SIP-adus Workshop 2021

Dynamic Map

TF3-21-220 III 6

FOTs in the Tokyo Waterfront area FY2019 to 2020 Results and Overview of Implementation in FY2021

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SIP

Cabinet Office

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1. History of the FOTs in the Tokyo Waterfront Area

- In preparation for the expansion of ODDs for advanced driving assistance and automated driving, research and testing results have been steadily produced. This includes the establishment of static information infrastructure (FY2017-2018) and the evaluation of the effectiveness of dynamic information (FY2019-2020).
- In FY2021, the project will envision the traffic environmental information that will be essential in the future and construct a system of utilizing dynamic information in order to realize advanced, cooperative drive assistance and automated driving by providing information over wide areas using public networks (V2N)

SIP Phase 2 FOTs in the Tokyo Waterfront Area (FY2021)
- Added traffic environmental information and delivered it using V2N
- Verified effectiveness of various traffic environmental information and technologies for sharing this information via V2N

See P.9 onwards

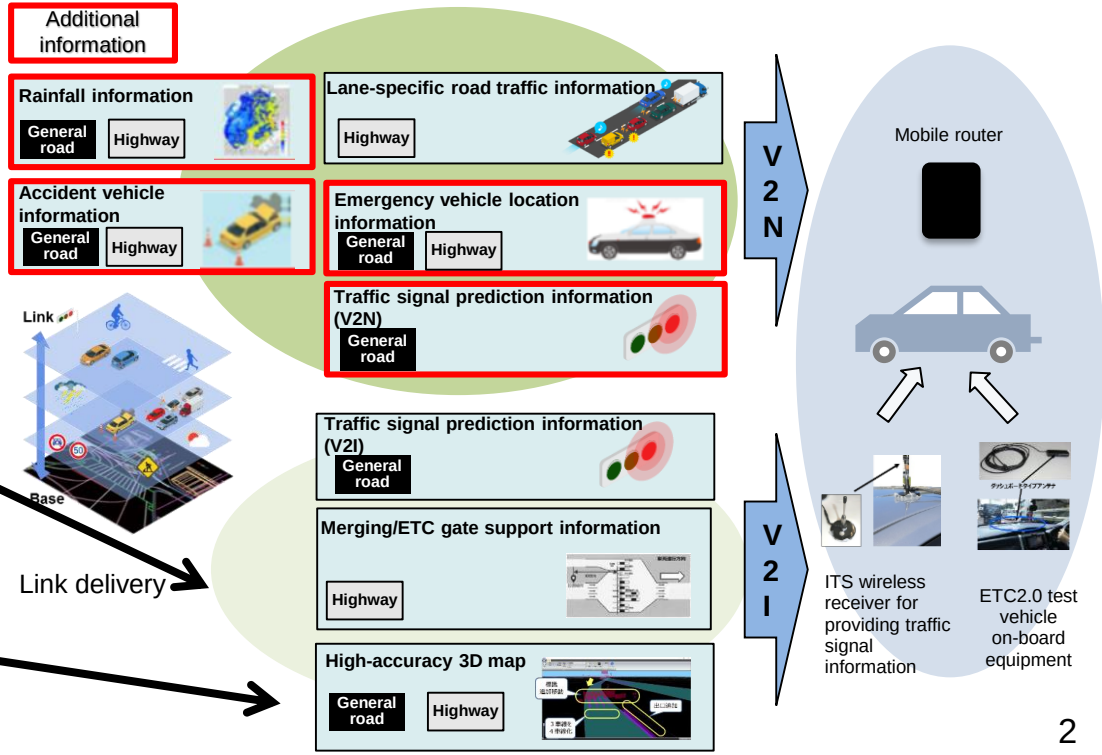
Expansion of information types and provision methods

SIP Phase 2 FOTs in the Tokyo Waterfront Area (FY2019-2020)
- Provided traffic environmental information (traffic signal information, merging support, ETC gate passing support information) via V2I
- Established effectiveness of dynamic information

See P.4 to 8

Superposition of static and dynamic information

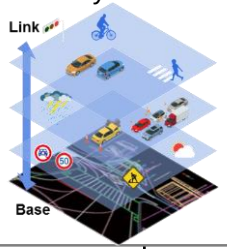
SIP Phase 1 Dynamic Map (FY2017-2018)
- Deliberation regarding dynamic map concept and high-accuracy 3D map, prototyping, and evaluation
- Consensus regarding cooperative area high-accuracy 3D map specifications



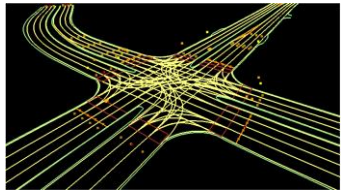
1. History of the FOTs in the Tokyo Waterfront Area

		2014	2015	2016	2017	2018	2019	2020	2021	2022
SIP Phase 1	Prototyping of lane-level dynamic map (DM) and fleshing out of use cases									
	Coordination of DM data specifications proposals, etc., and of prototype requirements for DM data and viewer									
	Dynamic Map Large-scal Field Operational Test									
SIP Phase 2	FOTs in the Tokyo Waterfront area Phase 1 (V2I)									
	FOTs in the Tokyo Waterfront area Phase 2 (V2N)									

Deliberated regarding DM 4-layer model



Prototyped and evaluated dynamic map, reached consensus regarding data specifications



- Road shoulder
- Road center line
- Lane line
- Road edge
- Stop line
- Pedestrian crossing
- Road marking
- Traffic signal
- Road sign
- Road node linkage
- Lane node linkage
- Lane node linkage within intersection
- Intersection
- CRP node

Prepared a DM with a total length of 758.7 km
Evaluated DM together with FOTs participants

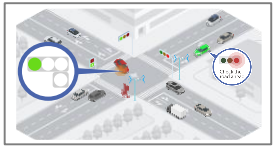
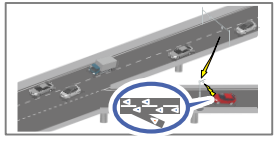
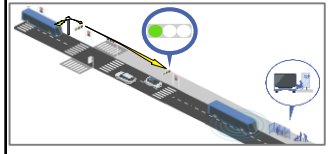
Provided information via V2I
Evaluated traffic signal information, ETC gate information, and merging support information, verified precision automated bus docking precision and punctuality

Provided information via V2N transmission
Distributed and evaluated traffic signal prediction information, lane-specific road traffic information, mock emergency vehicle location information, and rainfall information

2. FY2019 to 2020 Results

(1) FY2019-2020 issues, verification items, and objectives

Today's explanation

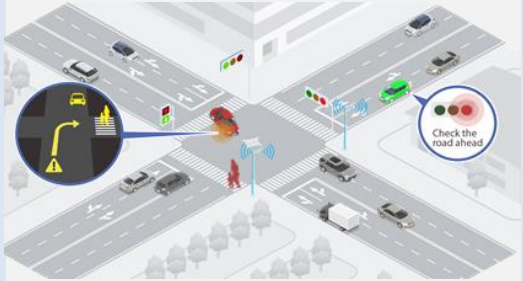
Region	Test contents	Issue	Verification item	Objective
Water front City	Infrastructure information utilization in intersections with traffic signals 	• Ensure reliability of signal recognition • Avoid disturbing traffic flow in dilemma zones	(1). Traffic signal information effectiveness and conditions (a) Effectiveness of traffic signal color information (b) Effectiveness of traffic signal remaining seconds information (2) Assess impact of autonomous vehicle driving on traffic flow and the factors involved	• Verify effectiveness of traffic signal information distribution • Reach consensus with test participants regarding standardized specifications • Identify traffic signal information distribution conditions • Clarify issues to be addressed in order to cultivate a sense of acceptability in society
Express ways	ETC gate passing/merging support information distribution 	• Smooth toll booth gate passing • Support for merging with cruising lines based on actual cruising line vehicle speeds	(1) Confirm the effectiveness of ETC gate passing support information (2) Confirm the effectiveness of merging support information	• Develop infrastructure information provision specifications • Determine infrastructure installation conditions • Clarify issues in order to define specifications based on FOTs • Identify infrastructure needs and prioritization requirements
Haneda Airport	Environmental conditions for practical implementation of level 4 ART 	• Clarify environmental conditions required for practical implementation of level 4 ART in mixed transportation environments	(1) Analyze factors necessitating driver involvement in mixed transportation environments (2) Effectiveness of cooperative infrastructure in regularly scheduled transport (3) Comfort when boarding/exiting (4) Assess impact of autonomous vehicle driving on traffic flow, and factors causing this impact	• Clarify which infrastructure is required for the expansion of ODD • Identify what infrastructure conditions are required for the improvement of ART service • Clarify issues to be addressed in order to cultivate a sense of acceptability in society

2. FY2019-2020 results (Waterfront City area)

(2) Contents of FOTs in the Waterfront City area and FOTs area

1) Verification contents

Transmitting traffic signal information by wireless ITS devices to **implement advanced automated driving on general roads**



2) FOTs area

(a) Waterfront City area

2. FY2019-2020 results (Waterfront City area)

(3) Waterfront City area FOTs results: Infrastructure information utilization in intersections with traffic signals - effectiveness and conditions

(a) Effectiveness of traffic signal color information [factors that interfere with traffic signal color recognition*1]

Backlighting

It is difficult to determine the traffic signal color due to light sources such as the sun, the headlights of oncoming vehicles, or reflections from buildings

Direct lighting

It is difficult to identify traffic signal colors due to light sources such as the sun

Concealment/obstruction*2

The view of the traffic signal is obstructed by large nearby vehicles, vegetation, elevated road sections, or other structural elements

Blending into background

* From materials prepared by the Kanazawa University Promotion Committee

While the color of a traffic signal can itself be determined, the outline, etc. of the traffic signal blends in with the building behind it or other background elements, reducing the reliability of traffic signal detection.

Nighttime

At night, there are light sources such as street lamps and building lights that make traffic signal color recognition difficult

Raindrops

Raindrops cling to the camera, making it difficult to identify traffic signal colors

*1 Identified based on test participant driving data and feedback regarding it

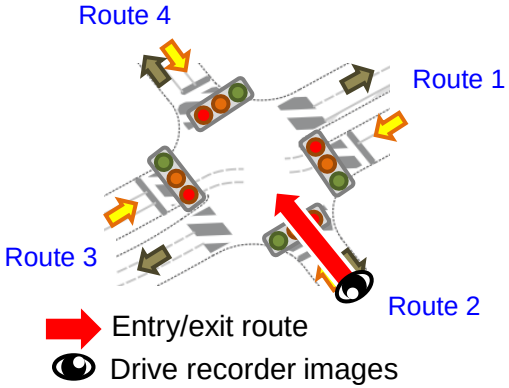
*2 This refers to situations in which there are obstructions, such as preceding vehicles or nearby structures, between a test vehicle and a traffic signal, preventing the vehicle's on-board camera from being able to identify the traffic signal color (This includes curves, grades, and other road structures)

- **The evaluation of the effectiveness of traffic signal color information was performed using driving data for all intersections**
- **Information regarding conditions when interference factors occurred were collected from all Waterfront City area intersections on a per-factor basis**

2. FY2019-2020 results (Waterfront City area)

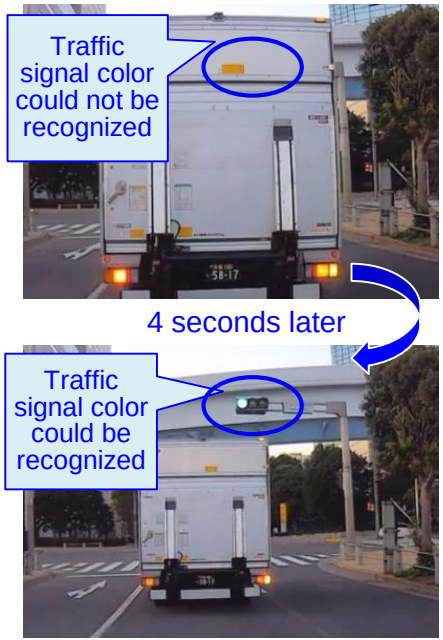
(3) Waterfront City area FOTs results: Infrastructure information utilization in intersections with traffic signals - effectiveness and conditions

(b) Effectiveness of traffic signal color information [Examples of concealment/obstruction]

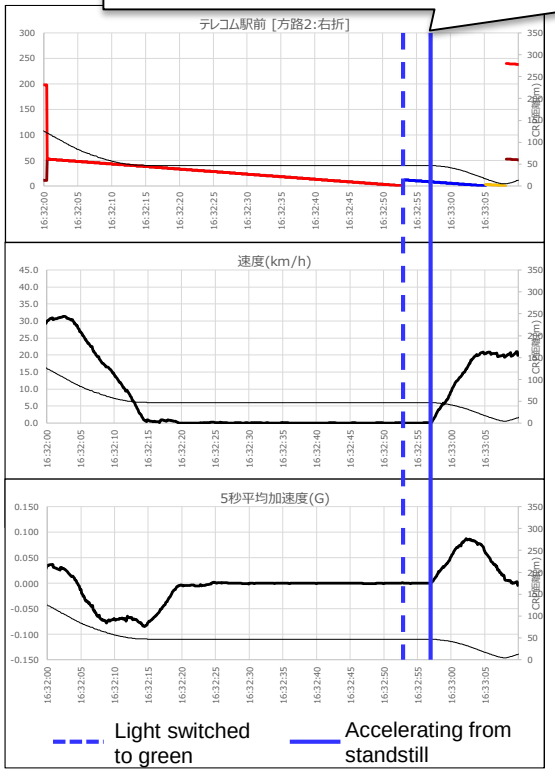


Experiment date/time	Automated driving	Intersection no.	Name of intersection	Conditions
2020/10/26 16:33	-	B	Telecom Station-mae	Concealment/ obstruction

Entry route	Exit route	Traffic signal color	Duration of period when traffic signal color could not be recognized
Route 2	Route 1	Red → Green	4 seconds



The traffic signal color could not be recognized until four seconds after the traffic signal turned green



2. FY2019-2020 results (Waterfront City area)

(4) Guidelines on the creation of dynamic maps and high-accuracy 3D map data

自動走行システム向け地図データ仕様への提案

Ver.1.1

【地図データ作成時におけるガイドライン】

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

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

令和３年３月

東京臨海部実証実験コンソーシアム

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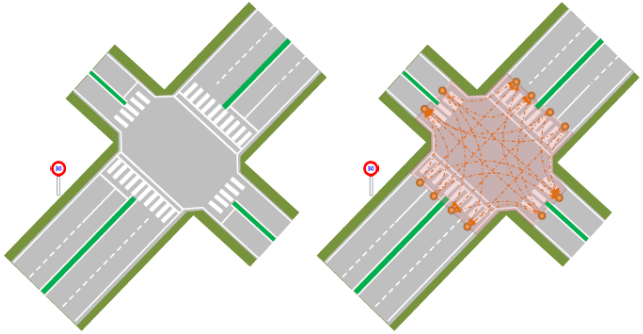
(37) **交差点内車線リンク**

交差点内車線リンクが定義される具象クラス。



地図作成時の留意事項

①走行可能な経路の取得位置に関する対応

a) 交差点内車線リンクは曲線で記述すること。但し、高速道路においては直線を認める。

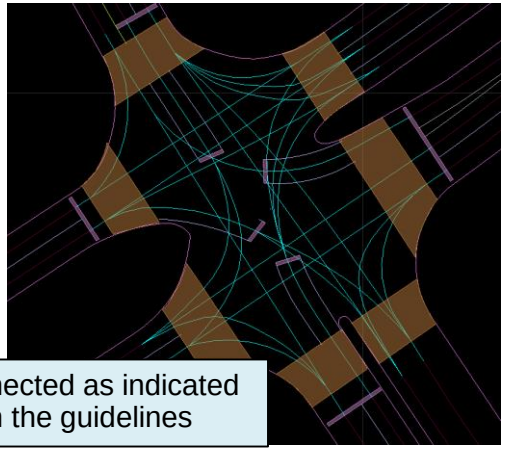
b) 交差点内車線リンクは車道外に出ないこと。

c) 進入方路の各車線から接続可能なすべての交差点内車線リンクを接続すること。但し、U ターンは除外する。

d) 進入方路にて道路標示等により進路が指定されている場合、その内容を遵守して交差点内車線リンクを接続すること。

e) 進入方路、退出方路とも、すべての車線は交差点内車線リンクを少なくとも１つは接続すること。

All drivable lane node linkages are connected in the data



Connected as indicated in the guidelines

3. Overview of Implementation in FY2021

(1) Overview, implementation items, and objectives

Overview of initiatives

- Create a wide area information distribution system envisioned for social deployment and perform FOTs in actual roadway traffic environments with the aim of expanding the Operational Design Domain (ODD) of mobility and logistics services using advanced drive assistance, autonomous vehicles, and automated driving technologies by providing dynamic information via infrastructure (vehicle-infrastructure cooperation)

FY2021 implementation items

Deliver traffic environmental information via V2N and confirm the information's effectiveness and specifications

- Traffic signal prediction information
- Lane-specific roadway traffic environmental information
- Simulated emergency vehicle location information
- Rainfall information

FY2021 objectives

- Verify use of cooperative systems in tackling challenges involved in implementing advanced automated driving
  - ➢ Verify the effectiveness of different traffic environmental information used in the FOTs
  - ➢ Confirm standardization specifications and reach consensus by test participants
  - ➢ Issue recommendations for the test equipment (infrastructure) used in these FOTs
  - ➢ Clarify issues to be addressed in order to cultivate a sense of acceptability in society
  - ➢ Share results with related organizations (JAMA, etc.)

(2) Evaluation approach and structure of test system

Equipment-side evaluation

Build a new traffic environmental information V2N delivery environment and identify issues involved in societal deployment

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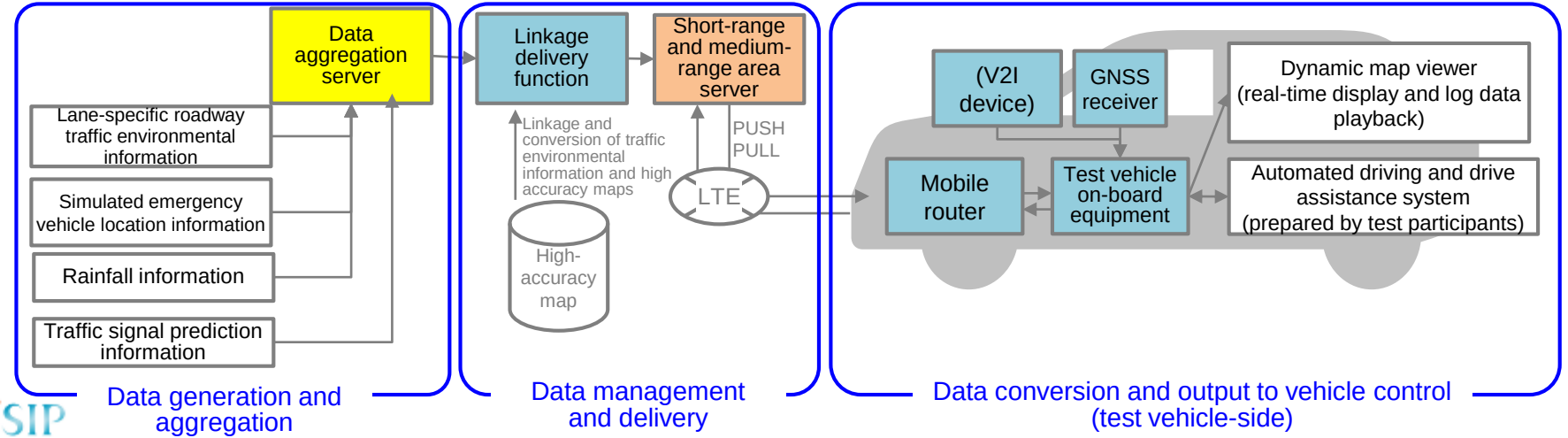
Evaluation by test participants

Verify effectiveness of traffic environmental information for automated driving systems and drive assistance systems.



3. Overview of Implementation in FY2021

(3) The data and communication media of the FOT

Data	Data: detail	Media
(1)Dynamic	Traffic signal information	V2I:Advanced infrared beacon & ITS RSU(760MHz)
	Traffic signal prediction information	V2N:LTE
	Simulated emergency vehicle location information	V2N:LTE
(2)Semi-dynamic	Lane-specific roadway traffic environmental information	V2N:LTE
	Rainfall information(wide area)	V2N:LTE
(3)Semi-static	Rainfall information(narrow area)	V2N:LTE
(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

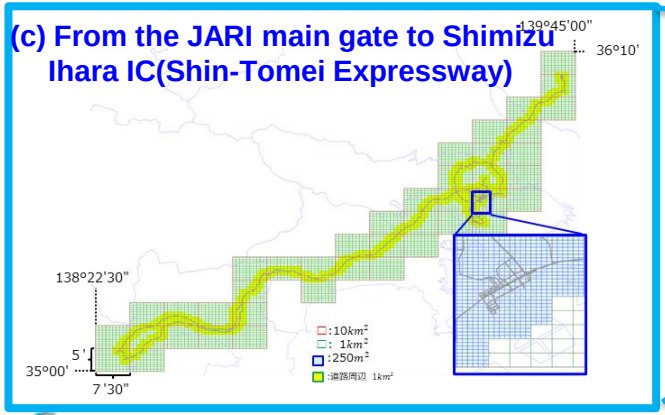
3. Overview of Implementation in FY2021

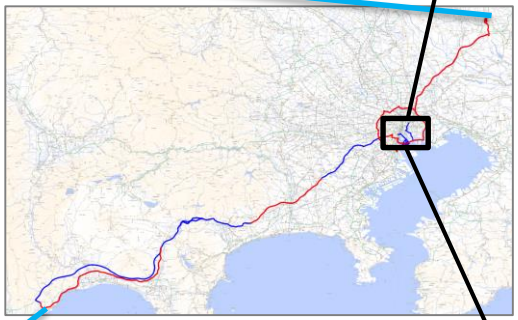
(4) FOTs area

- **The wide-area dynamic map created in SIP Phase 1 and the same map updated with the latest data during SIP Phase 2 will be used**

(b) Expressway routes connecting Haneda Airport and the Waterfront City area, etc.

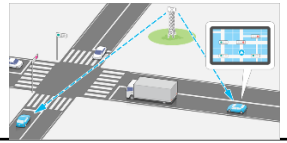
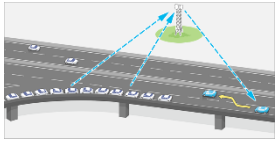
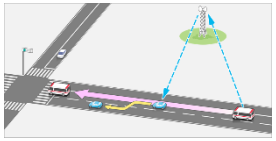
(c) From the JARI main gate to Shimizu Ihara IC(Shin-Tomei Expressway)





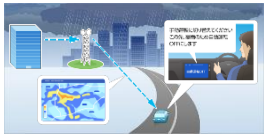
3. Overview of Implementation in FY2021

(5) Delivered information, issues, verification items, and objectives

Delivered information	Issue	Verification item	Objective
Traffic signal prediction information (V2N) 	• Confirm achievement of reliable signal recognition • Confirm usage methods and effectiveness of information delivered via V2N communications (planned)	• Confirm operations used to deliver traffic signal prediction information • Collect traffic signal information through actual driving (V2I, V2N) • Propose effective methods of utilizing traffic signal prediction information, including in applications other than vehicle control as well	• Confirm effectiveness of traffic signal prediction information delivery (V2N) (clarify at which intersections the information can be effectively delivered via V2I/V2N, limiting conditions, etc.) • Confirm the specifications of traffic signal prediction information (V2N). Summarize participant consensus, requests, etc.
Lane-specific road traffic information (Caution information) 	• There are restrictions on driving using vehicle-mounted sensors alone and limits to the distance at which vehicle-mounted sensors can detect obstacles, so infrastructure look-ahead information must also be provided	• Verify system used to supply lane-specific road traffic information (caution information) • Verify improvements in accuracy due to increase of number of samples of probe information compared to FY2020 • Confirm accuracy of information through driving in actual traffic environments (confirm effectiveness in path planning)	• Verify effectiveness of delivery of lane-specific road traffic information (caution information) (clarify limiting conditions) • Prepare lane-specific road traffic information (caution information), confirm delivery specifications, and obtain consensus of participants
(Mock) Emergency vehicle location information 	• Appropriate response when an emergency vehicle approaches during automated driving* (stopping, pulling off onto the shoulder, etc.)	• Verify system used to provide emergency vehicle location information • Confirm accuracy of information in actual driving environments (actual position of mock emergency vehicle, comparison versus received information, etc.) • Reflect findings in specifications based on deliberations regarding vehicle behavior taken in response to mock emergency vehicle location information	• Confirm effectiveness of delivery of emergency vehicle location information (clarify the limiting conditions that apply to the use of emergency vehicle location information) • Prepare emergency vehicle location information, confirm delivery specifications, and obtain consensus of participants

3. Overview of Implementation in FY2021

(5) Delivered information, issues, verification items, and objectives

Delivered information	Issue	Verification item	Objective
Rainfall information 	● Make decisions regarding automated driving during poor weather and issue TORs sufficiently in advance	● Confirm operations used to deliver rainfall information ● Reflect findings in specifications based on investigation of vehicle behavior taken in response to provision of rainfall information within provision scope *TOR: Take Over Request	● Verify effectiveness of rainfall information delivery format and weather prediction information (clarify limiting conditions) ● Prepare rainfall information, confirm delivery specifications, and obtain consensus of participants

(6) FY2021 FOTs Schedule

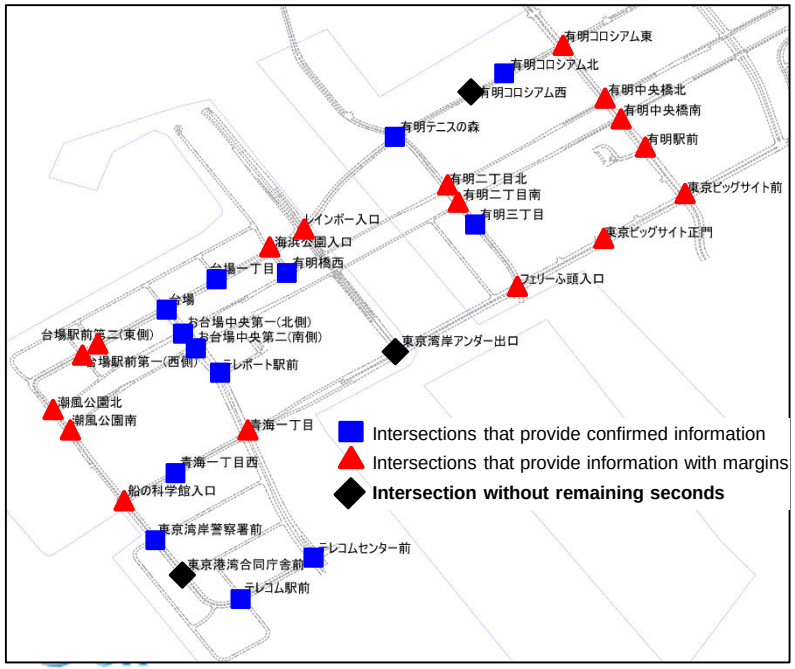
Item	Information provision location		2021				2022		
	Waterfront City	Express-ways	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Milestone					■ SIP-adus WS: Nov. 9, 10				
FOTs (V2N) 1) Rainfall information	○	○							
2) Lane-specific traffic environmental information	-	○							
3) Traffic signal prediction information	○	-							
4) Simulated emergency vehicle location information	○	-							

4. FY2021 traffic signal prediction information transmission test

(1) Intersections within traffic signal prediction information delivery scope

Preparation of scope of intersections involved in the Waterfront City area FOTs
"Confirmed information" "Information with margins"
"No traffic signal current status/remaining seconds"

The test will be performed for 30 intersections that provide confirmed information and information with margins



ID	Name of intersection	Provided information
2	Telecom Station-mae	Confirmed
89	Tokyo Wangan Police Station-mae	Confirmed
91	Ariake Coliseum East	Margin
92	Ariake Station-mae	Margin
95	Shiokaze Park North	Margin
96	Shiokaze Park South	Margin
97	Museum of Maritime Science Entrance	Margin
98	Tokyo Port Bay Godo-chosha Bldg-mae	Remaining seconds information not available
99	DaibaEkimae No. 2 (East)	Margin
100	DaibaEkimae No. 1 (West)	Margin
101	Aomi 1-chome West	Confirmed
102	Daiba	Confirmed
103	Central Odaiba No. 1 (North)	Confirmed
104	Central Odaiba No. 2 (South)	Confirmed
105	Teleport Ekimae	Confirmed
106	Telecom Center-mae	Confirmed

ID	Name of intersection	Provided information
107	Daiba 1-chome	Confirmed
108	Kaihin Park Entrance	Margin
109	Ariakebashi West	Confirmed
110	Rainbow Entrance	Margin
111	Tokyo Wangan Underpass Exit	Remaining seconds information not available
112	Ariake Tennis-no-mori Park	Confirmed
113	Ariake 2-chome North	Margin
114	Ariake 2-chome South	Margin
115	Ariake 3-chome	Confirmed
116	Ferry Terminal Entrance	Margin
117	Ariake Coliseum West	Remaining seconds information not available
118	Tokyo Big Sight Front Entrance	Margin
119	Ariake Coliseum North	Confirmed
120	Ariake Chuobashi North	Margin
121	Ariake Chuobashi South	Margin
131	Aomi 1-chome	Margin
132	Tokyo Big Sight-mae	Margin

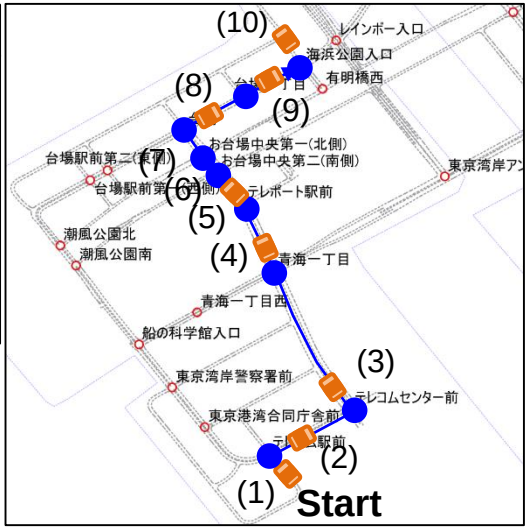
4. FY2021 traffic signal prediction information transmission test

(2) Conceptual image of changes to intersections for which information is delivered by PUSH delivery (specified intersection) based on vehicle position

Information is output for the maximum number of intersections for which information can be acquired (in this example, three intersections), starting from the first intersection on the traversed intersection list, excluding intersections that have already been traversed

Note) The number of intersections setting can be changed
Output all 30 intersections - output minimum of 1 intersection
: Can be used to test load, processing capabilities, etc.

Traversed intersection list
Telecom Station-mae
Telecom Center-mae
Aomi 1-chome
Teleport Ekimae
Central Odaiba No. 2 (South)
Central Odaiba No. 1 (North)
Daiba
Daiba 1-chome
Kaihin Park Entrance



Traffic signal prediction information acquisition/output intersection matrix

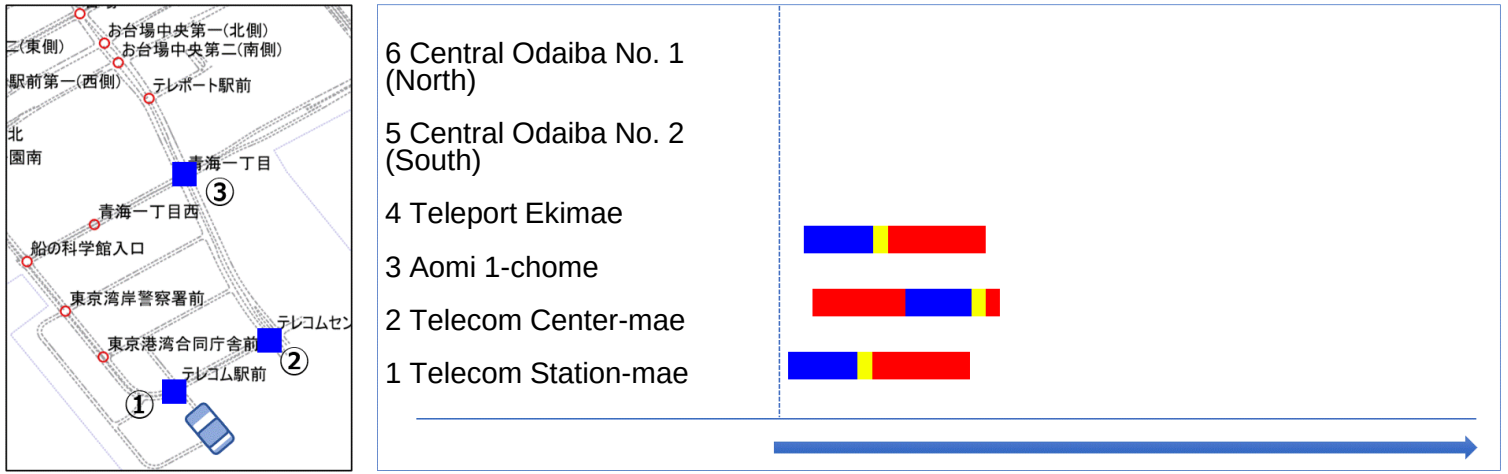
Timing of info acquisition intersection switching / Selected intersection		(1) Start driving	(2) Traverse Telecom Station	(3) Traverse Telecom Center-mae	(4) Traverse Aomi 1-chome	(5) Traverse Teleport Ekimae	(6) Traverse Central Odaiba No. 2 (South)	(7) Traverse Central Odaiba No. 1 (North)	(8) Traverse Daiba	(9) Traverse Daiba 1-chome	(10) Traverse Kaihin Park Entrance
1	Telecom Station-mae	○		×	×	×	×	×	×	×	×
2	Telecom Center-mae	○	○		×	×	×	×	×	×	×
3	Aomi 1-chome	○	○	○		×	×	×	×	×	×
4	Teleport Ekimae		○	○	○		×	×	×	×	×
5	Central Odaiba No. 2 (South)	×		○	○	○		×	×	×	×
6	Central Odaiba No. 1 (North)	×	×		○	○	○		×	×	×
7	Daiba	×	×	×		○	○	○		×	×
8	Daiba 1-chome	×	×	×	×		○	○	○		×
9	Kaihin Park Entrance	×	×	×	×	×		○	○	○	
Unselected intersection		×	×	×	×	×	×	×	×	×	×

○ : Intersection for which traffic signal prediction information is acquired/output
X : Intersection for which traffic signal prediction information is not acquired/output

4. FY2021 traffic signal prediction information transmission test

(3) Conceptual image of delivery of traffic signal prediction information using PUSH delivery (specified intersection)

◆ Conceptual image of traffic signal prediction information graph



Thank you