SIP-adus Workshop 2020

Dynamic Map

Status report of FOTs in the Tokyo Waterfront area

MITSUBISHI ELECTRIC CORPORATION
YOSHIAKI TSUDA

11th,November,2020

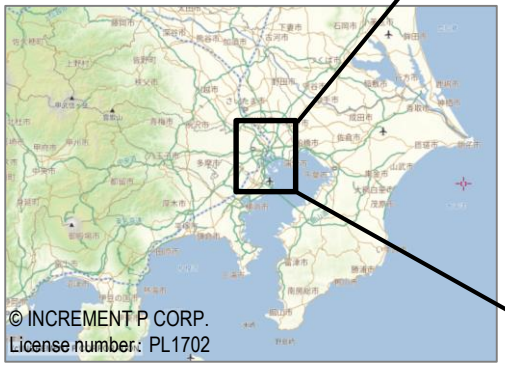
SIP

Cabinet Office

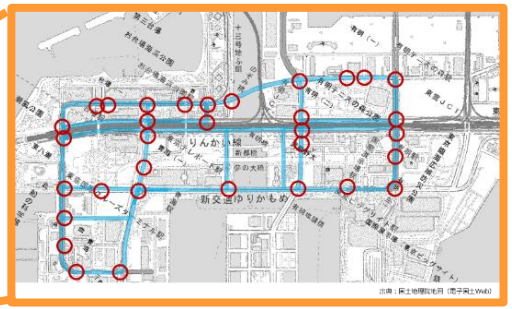
1. Overview of the FOTs in the Tokyo Waterfront area

(1) Testing areas

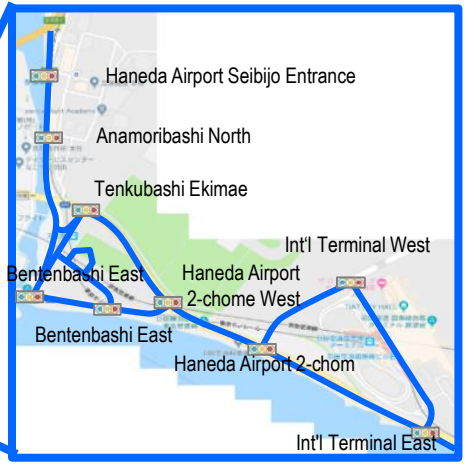
② Expressway routes connecting Haneda Airport and the Waterfront City, etc.



① Waterfront City Area



③ Haneda Airport area



SIP

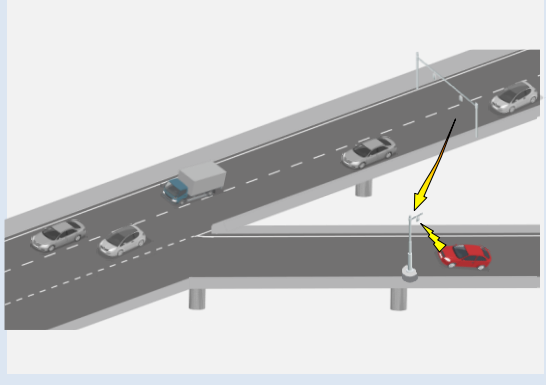
1. Overview of the FOTs in the Tokyo Waterfront area

(2) Implementation contents for each testing area

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

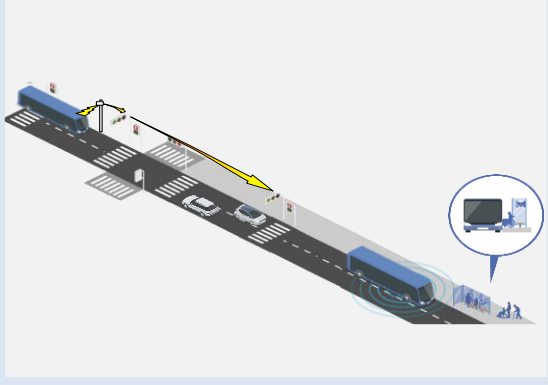
① Waterfront City Area
③ Haneda Airport area

Transmitting driving support information and lane-level traffic environment information 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. Overview of the FOTs in the Tokyo Waterfront area

(3) Organization of the FOTs in the Tokyo Waterfront area WG

Cabinet Office /
New Energy and Industrial Technology Development Organization(NEDO)

↑

FOTs in the Tokyo Waterfront area TF

↕

FOTs in the Tokyo Waterfront area WG

FOTs in the Tokyo Waterfront Area Consortium＊

↕

FOTs Participants

FOTs in the Tokyo Waterfront Area Consortium

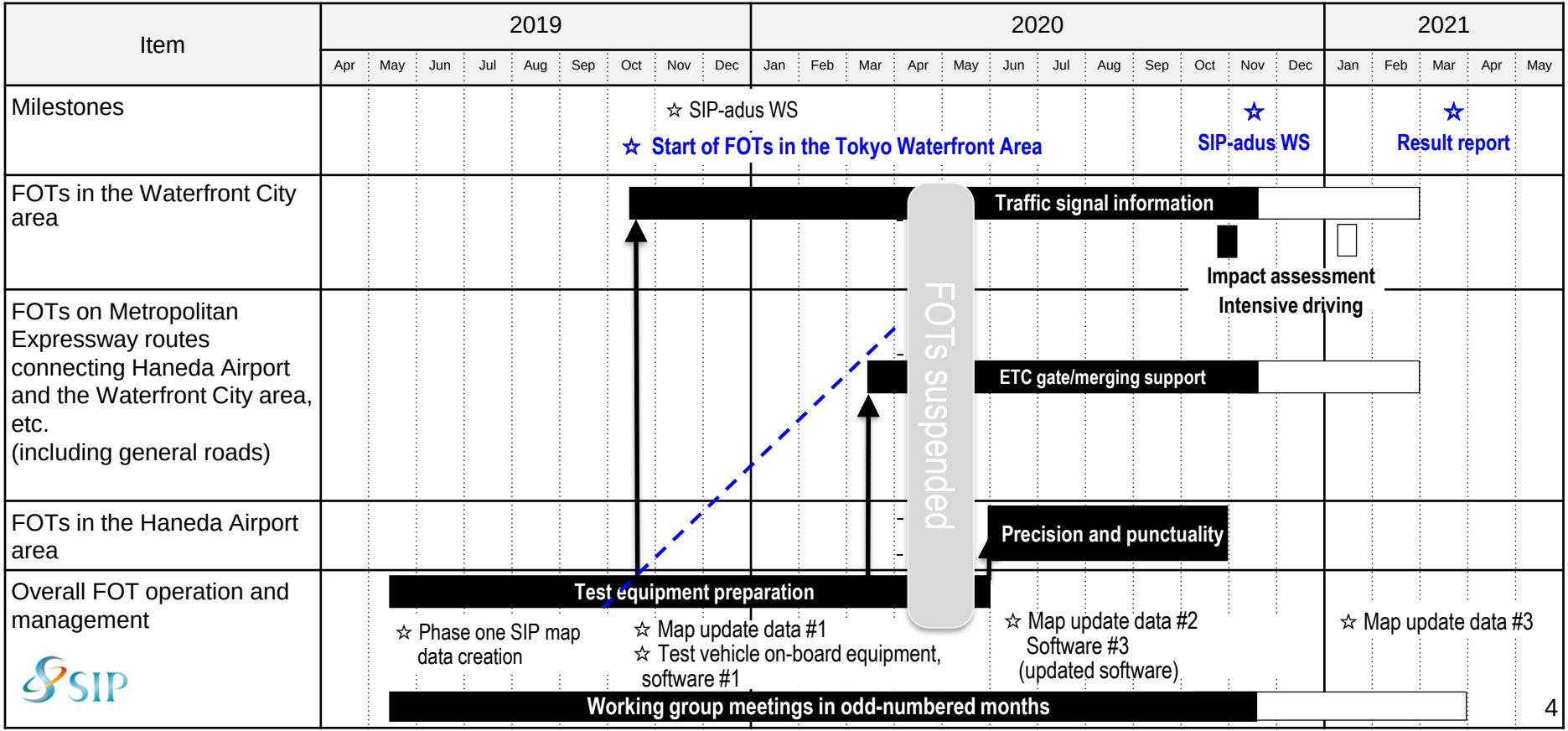
Mitsubishi Electric Corporation (representative)
Aisan Technology Co., Lt
Increment P Corporation
Toyota Mapmaster Incorporated
Pacific Consultants Co., Ltd.
Zenrin Co., Ltd.
Pasco Corporation
Nippon Koei Co., Ltd.
Sumitomo Electric Industries, Ltd.

Stakeholders of the FOTs

	JPN	Overseas
OEMs	9	4
Overseas	3	2
Universities	5	—
Others	4	2
Total	29 parties	

1. Overview of the FOTs in the Tokyo Waterfront area

(4) FOTs in the Tokyo Waterfront area schedule



1. Overview of the FOTs in the Tokyo Waterfront area

(5) The data and communication media of the FOT

Data	Data: detail	Media
(1)Dynamic	Traffic signal information	Advanced infrared beacon & ITS RSU(760MHz)
	Expressway gate information Merging support information	Test vehicle on-board equipment and RSU for expressway experiments
(2)Semi-dynamic	NA	NA
	NA	NA
(3)Semi-static	NA	NA
(4)Static	Map data	Cloud Server
	Updated data	Cloud Server

(4) Static data : Features of high-accuracy 3D map

* Road shoulder
* Center line
* Lane line
* Lane edge
* Stop line
* Pedestrian crossing
* Road marking
* Traffic signal
* Road sign
* Carriageway link
* Lane link
* Intersection lane link
* Area-formed intersection
* CRP node

1. Overview of the FOTs in the Tokyo Waterfront area

(6) System for FOTs in the Tokyo Waterfront area

[Test Car] Passenger car : 97 Bus : 5

Expressway gate information
Merging support information

Traffic signal information

Map data
Updated data

The FOTs
Consortium

Test vehicle on-board equipment for expressway experiments

760MHz-RSU

Cloud Server

Submit

Antenna for 5.8HzDSRC + IR

Advanced IR beacon
&
Test vehicle on-board equipment
for expressway experiments

GNSS Receiver

PC
＊for data confirmation

Log data

Movement managem ent system

Drive recorder

Tally counter

760MHz Receiver

Antenna for 760MHz

BOX-PC

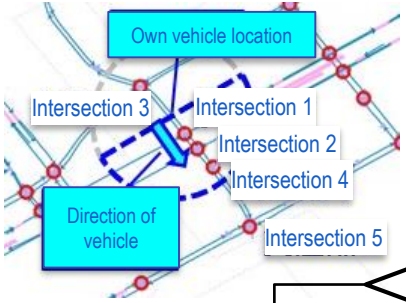
Vehicle Control unit
＊Prepared by Test participants

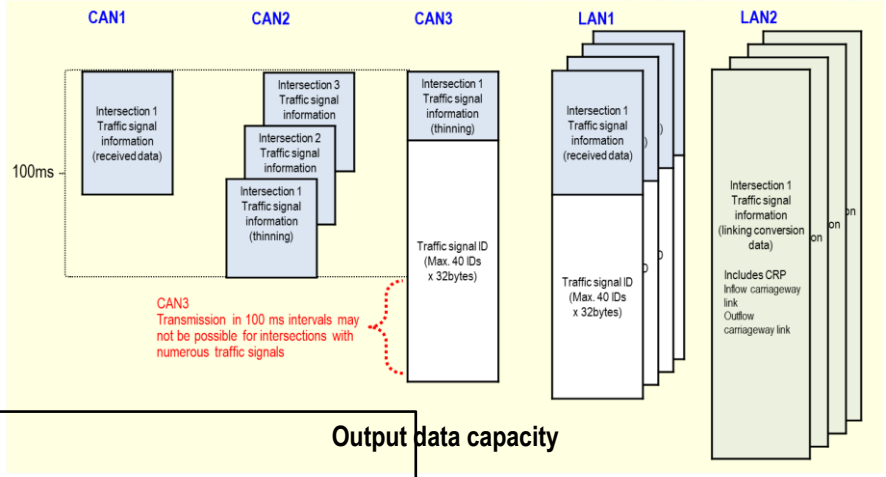
2. FOTs preparation

(1) Method of output to vehicle control

① Data output interface and output data approach

- Five output methods are prepared for outputting to vehicle control devices
- CAN/LAN-IF is selected by test participants





Dynamic information (signal information, etc.)

CAN output | LAN output

Data thinning?

Thinning not performed

Thinning performed

Traffic signal ID exists?

Data linking conversion?

No conversion

Conversion

CAN1
Traffic signal information for nearest single intersection output from information from multiple traffic signals

CAN2: Diagram at upper right
Traffic signal information for nearest three intersections output from information from multiple traffic signals

CAN3
CAN1 output and traffic signal ID output

LAN1
Multiple traffic signal information and traffic signal IDs output every 100 ms

LAN2
Link conversion data (all data)

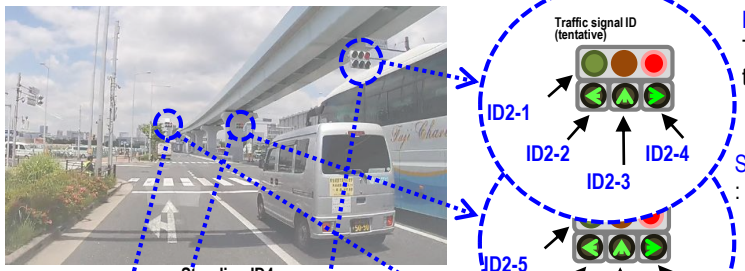
2. FOTs preparation

(2) Mapping of high-accuracy 3D map traffic signal IDs and ITS wireless roadside unit traffic signal information

Mapping of high-accuracy 3D map traffic signal IDs and ITS wireless roadside unit traffic signal information:

Preparation of a traffic signal information mapping table

(mapping of vehicle control recognition high-accuracy 3D map traffic signal IDs and received traffic signal data)

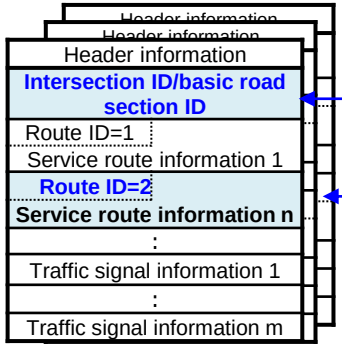


High-accuracy 3D map

Traffic signal IDs are defined for individual traffic signal units and green arrows

Service route information 1

: Determine current ability to drive straight, turn left, or turn right, and number of seconds remaining before light change



Received data traffic signal information

Traffic signal information mapping table

High-accuracy 3D map		Traffic signal information	
Traffic signal ID	Mesh number	Route ID	Intersection ID /basic road section ID
:	:	:	:
ID1-1	Mesh	1	
:	:		
ID1-12	Mesh		
ID2-1	Mesh	2	Ariake Coliseum East
ID2-2	Mesh		
ID2-3	Mesh		
ID2-4	Mesh		
ID2-5	Mesh		
:	:		
ID2-12	Mesh		
:	:	:	
:	:	:	:

Traffic signal
(main unit, ←↑→ green arrows)
Traffic signal orientation (front)

Stop line IDs and traffic signal IDs are mapped to each other using the high-accuracy 3D map

Example: Ariake Coliseum East intersection

3. Verification of evaluation

(1) Waterfront City Area : Evaluation on consortium side for test equipment

High-accuracy map evaluation (October 2019 release)

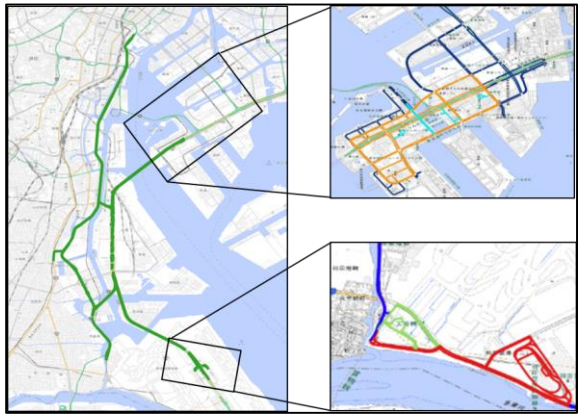
	Driving video (September 2019)	Viewer/measurement images
Evaluation		 Status when measurement was performed (July 5, 2019) There was no zebra crossing zone, no carriageway edge line, and the carriageway markings stopped mid-way 

<Differences 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.

① Waterfront City Area



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

③ Haneda Airport area

- Differences were found between the June/July 2019 measurement and the September consortium evaluation
- The update timing of the map data is important.

3. Verification of evaluation

(2) Waterfront City Area : Evaluation on test participant side

a. Validity of infrastructure traffic signal information for automated driving

Deterioration factor of traffic signal recognition by on-board sensor (hypothesis)	Concept of Selecting Analyzed Sites (Proposal)
Oncoming from sunrise, sunset, car lights, etc.	Sunrise: Sunrise time zone, facing east Sunset: Sunset time zone, facing west ➡Its is necessary to analyze traffic light intersections running east and west.
Shielding by large vehicles, trees, traffic signs, etc.	Mixed environment of small and large vehicles ➡Its is necessary to analyze traffic light intersections on wide roads

b. Validity of read-ahead traffic signal information (remaining seconds)

Situation that could lead to a dilemma	Concept of selecting sites for analysis (Proposal)
The vehicle enters the intersection as it is unable to pass the stop line while the light is yellow	Running at a speed of 50 km/h or more ➡The supplement, at a speed of 60 km/h, during a relatively smooth time zone

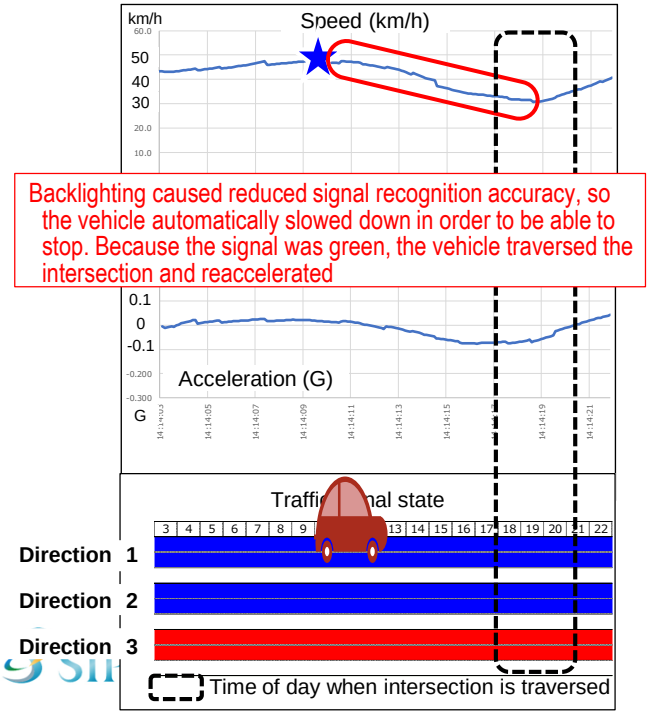
3. Verification of evaluation

(2) Waterfront City area: Evaluation by test participants

a. Effectiveness of infrastructure traffic signal information in automated driving

Expected output
Even when vehicle sensor recognition rates decline, traffic signal information can be used to traverse intersections

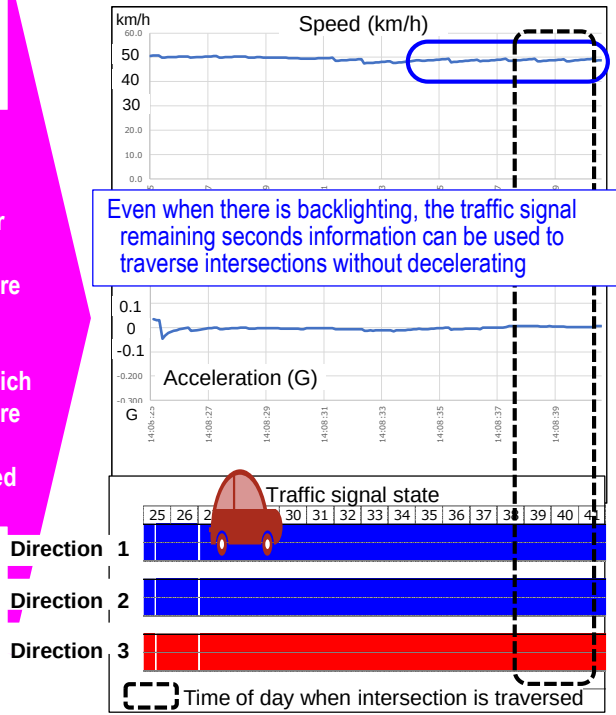
When not using infrastructure information (actual measurement data)



Backlighting caused reduced signal recognition accuracy, so the vehicle automatically slowed down in order to be able to stop. Because the signal was green, the vehicle traversed the intersection and reaccelerated

Changes in vehicle behavior for use of infrastructure information based on cases in which infrastructure information was not used

When using infrastructure information (actual measurement data)



Even when there is backlighting, the traffic signal remaining seconds information can be used to traverse intersections without decelerating

On-board camera image (with backlighting)

On-board camera image (without backlighting)

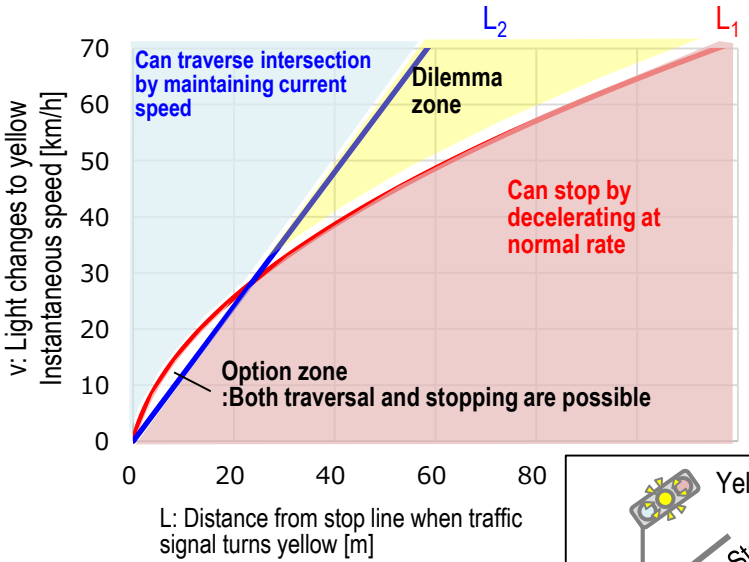
3. Verification of evaluation

(2) Waterfront City area: Evaluation by test participants

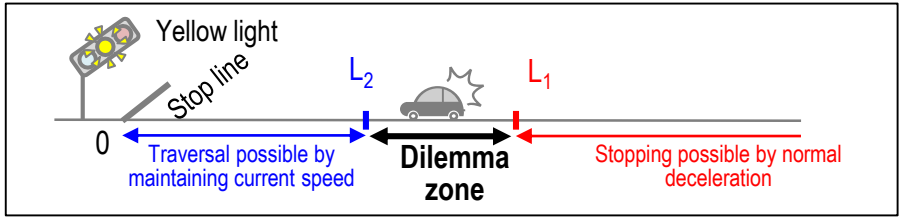
b. Effectiveness of predictive traffic signal information (number of remaining seconds)

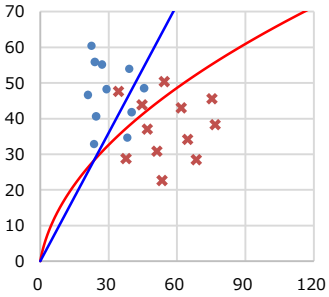
Expected output
Traffic signal remaining seconds information can be used to make traversal/stop decisions in advance and avoid encountering dilemma zones

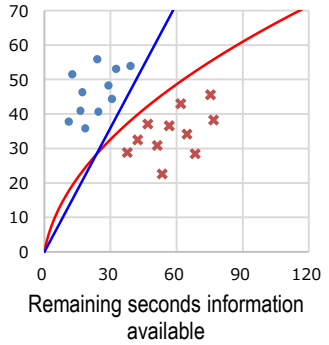
Dilemma zone definition
Region in which, when the traffic light turns yellow, the vehicle would not be capable of stopping before the stop line when decelerating at the normal deceleration rate but the vehicle would not be able to traverse the intersection (stop line) while the traffic light was still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



$L_1 = \tau v + v^2/2d$
$L_2 = Yv$
Where
L1: Stopping distance at normal deceleration rate
L2: Distance that can be covered at current speed while light is still yellow
v: Current vehicle speed [m/s] (←[km/h])
d: Normal deceleration rate [m/s^2] (←[G])
τ: Driver response time [s]
Y: Yellow light duration [s]



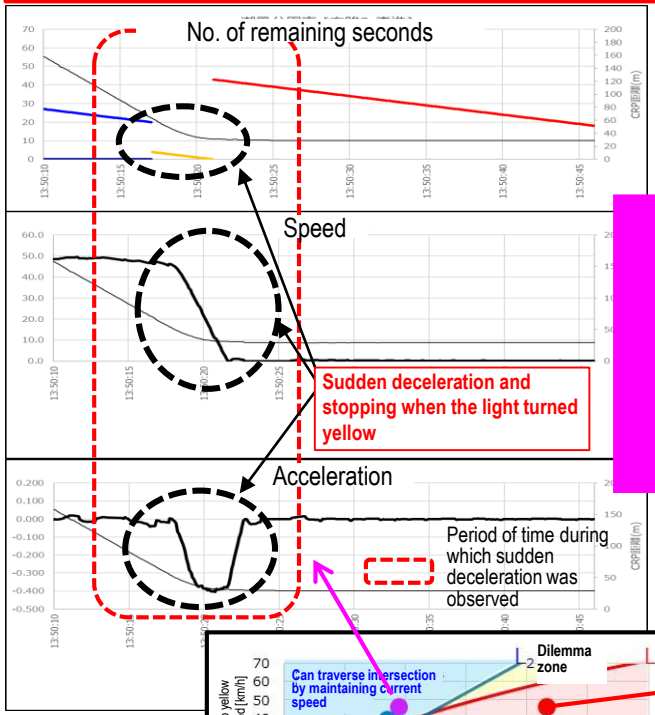


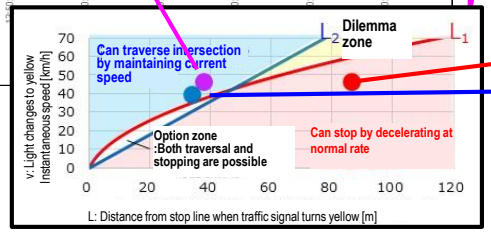


3. Verification of evaluation

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

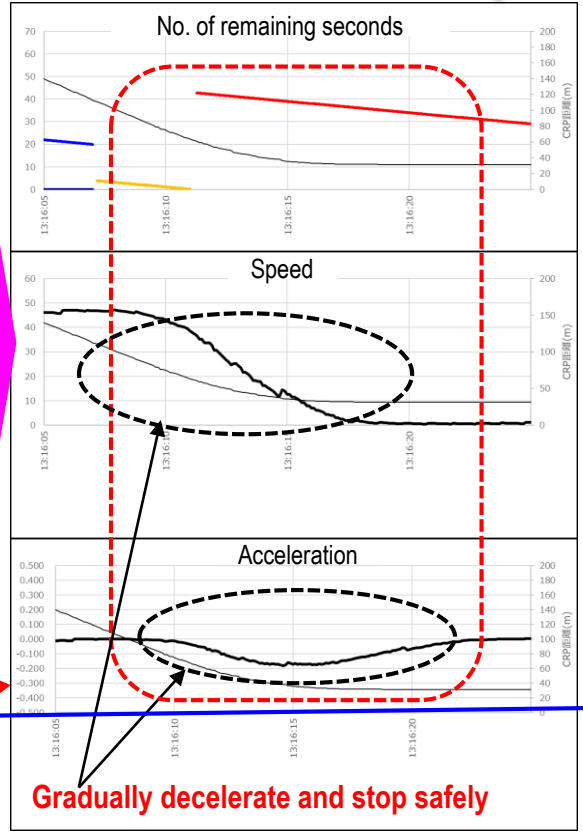
Cases of sudden deceleration and stopping in traversal area

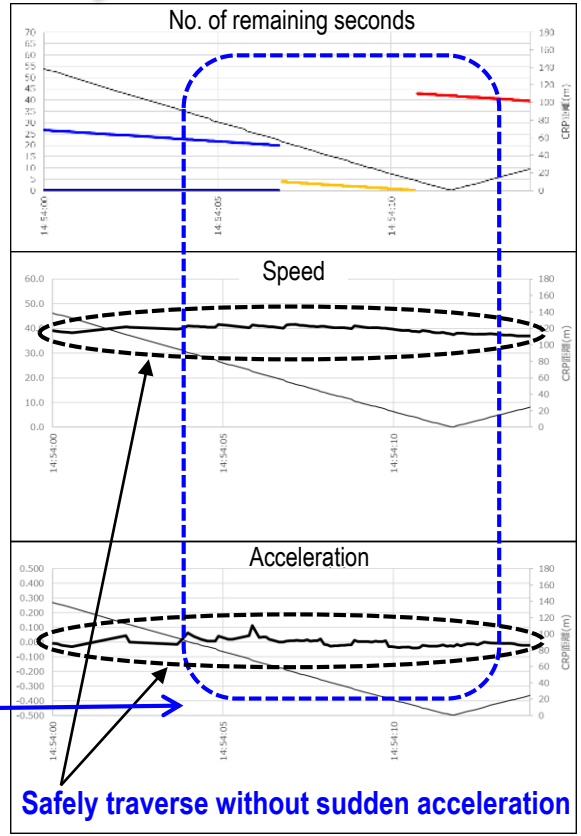




Use of traffic signal remaining seconds information for vehicle control (actual measurement data)

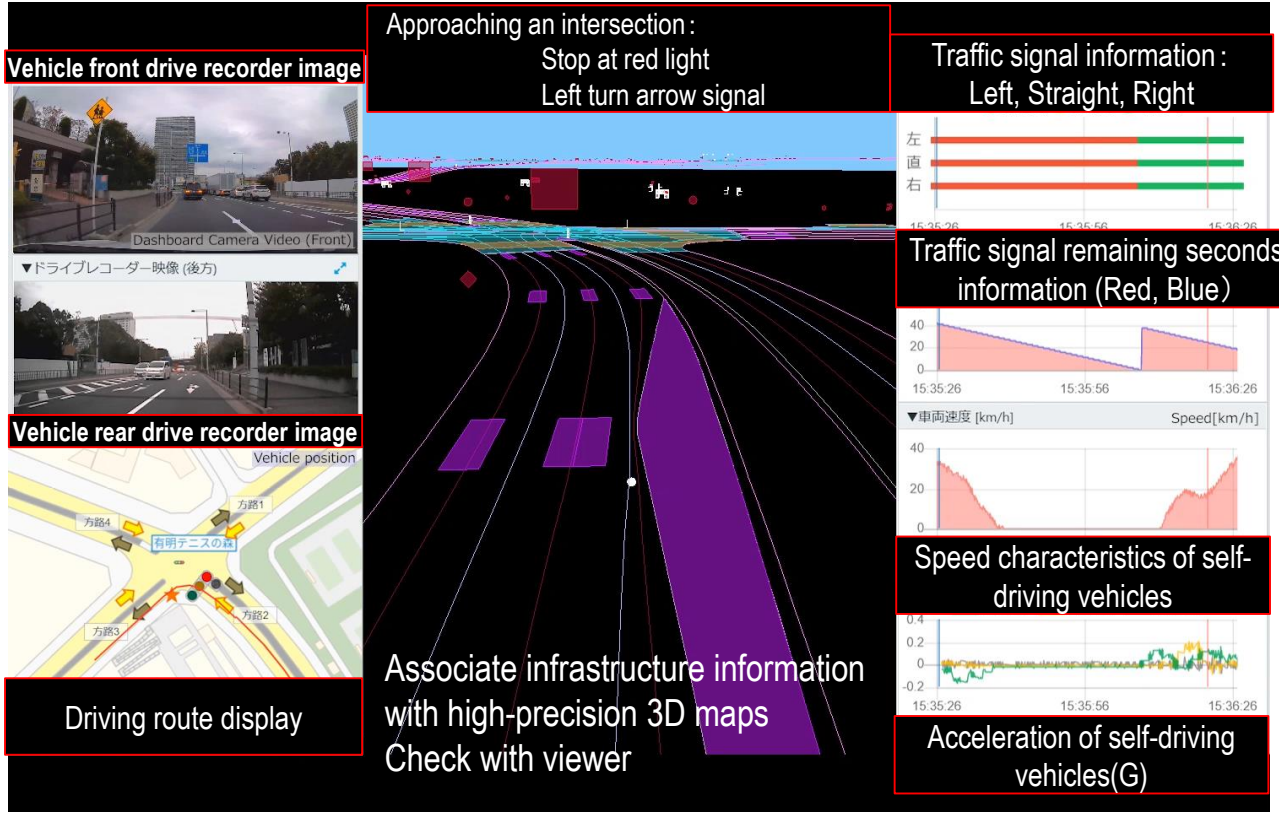
Stopping determined possible in advance ⟷ **Traversal** determined possible in advance





3. Verification of evaluation

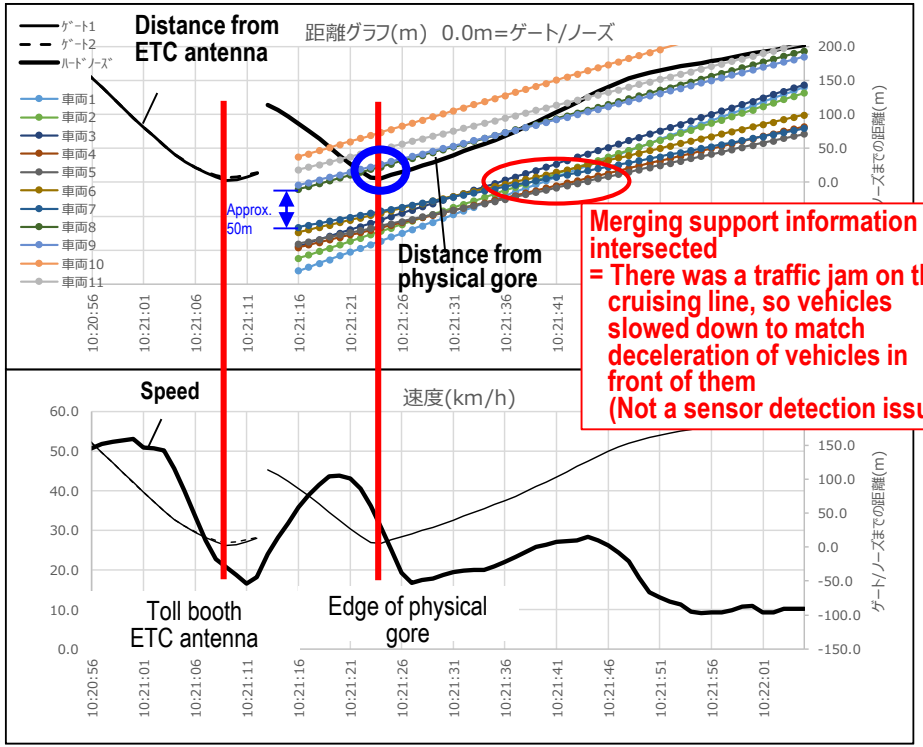
◆ Waterfront City Area : Validity of traffic signal information



3. Verification of evaluation

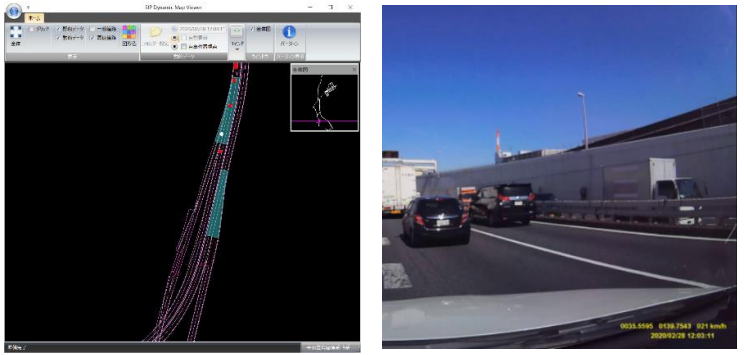
(3) Metropolitan Expressway

Example of data provided by infrastructure and vehicle behavior



Merging support information intersected
= There was a traffic jam on the cruising line, so vehicles slowed down to match deceleration of vehicles in front of them
(Not a sensor detection issue)

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

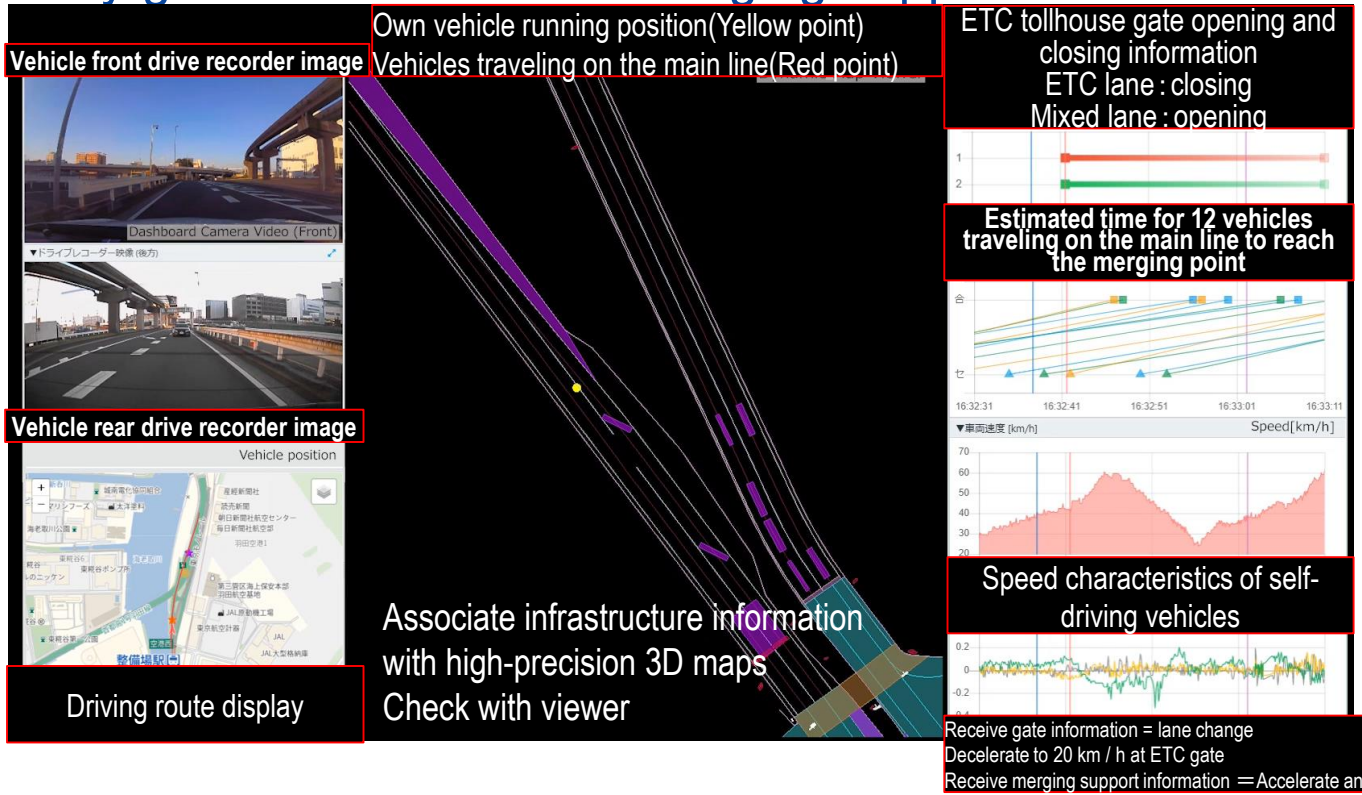


Merging support information
(comparison of viewer display and test video data recording device image)
Feb 28, 2020 12:03:11

SIP [Findings]
- Merging support information received and vehicle merging into cruising line vehicle gap
- Cruising line vehicles driving at low speed, approx. 20 to 30 km/h after cruising line merging

3. Verification of evaluation

◆ Metropolitan Expressway：
Expressway gate information and Merging support information



Thank you