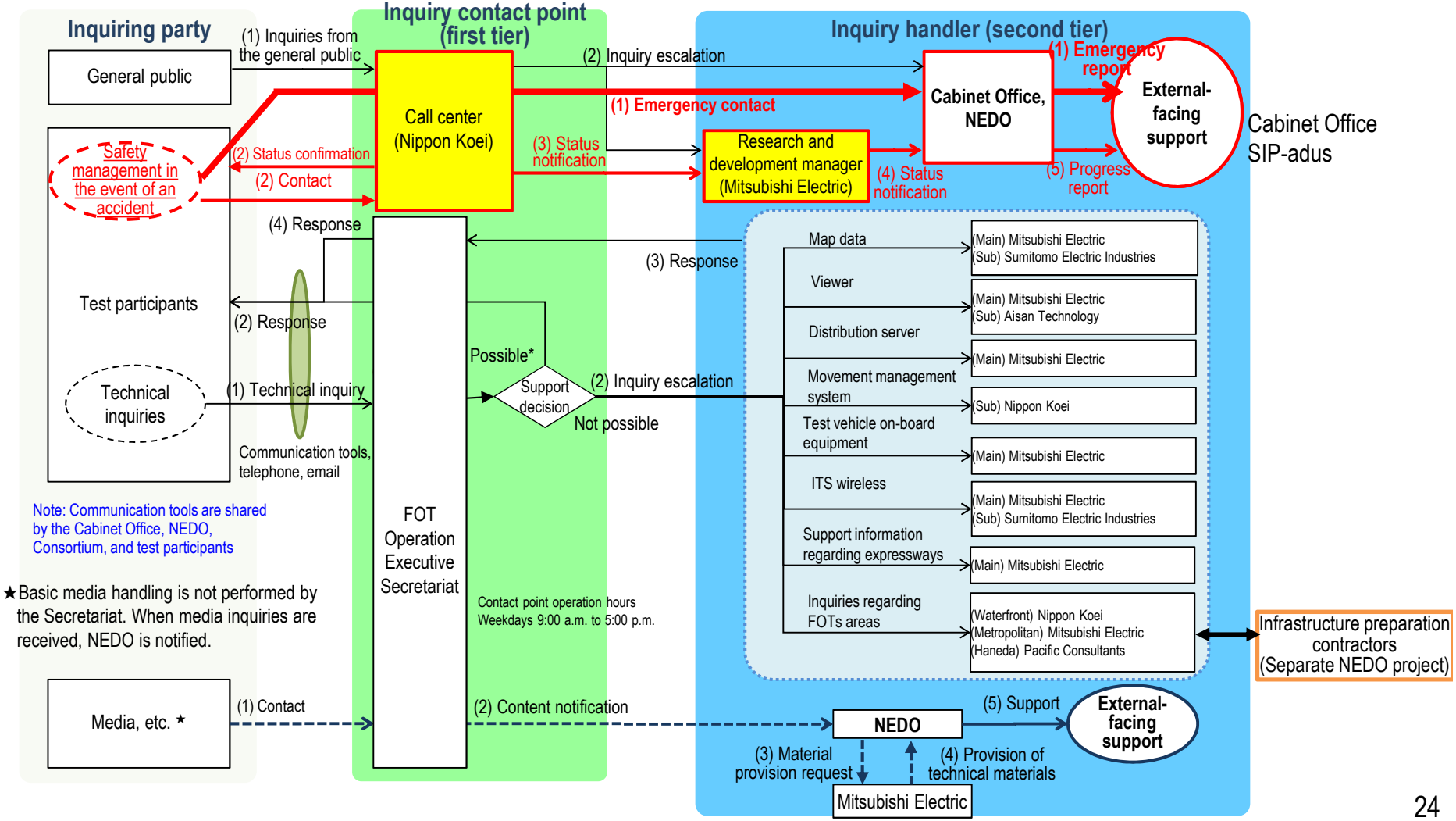
(1) Establishment of the FOTs in the Tokyo Waterfront area WG



4. FOTs preparation

4.1 Design of FOTs system

(2) Safety management/general public inquiries (call center), test participants (Secretariat)



4. FOTs preparation

4.1 Design of FOTs system

(3) Communication with test participants

- The communication tool is used to share information related to the FOTs with all test participants.
- Inquiry functions, opinion-seeking functions, and other functions promote the free and active exchange of ideas and opinions.

Sharing of information via the forum	135 times
Handling of inquiries from test participants	332 times
Opinion-seeking from test participants	15 times

* All figures current as of March 31, 2020

4. FOTs preparation

4. 2 FOTs in the Tokyo Waterfront area working group

	Date/time	Main agenda
1st meeting	May 31, 2019	Introduction of working group participants, overview of FOTs, Status of infrastructure preparation in each area, test equipment lent by contractors Verification contents and evaluation methods for each area, communication tool usage policy
2nd WG meeting	July 24, 2019	Status of infrastructure preparation in each area, test equipment lent by contractors Test vehicle on-board equipment output specifications, overview of the FOTs
3rd meeting	September 25, 2019	Status of infrastructure preparation in each area, explanation of usage of test equipment and maps Test vehicle on-board equipment output specifications, overview of the FOTs
4th WG meeting	November 20, 2019	Status of infrastructure preparation in each area, topics suggested by test participants Traffic light information equipment-side evaluation results, manual for performing FOT evaluation
5th WG meeting	January 29, 2020	Status of infrastructure preparation in each area, topics suggested by test participants Traffic light information equipment-side evaluation results, overview of the expressway FOTs
6th WG meeting	March 30, 2020	Exchanged opinions on status of infrastructure preparation in each area, the report of the experimental equipment tests result, the FOTs results in FY2019 by communication tool

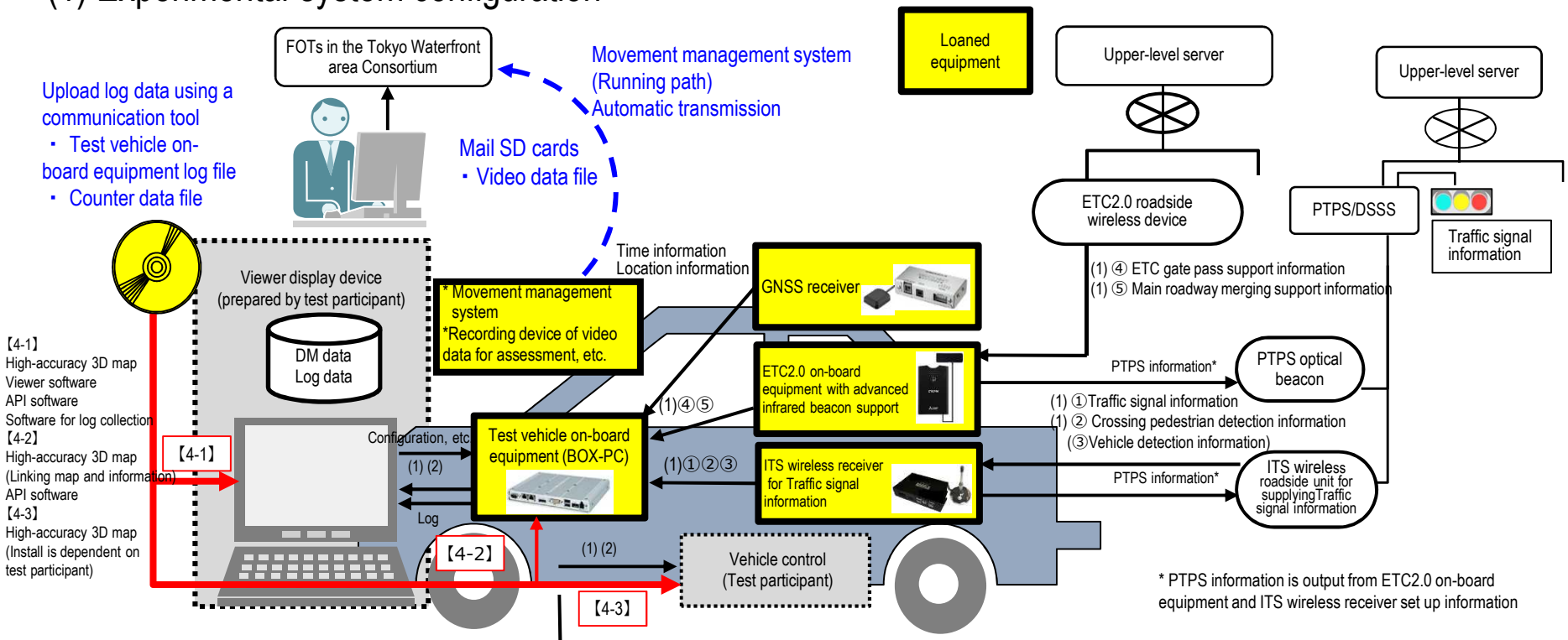
FOTs will be carried out using working groups and communication tools to actively exchange ideas and opinions

- Consensus with test participants regarding evaluation methods and conceptual images of output
- Sharing of information such as test equipment, data, etc., and sharing of opinions regarding improvements
- Reporting on test status, etc., by test participants

4. FOTs preparation

4.3 Overview of test equipment and data

(1) Experimental system configuration



(1) Dynamic information: Information received from ITS wireless receivers【① Traffic signal information, ② crossing pedestrian detection information, (③ vehicle detection information) 】
Information received via ETC2.0 on-board equipment【④ ETC gate pass support information, ⑤ main roadway merging test information】

(2) Semi-dynamic information: —

(3) Semi-static information: —

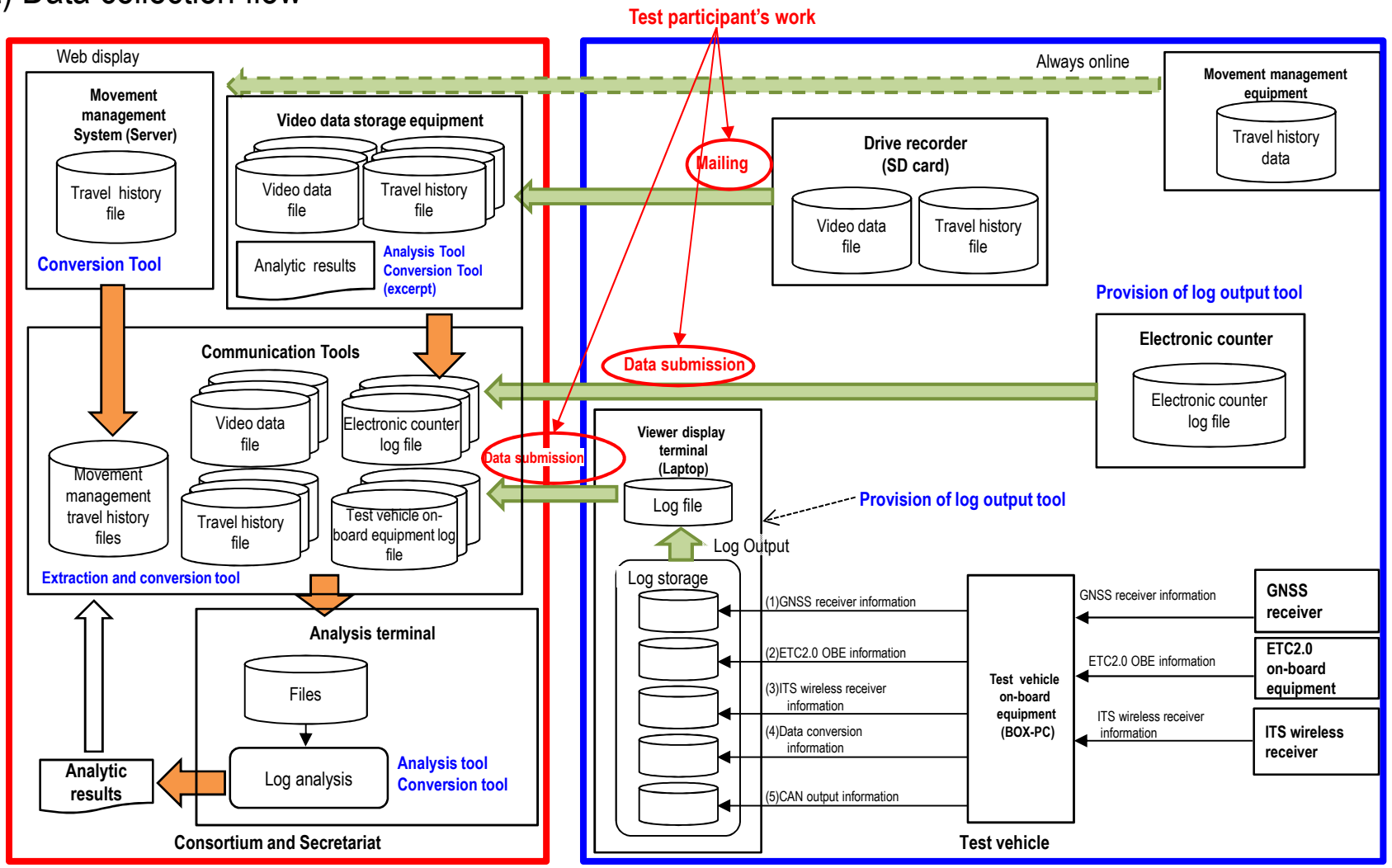
(4) Static information: High-accuracy 3D map, map update data (test area only)

DSSS: Driving Safety Support Systems
PTPS: Public Transportation Priority Systems
DM: Dynamic map (High-accuracy 3D map)

4. FOTs preparation

4.3 Overview of test equipment and data

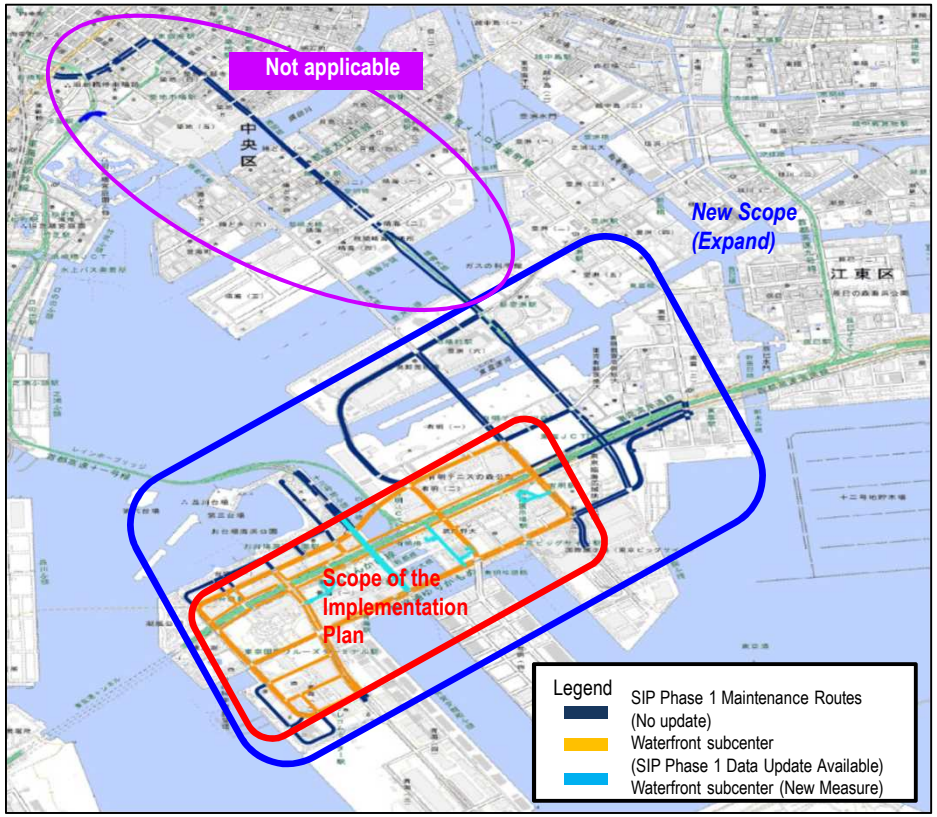
(2) Data collection flow



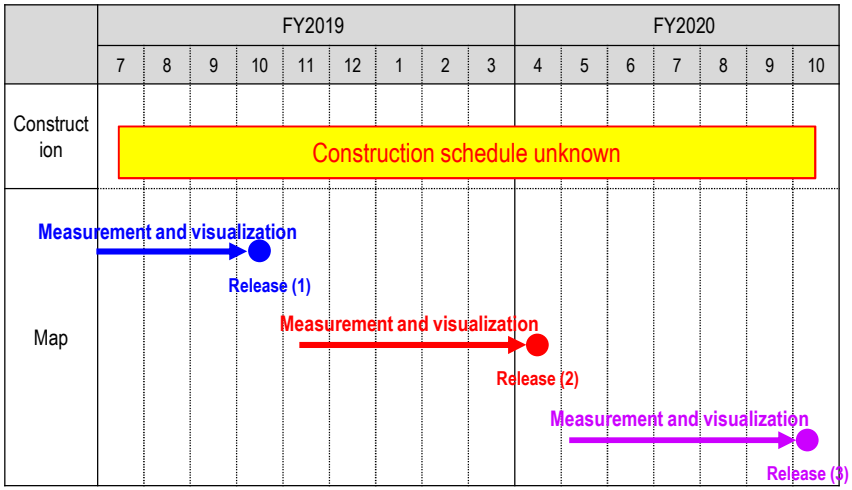
4. FOTs preparation

4.3 Overview of test equipment and data
(3) Create and update High-accuracy 3D map

①Changing the scope of mapping all areas of the waterfront subcenter (excluding the section from Shinbashi to Harumi Ohashi Bridge)



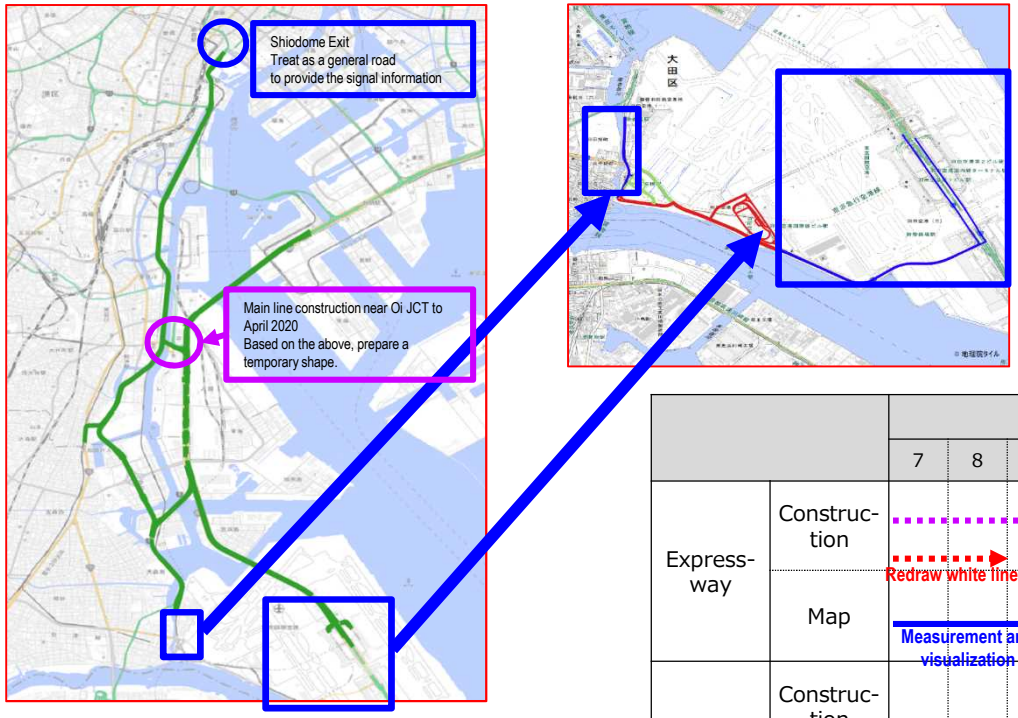
Measurement conditions	MMS measurement approx. 54 km x 2 times 60 GCPs installed
Scope of the diagram	Approximately 19 km
When to release	(1) October 2019 (2) April 2020 (3) October 2020 (Cabinet Office decision pending)



4. FOTs preparation

4.3 Overview of test equipment and data
(3) Create and update High-accuracy 3D map

①2nd release for the Haneda Line : March 2020
②Wangan Line Oi JCT, renewal of support for construction of connecting road between the Haneda Line and the Wangan Line (May 2020)
③Signal information support at the Shiodome Exit (Not included in the implementation plan)



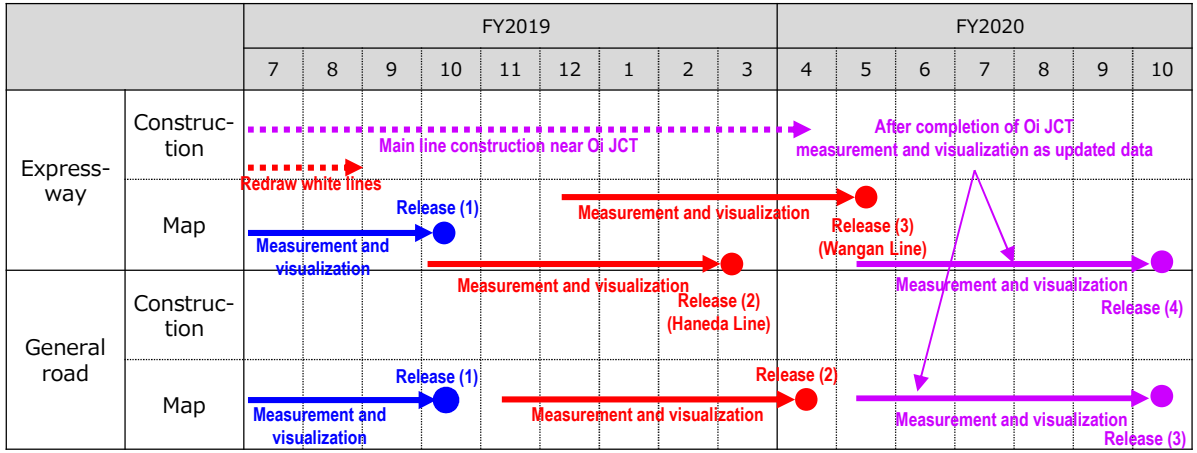
Metropolitan Expressway: Haneda and Wangan routes
Routes: Measurable points in Haneda Airport area

<Scale of expressway>

Measurement conditions	MMS Measurement Approx. 26 km (Haneda Line) + Approx. 9 km (Wangan Line)
Scope of the diagram	Renewal: Approx. 47 km (license fee) New approx. 26 km (Haneda Line) + approx. 9 km (Wangan Line)
When to Release	(1) October 2019 (2) Early March 2020 (2nd Haneda Line) (3) Around May 2020 (Second Wangan Line) (4) Around October 2020 (Cabinet Office decision pending)

<Road size (Reference)>

Measurement conditions	MMS measurement: approx. 9.8 km with GCP installed: 10 sites
Scope of the diagram	Approximately 9.8 km
When to Release	(1) October 2019 (2) April 2020 (3) Around October 2020 (Cabinet Office decision pending)

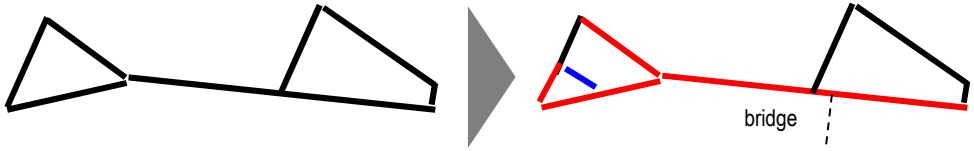


4. FOTs preparation

4.3 Overview of test equipment and data

(3) Create and update High-accuracy 3D map

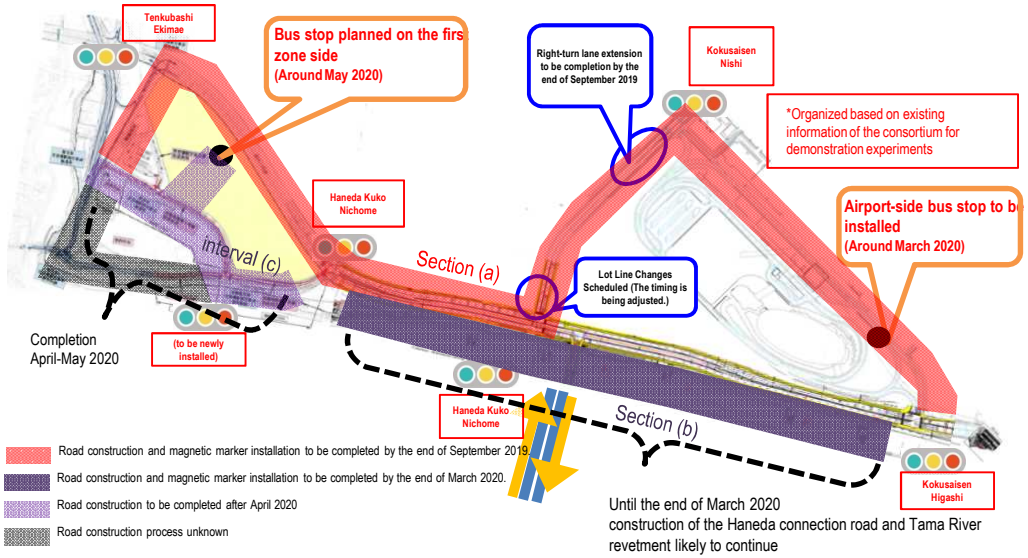
①April, 2020：Create map of Haneda Airport area (current version assuming update)
②October, 2020：Update the map corresponding to road construction and create a complete map reflecting the new road connection



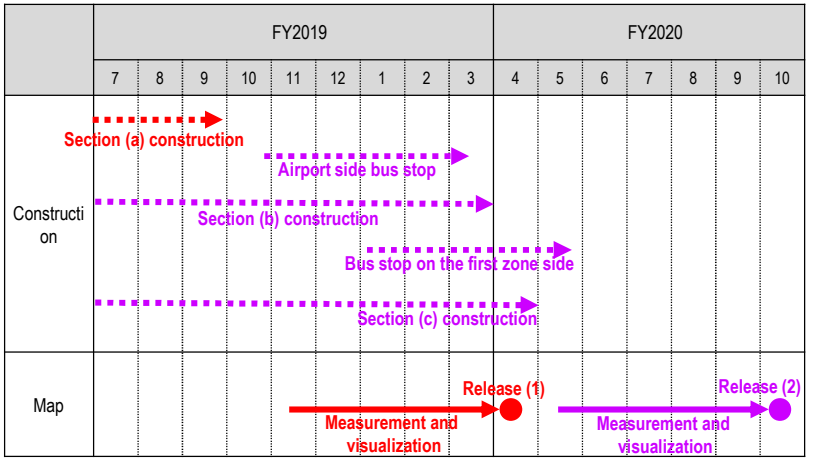
①Shaping = experiments and demonstrations possible : April 2020

②Support for road construction = update + new road : October 2020

Measurement conditions	MMS measurement approx. 20.8 km 20 sites with GCP
Scope of the diagram	Approximately 14 km
When to release	(1) April 2020 (2) October 2020



Until the end of March 2020 construction of the Haneda connection road and Tama River revetment likely to continue



5. Verification of evaluation

5.1 Evaluation using equipment side test equipment

(1) High-accuracy map evaluation (October 2019 release)

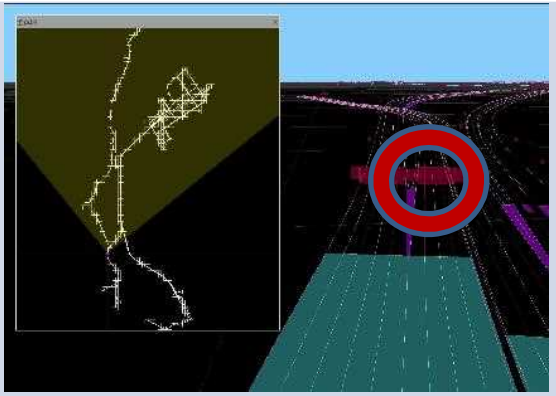
	Driving video (September 2019)	Viewer/measurement images
Evaluation	 <Differences between viewer images and driving videos> A new carriageway edge line was added on the left side of the carriageway and a new zebra crossing zone was added on the right side. The way the lines were drawn was also found to have changed between when the map was created and when the carriageway markings were drawn.	 Status when measurement was performed (July 5, 2019) There was no zebra crossing zone, no carriageway edge line, and the carriageway markings stopped mid-way 

- Differences were found between the June/July 2019 measurement and the September equipment evaluation (this information was also supplied to test participants)
- Based on these differences, plans have been made to supply updated map data in April 2020

5. Evaluation and verification

5.1 Evaluation using equipment side test equipment

(1) High-accuracy map evaluation (March 2020 release)

	Driving video (February 2020)	Viewer/measurement images
Evaluation	 <Differences between viewer images and driving videos> The destination sign was found to have been removed. This was due to change over time, and is not a problem.	 Status when measurement was performed (November 9 to 11, 2019) Destination sign present 

- Differences were found between the November 2019 measurement and the March equipment evaluation (this information was also supplied to test participants)

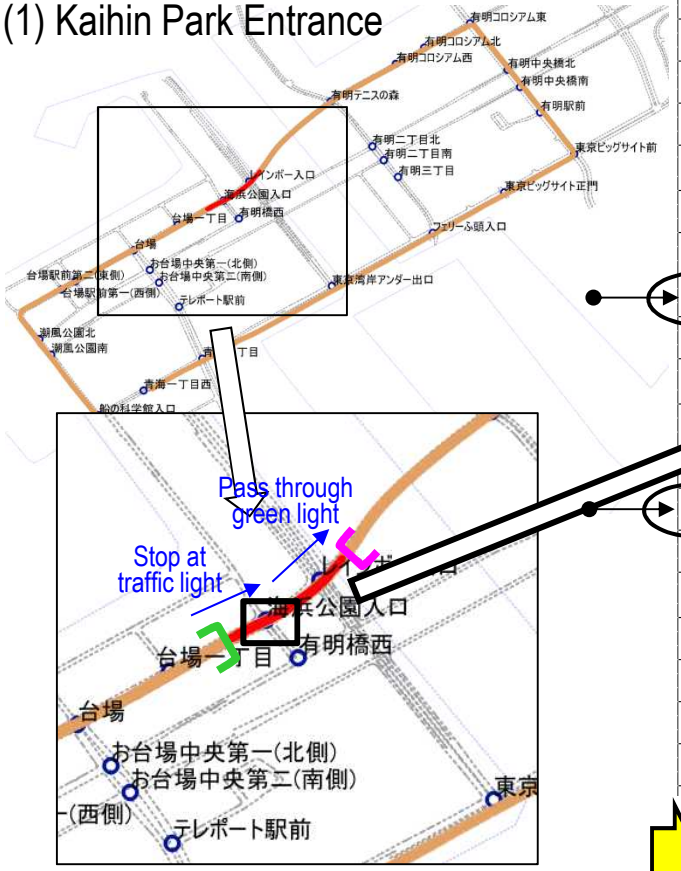
5. Evaluation and verification

5.1 Evaluation using equipment side test equipment

(2) ITS wireless receiver evaluation

The reception of traffic light information from ITS wireless roadside units was tested in the Waterfront City and Haneda Airport areas

(1) Kaihin Park Entrance



October 30 6:22 p.m.

The test vehicle was caught in a traffic jam before the intersection, and was going straight forward (route 3 -> route 1), so after receiving one cycle of traffic light information, it moved forward

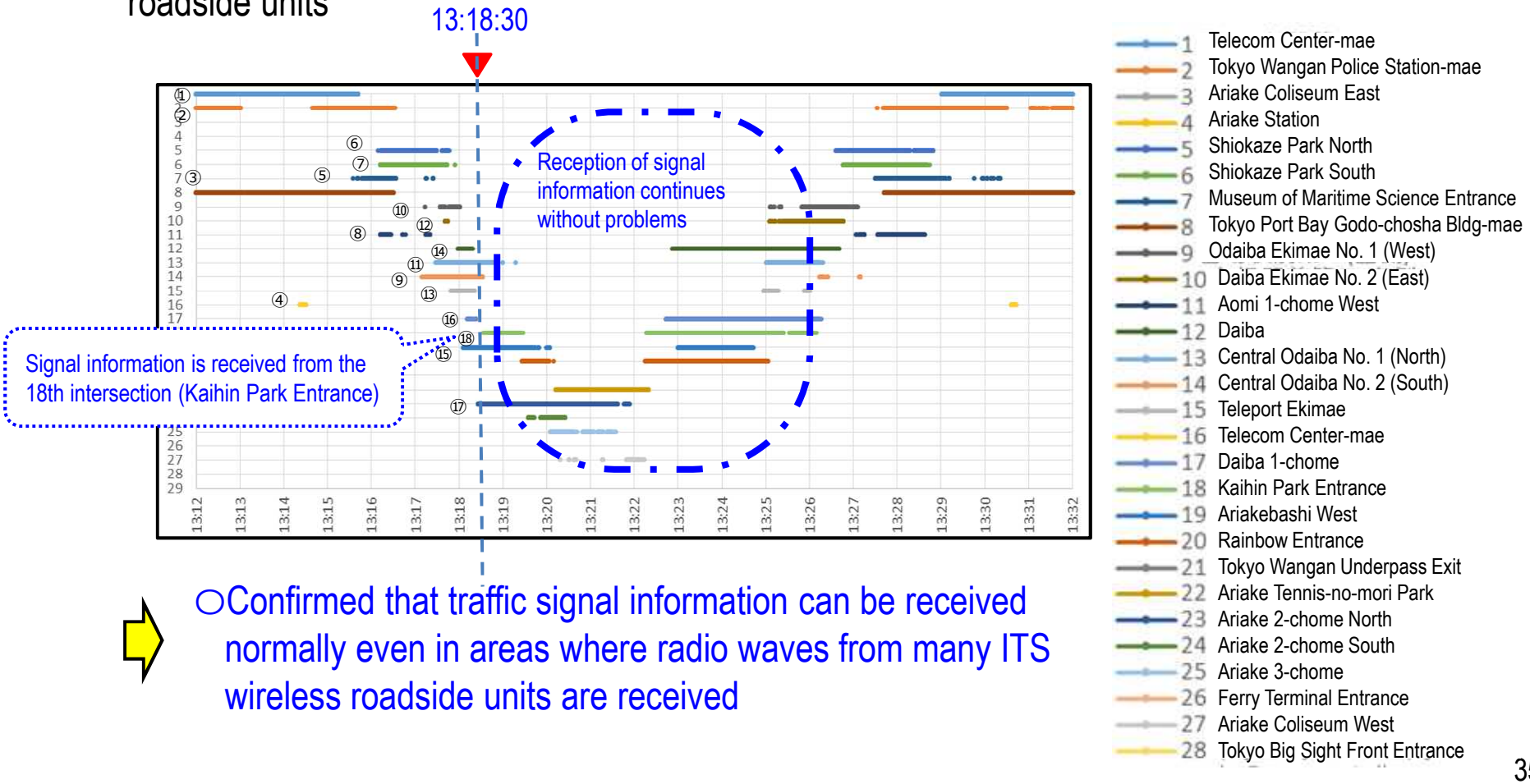
○Confirmation of traffic light information reception, linking of traffic light information to high-accuracy 3D map, and output to vehicle control (CAN1, CAN2, CAN3, LAN1, and LAN2)

5. Evaluation and verification

5.1 Evaluation using equipment side test equipment

(2) ITS wireless receiver evaluation

Implementation of driving experiments in areas receiving radio waves from many ITS wireless roadside units



○Confirmed that traffic signal information can be received normally even in areas where radio waves from many ITS wireless roadside units are received

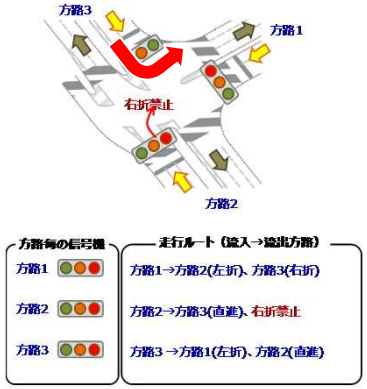
5. Evaluation and verification

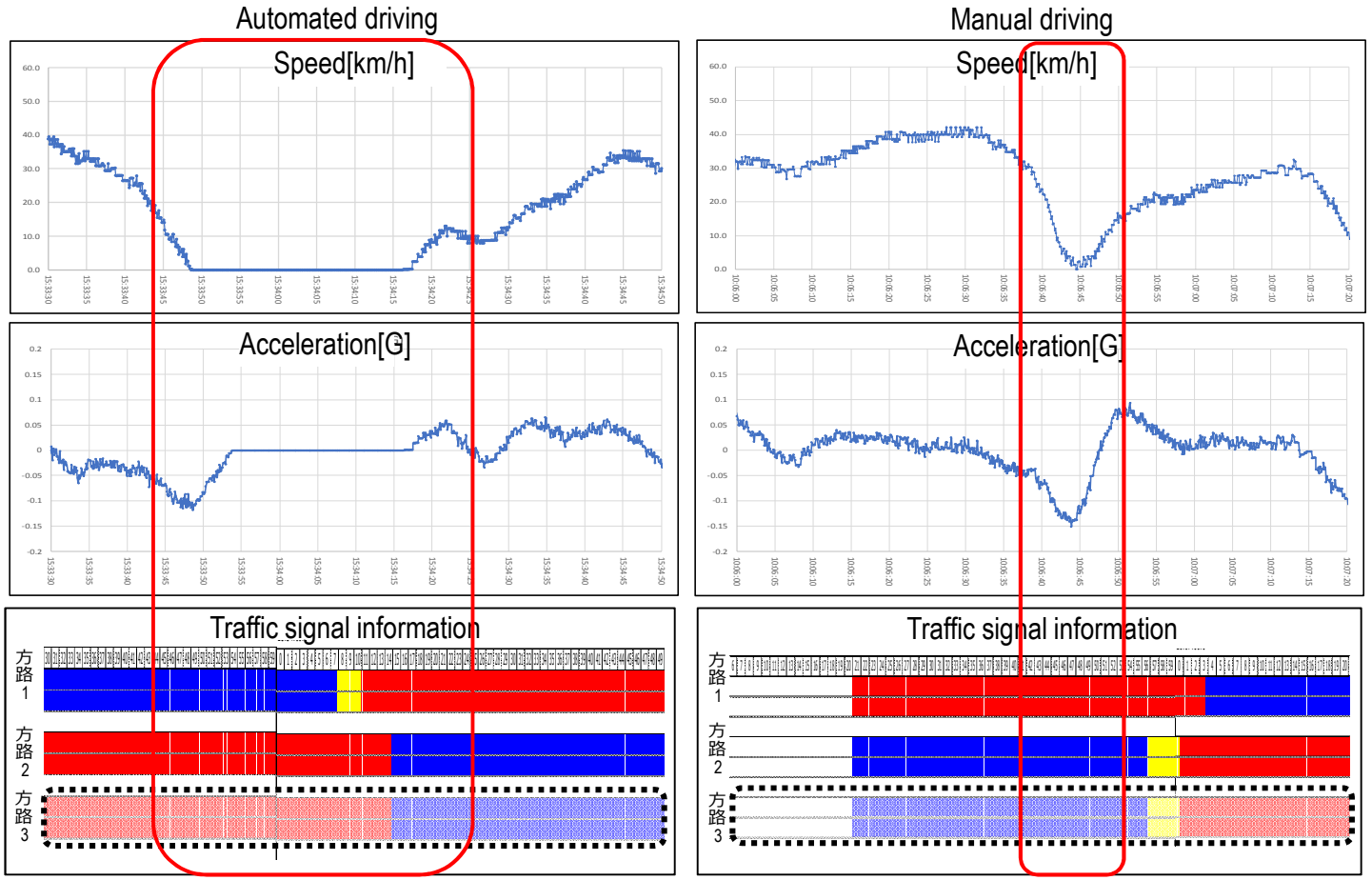
5.1 Evaluation using equipment side test equipment

(2) ITS wireless receiver evaluation

Outputs driving profiles of automated driving and manual driving

Museum of Maritime Science
Entrance Intersection



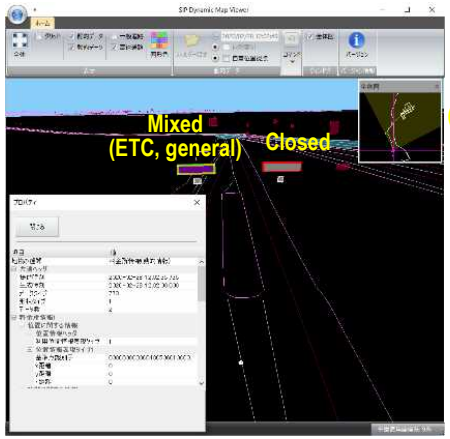


5. Evaluation and verification

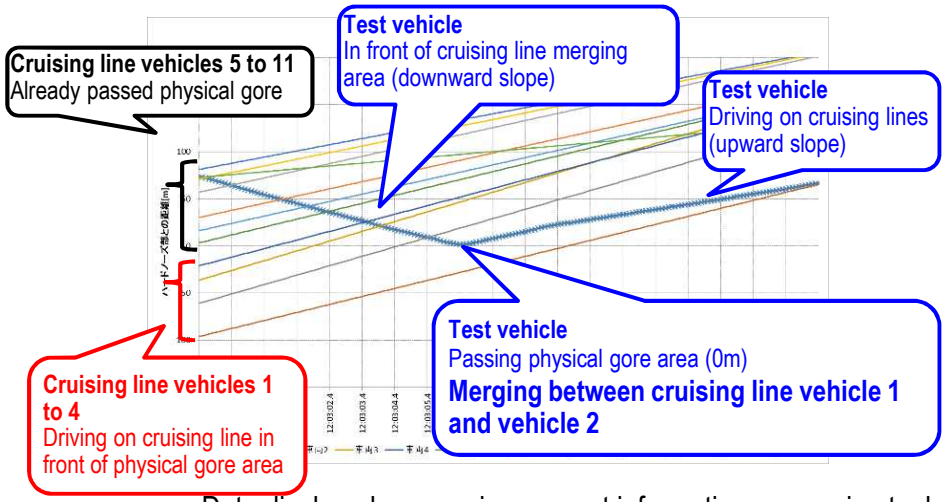
5.1 Evaluation using equipment side test equipment

(3) Expressway test vehicle on-board equipment evaluation

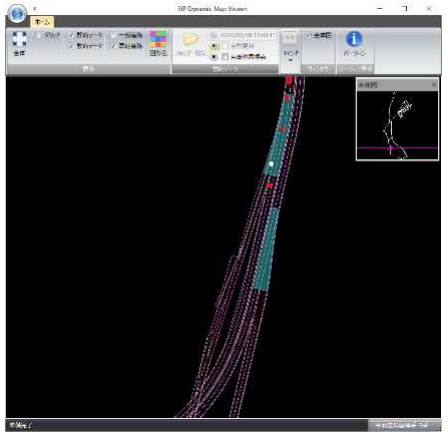
	Test item	Results
ETC gate passing support information	Information pattern: 4x4=16 patterns (booth 1=ETC, mixed, general, not defined) (booth 2=ETC, mixed, general, not defined)	OK
	Change to number of vehicle control outputs	OK
Merging support information	Driving pattern change (normal driving/driving off-center/side-by-side two vehicle driving)	OK
	Change to number/timing of vehicle control outputs	OK
	Sensor abnormality display confirmation	OK



ETC gate passing support information
(comparison of viewer display and test video data recording device image)
February 28, 2020, 12:02:49



Data displayed on merging support information conversion tool



Merging support information
(comparison of viewer display and test video data recording device image)
February 28, 2020, 12:03:11

5. Evaluation and verification

5.1 Evaluation using equipment side test equipment

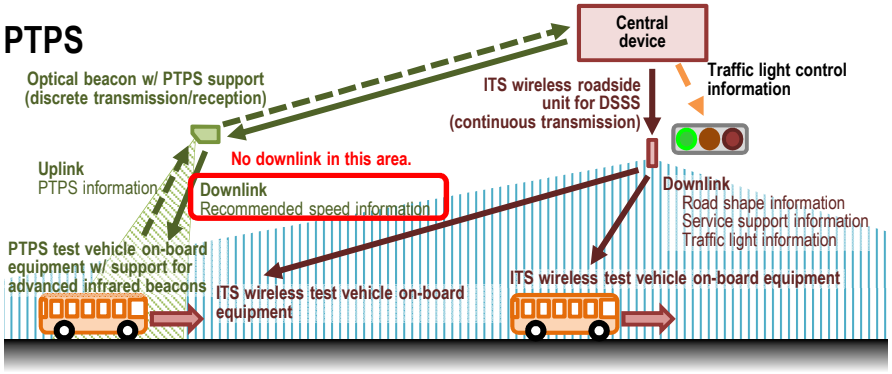
(4) PTPS test vehicle on-board equipment evaluation

Confirmation of transmission without priority control has already been performed

(1) Confirmation of transmission of optical beacons used by PTPS

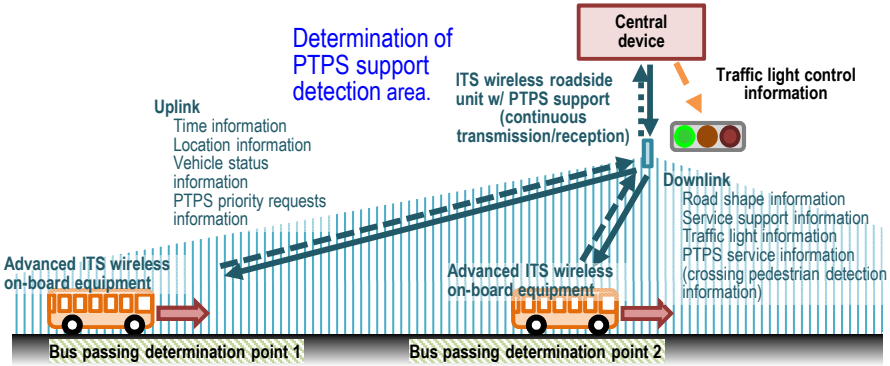
No.	Test item			Results
(1)	Haneda Airport 2-chome	Route 2	Confirmation of uplink	OK
		Route 3	Confirmation of uplink	OK
(2)	Int'l Terminal West	Route 3	Confirmation of uplink	OK
(3)	Tenkubashi Ekimae	Route 1	Confirmation of uplink	OK

* Confirmation is currently in progress for traffic light information (1) to (3) and output to vehicle control



(2) Confirmation of transmission of ITS wireless devices used by PTPS

No.	Test item			Results
(1)	Haneda Airport 2-chome West	Route 1	Confirmation of uplink and passing determination	OK
			Confirmation of downlink and outputting to vehicle control	OK
		Route 2	Confirmation of uplink and passing determination	OK
			Confirmation of downlink and outputting to vehicle control	OK
(2)	Int'l Terminal East	Route 1	Confirmation of uplink and passing determination	OK
			Confirmation of downlink	OK
(3)	Tenkubashi East	(scheduled for completion in May 2020)		



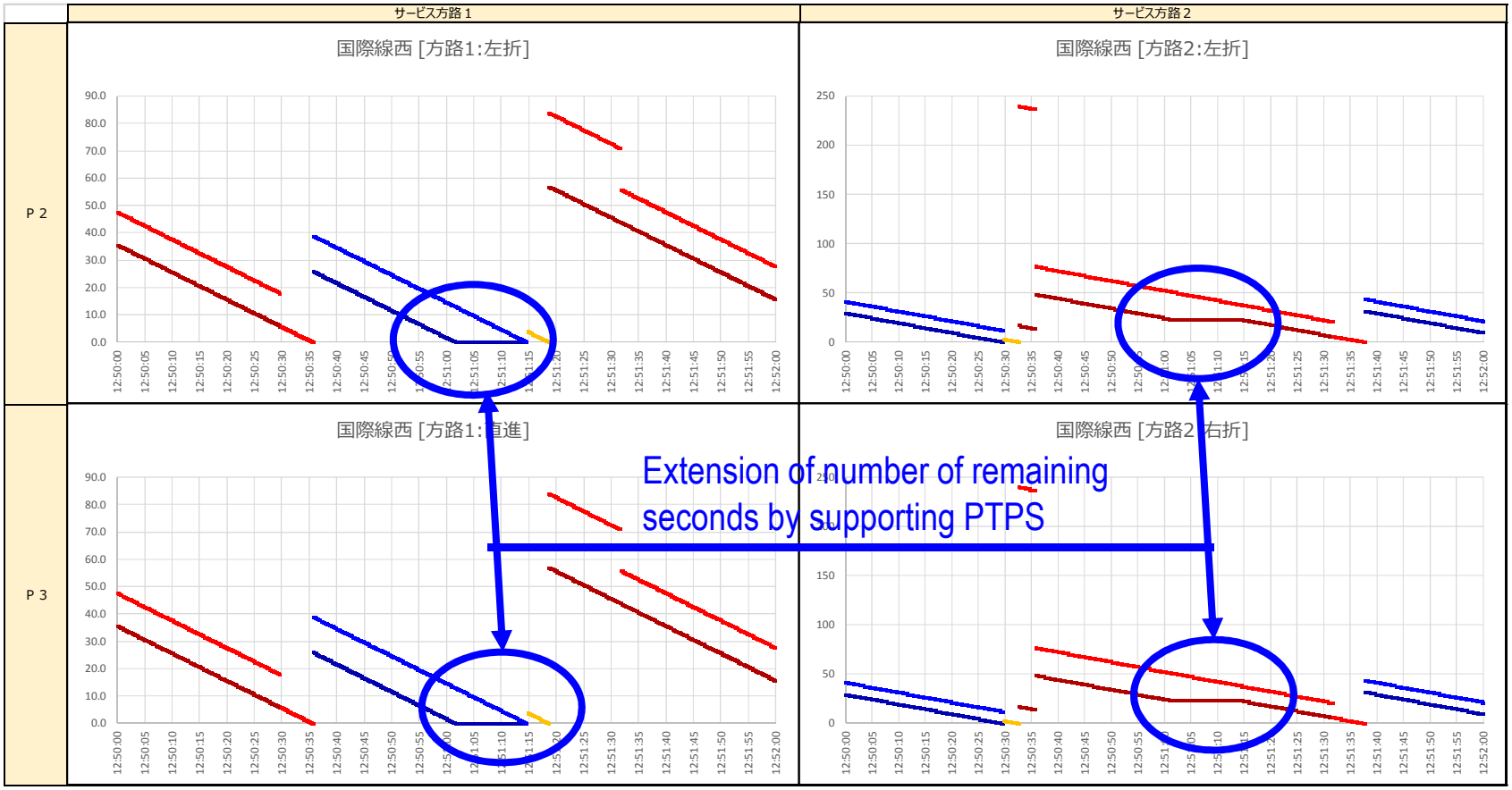
* Confirmation is currently in progress for traffic light information (1) and (2) and output to vehicle control
* (2) Confirmation of crosswalk pedestrian detection information and output to vehicle control are scheduled to be performed after information is provided

5. Evaluation and verification

5.1 Evaluation using equipment side test equipment

(4) PTPS test vehicle on-board equipment evaluation

Confirmed extension of number of remaining seconds by supporting PTPS at international west intersection in Haneda Airport area



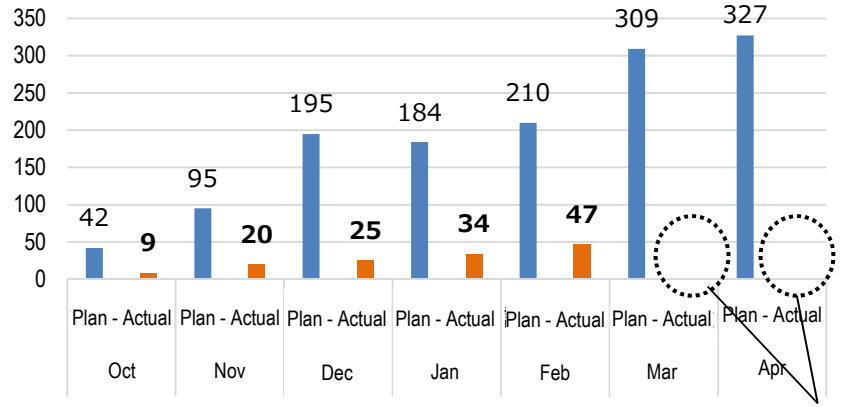
5. Evaluation and verification

5.2 Evaluation by test participants

(1) Driving plan/driving results

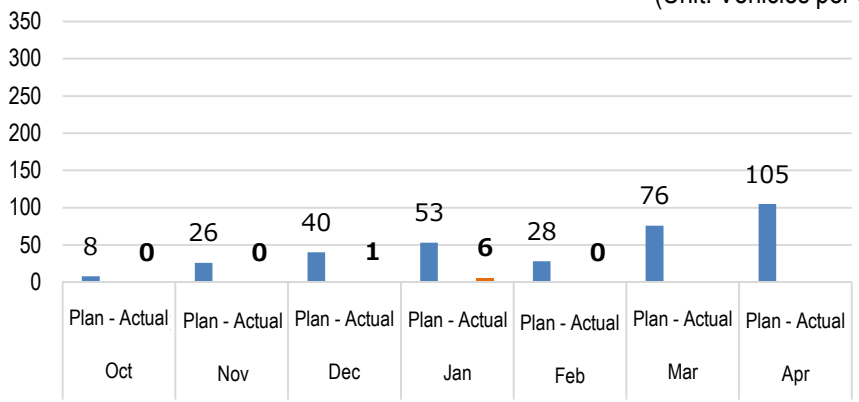
* Results as of March 11, 2020

(Unit: Vehicles per day)

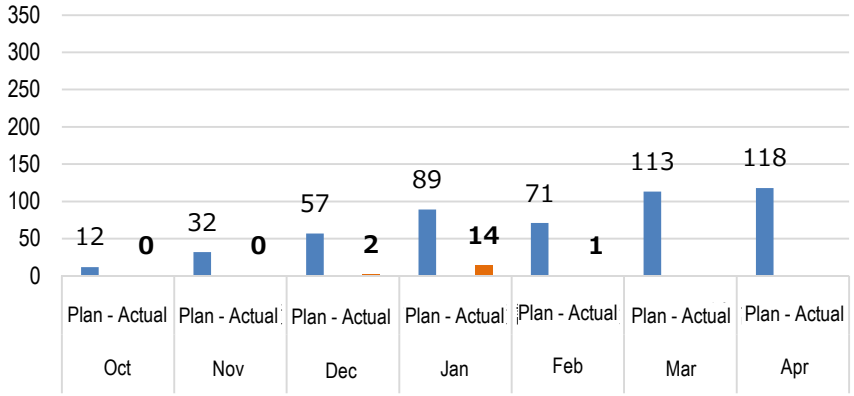


Waterfront City

Not yet recovered
(likewise for other areas)



Metropolitan Expressway



Haneda Airport

No. of test participants with driving plans/no. of test participants that actually performed driving

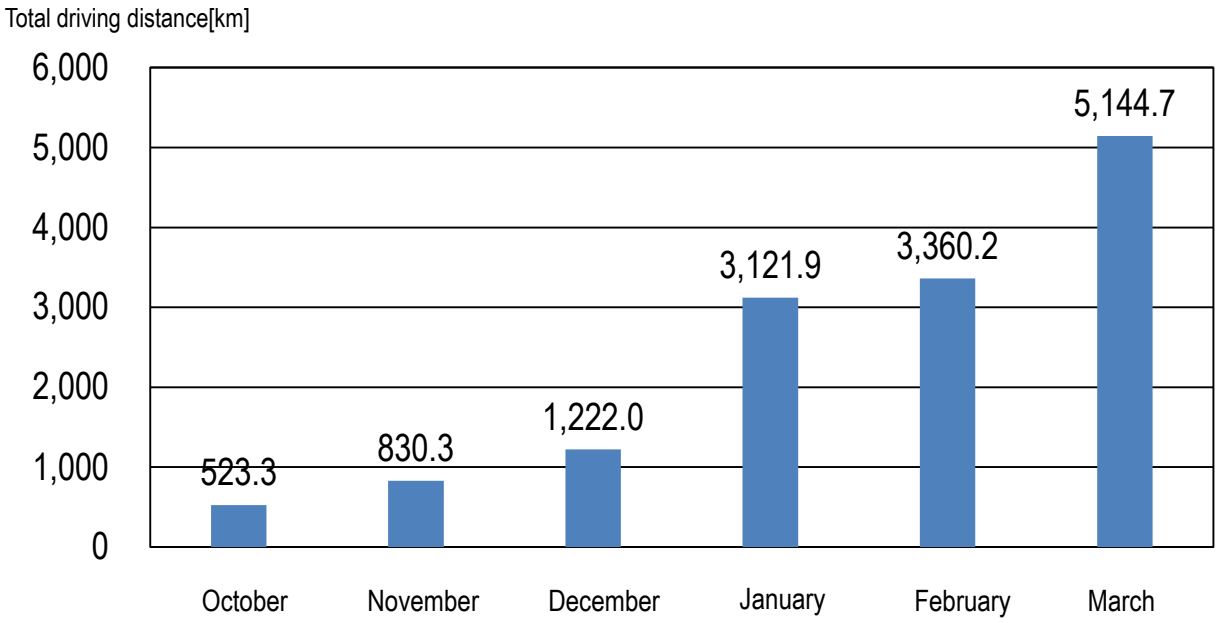
	Waterfront City		Metropolitan Expressway		Haneda Airport	
	Plan	Actual	Plan	Actual	Plan	Actual
October	6	4	1	0	2	0
November	8	4	2	0	3	0
December	14	10	3	1	3	2
January	13	8	3	1	5	2
February	14	8	3	0	6	1
March	13	-	4	-	6	-
April	14	-	7	-	6	-

5. Evaluation and verification

5.2 Evaluation by test participants

(2) Total driving distance

October 15, 2019, to March 31, 2020 (approx. 5 months and a half): **14,202.4 km**
(totals based on movement management system operation history)



Total driving distance, based on movement management system operation history
(as of March 31, 2020)

5. Evaluation and verification

5.2 Evaluation by test participants

(3) General overview

The number of days of driving, number of days of automated driving, goals of drives, etc., for individual test participants during the October 15, 2019, to March 11, 2020, period are shown below.

Participant identifier	Days of driving	Days of automated driving	Main targets for 2019	Remarks
a	38	11	Focus on acquiring data during local driving of autonomous vehicles	Confirmed remaining seconds with margins
b	3	0	Focus on acquiring local basic data for use in development	Performed confirmation of confirmed remaining seconds/remaining seconds with margins
c	3	0	Focus on acquiring local basic data for use in development	Generated dedicated maps for own vehicles
d	15	0	Focus on acquiring local basic data for use in development	Performed driving in Haneda area
e	28	0	Focus on acquiring local basic data for use in development	Drove in specific environment
f	6	0	Focus on acquiring local basic data for use in development	Confirmed GNSS reception status
g	37	0	Focus on acquiring local basic data for use in development	Specific driving route
h	0	0	Prepare test vehicle in 2019	Numerous inquiries regarding devices
i	2	0	Focus on acquiring local basic data for use in development	Performed comprehensive driving
j	5	0	Focus on acquiring local basic data for use in development	Drove around perimeter of area
k	0	0	Prepare test vehicle in 2019	-
l	4	1	Focus on autonomous vehicle tuning	Performed comprehensive automated driving

5. Evaluation and verification

5.2 Evaluation by test participants

(3) General overview

The number of days of driving, number of days of automated driving, goals of drives, etc., for individual test participants during the October 15, 2019, to March 11, 2020, period are shown below.

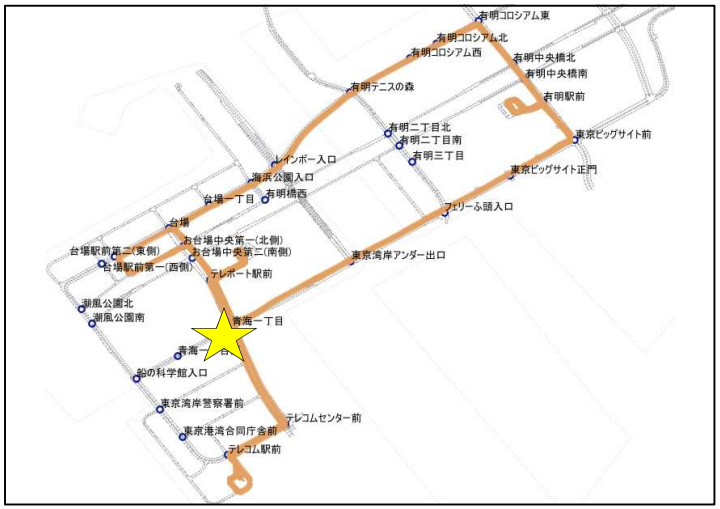
Participant identifier	Days of driving	Days of automated driving	Main targets for 2019	Remarks
m	5	0	Focus on acquiring local basic data for use in development	Specific driving route
n	2	0* * Reported performing automated driving	Focus on autonomous vehicle tuning	Specific driving route
o	0	0	Prepare test vehicle in 2019	-
p	21	0	Focus on acquiring local basic data for use in development	Specific driving route
q	2	0	Focus on acquiring local basic data for use in development	Confirmed remaining seconds with margins
r	0	0	Prepare test vehicle in 2019	-
s	3	0	Focus on acquiring local basic data for use in development	Performed comprehensive driving
t	2	0	Prepare test vehicle in 2019	-
u	6	0	Focus on acquiring local basic data for use in development	Specific driving route
v	0	0	Consider test contents in 2019	No test plan has been submitted

5. Evaluation and verification

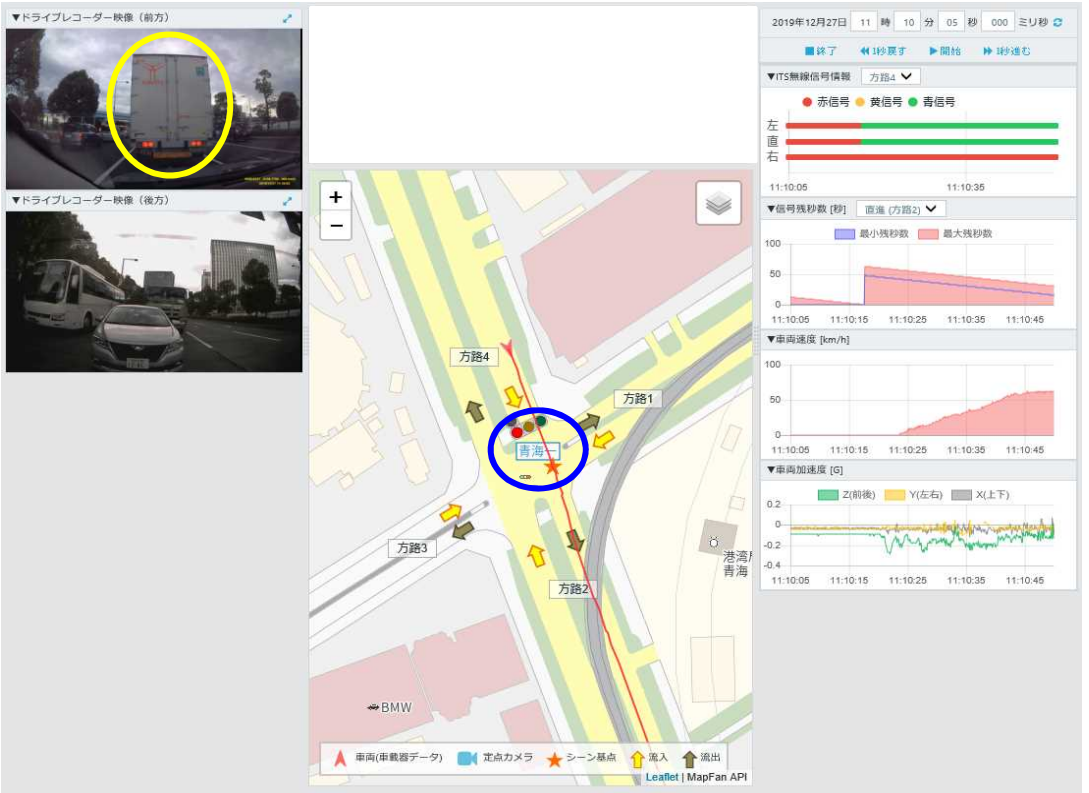
5.2 Evaluation by test participants

(4) Feedback to test participants

(1) Daiba: Friday, December 27, 2019, 10:10 to 10:10 (automated driving)



Intersection passing order	Name of intersection	Center point time	Direction of movement
1	Telecom Station-mae	10:02:03	Right turn
2	Telecom Center-mae	10:06:01	Right turn
	・ ・ ・		
55	Teleport Ekimae	10:08:39	Forward
56	Aomi 1-chome	10:10:32	Forward
57	Telecom Center-mae	10:11:10	Right turn



* An obstacle made it difficult to identify the color of the traffic light

* Traffic light information from the ITS wireless roadside unit was used for automated driving (straight)

5. Evaluation and verification

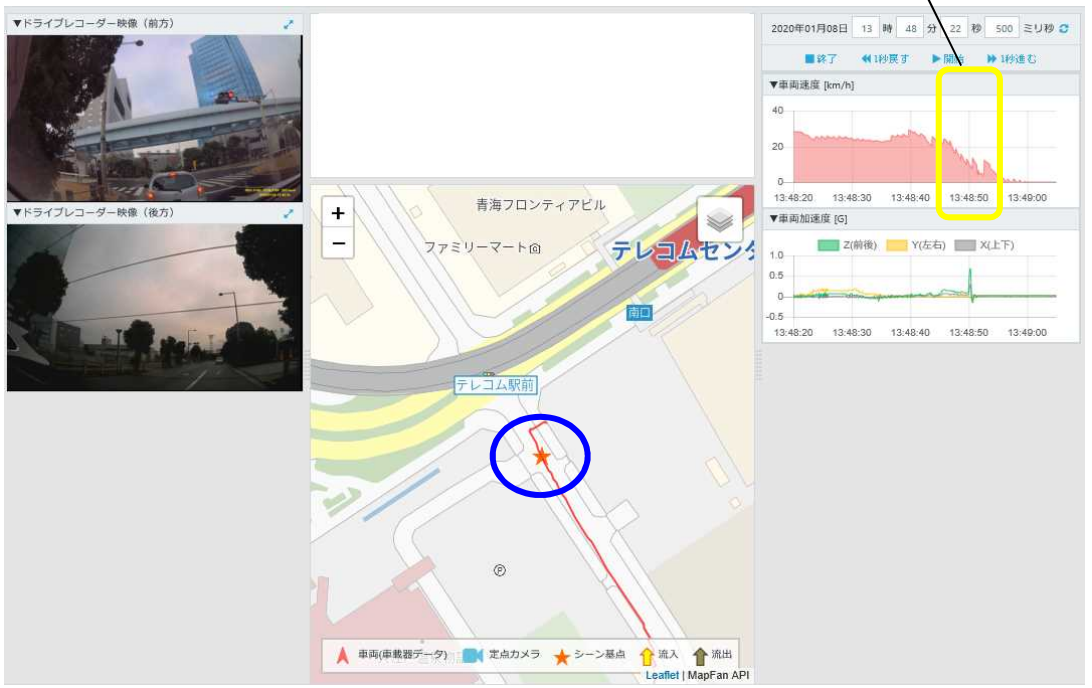
5.2 Evaluation by test participants

(4) Feedback to test participants

(2) Daiba: Wednesday, January 8, 2020 13:48 to 13:49 (automated driving)

Intersection passing order	Name of intersection	Center point time	Direction of movement
1	Telecom Center-mae	13:15:14	Right turn
2	Telecom Station-mae	13:15:57	Forward
・ ・ ・			
18	Tokyo Wangan Police Station-mae	13:37:39	Forward
19	Telecom Station-mae	※	※

Sudden deceleration (0.48G)



* Sudden deceleration in front of intersection providing remaining no. of seconds (confirmed)

* Traffic light information from the ITS wireless roadside unit was used for automated driving (stop)

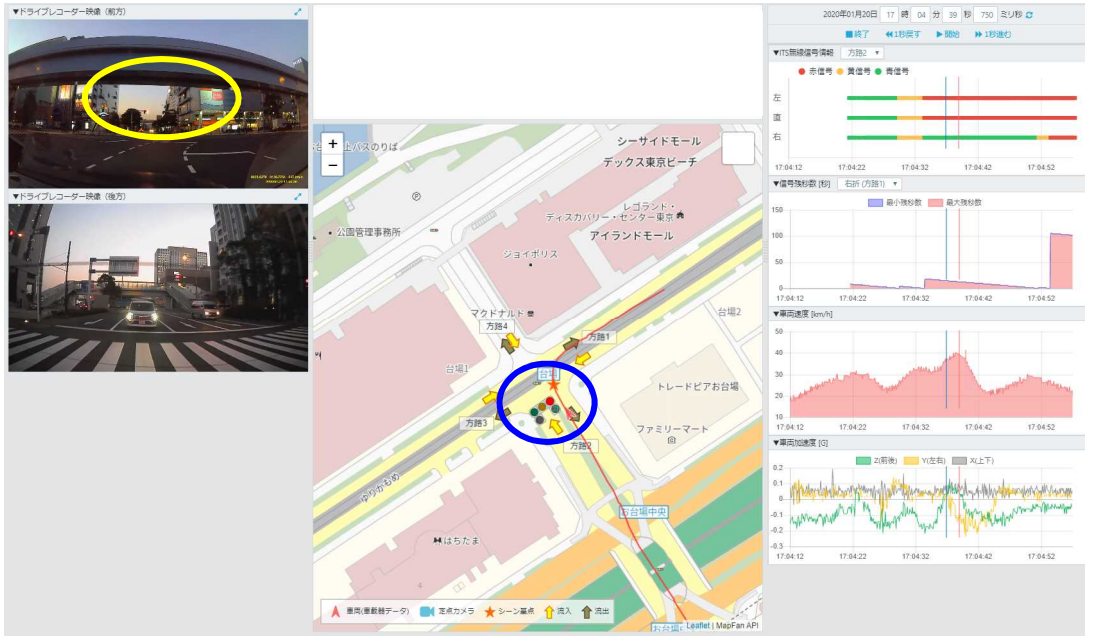
* The driving area ended in front of the Telecom Station-mae intersection, so there is no center point time for the intersection

5. Evaluation and verification

5.2 Evaluation by test participants

(4) Feedback to test participants

(3) Daiba: Monday, January 20, 2020, 17:04 to 17:05 (automated driving)



Intersection passing order	Name of intersection	Center point time	Direction of movement
1	Ariake 3-chome	15:18:15	Forward
2	Ariake 2-chome South	15:20:33	Left turn
・・・			
55	Central Odaiba No. 1 (North)	17:04:26	Forward
56	Daiba	17:04:40	Right turn
57	Daiba 1-chome	17:05:39	Forward

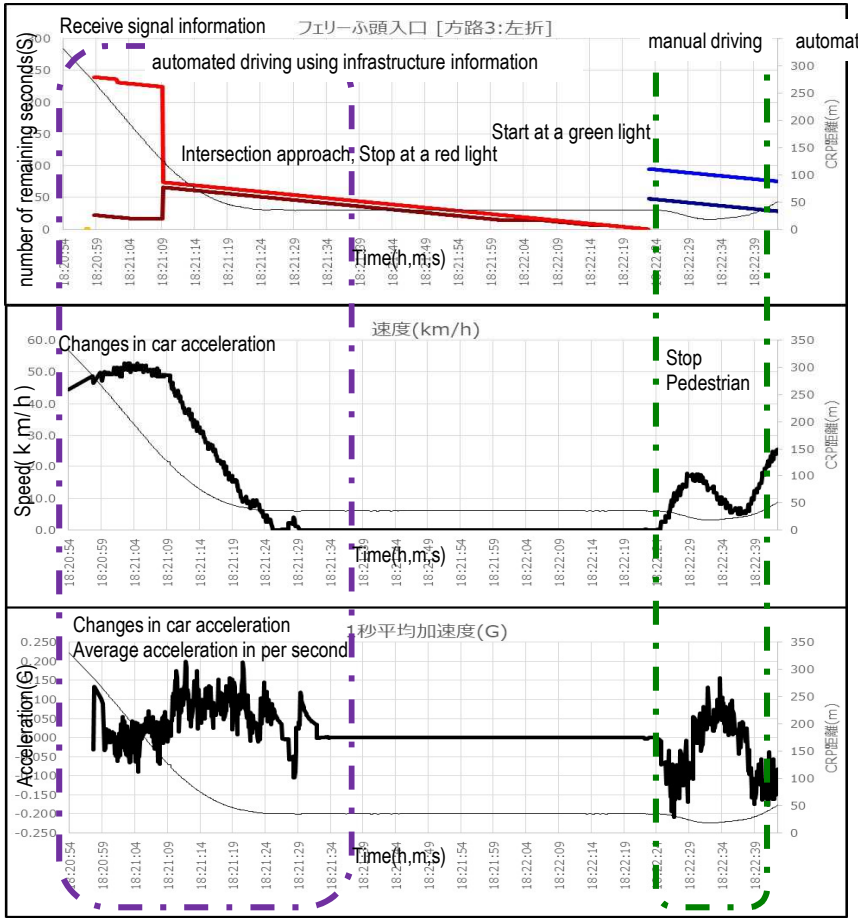
* Backlighting made it difficult to identify the color of the traffic light
* Traffic light information from the ITS wireless roadside unit was used for automated driving (right turn)

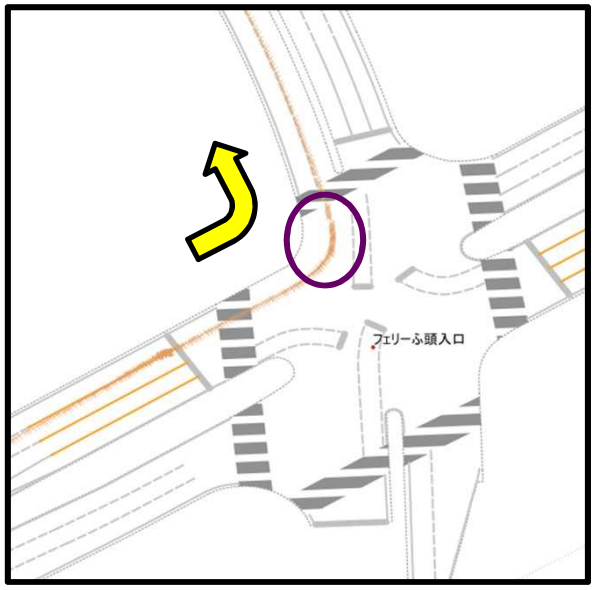
5. Evaluation and verification

5.2 Evaluation by test participants

(4) Feedback to test participants

(4) Daiba: Wednesday, March 25, 2020, 18:20 to 18:22 (automated driving)





automated driving

drive between intersections→enter the intersection→stop at line

manual driving

recognize a green light→start and turn left→

recognize pedestrian + stop→pass the ntersection

automated driving

pass the intersection→drive to the next intersection