戦略的イノベーション創造プログラム

The second phase of Cross-ministerial Strategic Innovation Promotion Program (SIP) - Automated Driving for Universal Services (Expansion of Systems and Services)/ Operations of Planning and Deliberation Council for the Creation of Systems for Generating and Providing Lane-level Road Traffic Information Using Probe Information

FY2021 Report

Mitsubishi Research Institute, Inc.

March, 2022

Background and objectives

Background

Lane-level road traffic information holds promise for use in predicting upcoming conditions which cannot be recognized by vehicle sensors. This can assist with automated driving and safe driving assistance. Roadside sensors can only perform fixed-point measurement, so there is a pressing need to consider systems for generating and providing lane-level road traffic information using vehicle probe information, which can assess traffic conditions over areas.

In order to tackle these issues, during the second phase of SIP, in 2019, technology specifications for FOTs related to lane-level road traffic information were created. In 2020 and in 2021, FOTs were conducted under the condition that information from private-sector vehicle probes from motor vehicle and navigation system manufacturers were processed and supplied as lane-level road traffic information. Furthermore, the technology specifications are being reviewed and revised based on the issues and necessary improvements discovered through these FOTs, with the aim of establishing specifications for the provision of lane-level road traffic information.

Objectives

In this study, we investigated the current state of vehicle probe information through deliberation council meetings of public and private sector stakeholders with the aim of creating a system for generating and providing lane-level road traffic information using vehicle probe information to contribute to automated driving and safe driving assistance. We also deliberated regarding the direction to be taken in the future.

2. Study items

This study was performed over the course of three fiscal years, 2019, 2020 and 2021, and consisted of the following four study items.

Table. Study items

Item	Overview
1. Interview study	We conducted interviews with motor vehicle manufacturers and navigation system manufacturers that handle vehicle probe information. We confirmed the current state of affairs and the vehicle probe information that could be collected in the future. (1) Method of collecting data from vehicles (2) Statistical processing technologies (3) Method of providing generated road traffic information (4) Data usage conditions, licensing, and privacy protection
2. Deliberation regarding future direction	Through discussions with related government agencies (Cabinet Office, National Police Agency, Ministry of Land, Infrastructure, Transport and Tourism, etc.) and major related organizations (Japan Automobile Manufacturers Association, Japan Road Traffic Information Center, Vehicle Information and Communication System Center), we deliberated on the future direction of systems for generating and providing lane-level road traffic information. (1) Method of use of lane-level road traffic information by vehicles (2) Types of information from private-sector vehicle probes provided by motor vehicle manufacturers, navigation system manufacturers, etc. (3) Information generated from vehicle probe information and update frequency (4) Process of information sharing between public and private sector stakeholders and division of data aggregation functions
3. Holding of deliberation council meetings	Meetings of the deliberation council, composed of related government agencies and major related organizations, were held with the aim of forming a consensus regarding the practical implementation of lane-level road traffic information and the implementation of FOTs • Demonstration system development approach • Overall FOTs policy and results evaluation • Identification of practical implementation challenges
4. Deliberations regarding merging support	We have investigated the Day 2 system, a service that provides merging support information being deliberated by NILIM, with the aim of improving lane-specific traffic flow information. • Administration of meetings • Study of merging area road alignment

Item1. Interview study

Outline of Interview study

We conducted interviews with motor vehicle manufacturers, navigation system manufacturers, etc., regarding the domestic and overseas measures related to the collection of vehicle probe information and the use of this information in automated driving. **Our objective was to assess current conditions and to gather basic information for use in deliberations regarding future direction,** with the ultimate aim of generating and providing lane-level road traffic information based on information from private-sector probes.

Table Interview items

Item	Interview item
(1) Hopes for lane-level road traffic information. Possibility of collaboration in FOTs.	• Needs and expectations for lane-level road traffic information • Content of possible collaboration in FOTs
(2) Method of collecting data from vehicles	• Contents of data collected and gathered from vehicles • Frequency and conditions applying to the collection of data from vehicles by OEM centers (uplink) • Positioning accuracy • Transmission method
(3) Statistical processing technologies	• Contents of information generated through statistical processing • Processing contents and processing frequency • Existence of technologies for generating lane-level road traffic information
(4) Method of providing generated road traffic information	• Method for providing information generated at OEM centers to vehicles (transmission method, provision frequency) • Data items
(5) Data usage conditions, licensing, and privacy protection	• Data usage conditions and terms (data usage purposes, restrictions regarding who to prove data, rights, etc.) • Privacy protection (technical measures and systems for anonymizing data, etc.) • Provision cost

Result of Interview study

- We conducted interviews with four companies collecting and using probe information: three motor vehicle manufacturers and one navigation system manufacturer.
- We asked each company about their expectations for lane-level road traffic information. We confirmed that the information currently being collected from commercially sold vehicles, which could be provided for use in FOTs, is carriageway-level(not lane-level), statistically processed information.

■ Needs and expectations for lane-level road traffic information
- Respondents had high hopes for the use of information in reliable automated driving control and improved route guidance accuracy (one step before automated driving).

■ Possibility of collaboration in FOTs
- The information currently being collected from commercially sold vehicles, which could be provided for use in FOTs, is, as a rule, carriageway-level information.
- From the perspective of protecting personal information as specified in agreements between service users and individual companies, the data that could be used would be statistically processed data*.

  * Statistically processed data: Anonymized data such as (1) link-specific average travel time, (2) the number of probe vehicles used to generate the data in (1), (3) the number of vehicles in each speed range, etc.
- Map matching processing is performed by each company using propriety maps. To integrate data, it will be necessary to make advance arrangements regarding which map to use as the base map.

Issues to be considered based on the actual state of probe information collection, processing, and use by individual OEMs and other companies

Technologies for processing and integrating probe information in order to generate lane-specific information
Methods of processing probe information necessary for generating lane-specific information
Methods of integrating information collected by multiple OEMs, etc.

Technologies for delivering lane-level information
Methods for delivering generated lane-specific information

Item2. Deliberation regarding future direction

Outline of the Deliberation

In cooperation with the entity that conducted the technical study work, we summarized the issues and discussed the direction of the project with regard to the ideal form and functions to be provided in order to realize the generation and provision of lane level road traffic information using private sector probe information.

1. Purpose of the Initiative

1.1. Necessity of Lane Level Road Traffic Information (Significance of Initiative)

1.2. Scope of these Initiatives

1.3. Target Use Cases and Benefits of Information Provision

1.4. Future Vision and Investigative Scope of these Initiatives

2. Contents of Technical Deliberation

2.1. Overview of Information Generation and Provision and Scope of Investigative Subject

2.2. Deliberation of Elemental Technologies

3. Technical Verification and Effectiveness Verification

3.1. Plans for Technical Verification and Effectiveness Verification

3.2. Verification Results

4. Technical Specifications Considered for these Initiatives (draft)

5. Courses of Action and Challenges for Practical Application

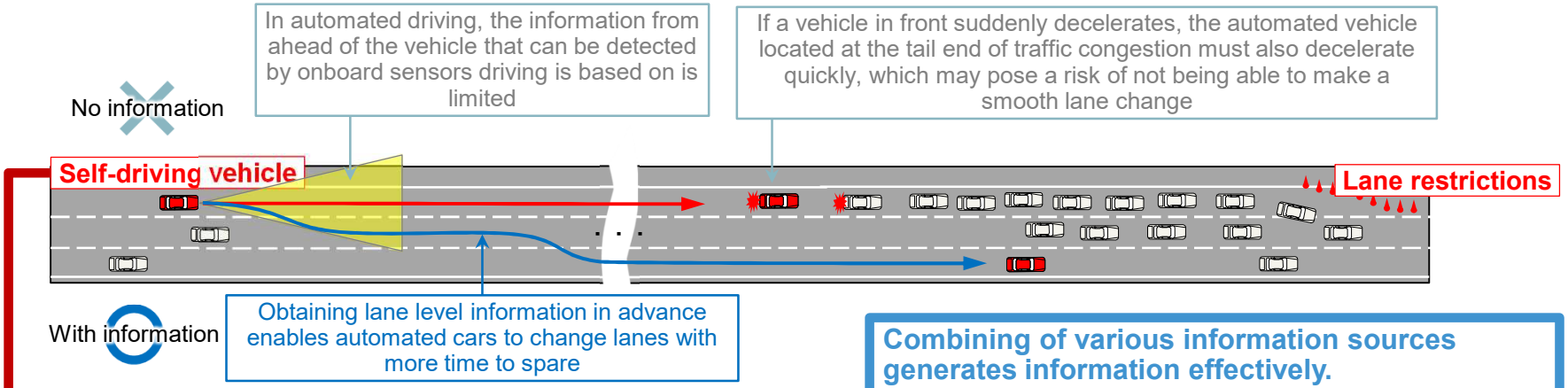
5.1. Investigative Steps and Procedures Toward Practical Application(draft)

5.2. Courses of Action for Division of Functions and Roles Towards Practical Application

1. Purpose of Initiative

1.1. Necessity of Lane Level Road Traffic Information

- Lane level road traffic information is necessary for achieving safe and smooth driving, such as by changing lanes in advance, by understanding the conditions ahead of the vehicle, which cannot be detected by onboard sensors.
- The use of vehicle probe information that allows for assessment of traffic conditions over areas is effective for generating lane level road traffic information and functionality enhancement is anticipated through combination with information from road and traffic administrators.



What the vehicle needs to know

- Which lane to drive in?
- When to make a lane change?

→**Lane level road traffic information is necessary** when making the decisions described above.

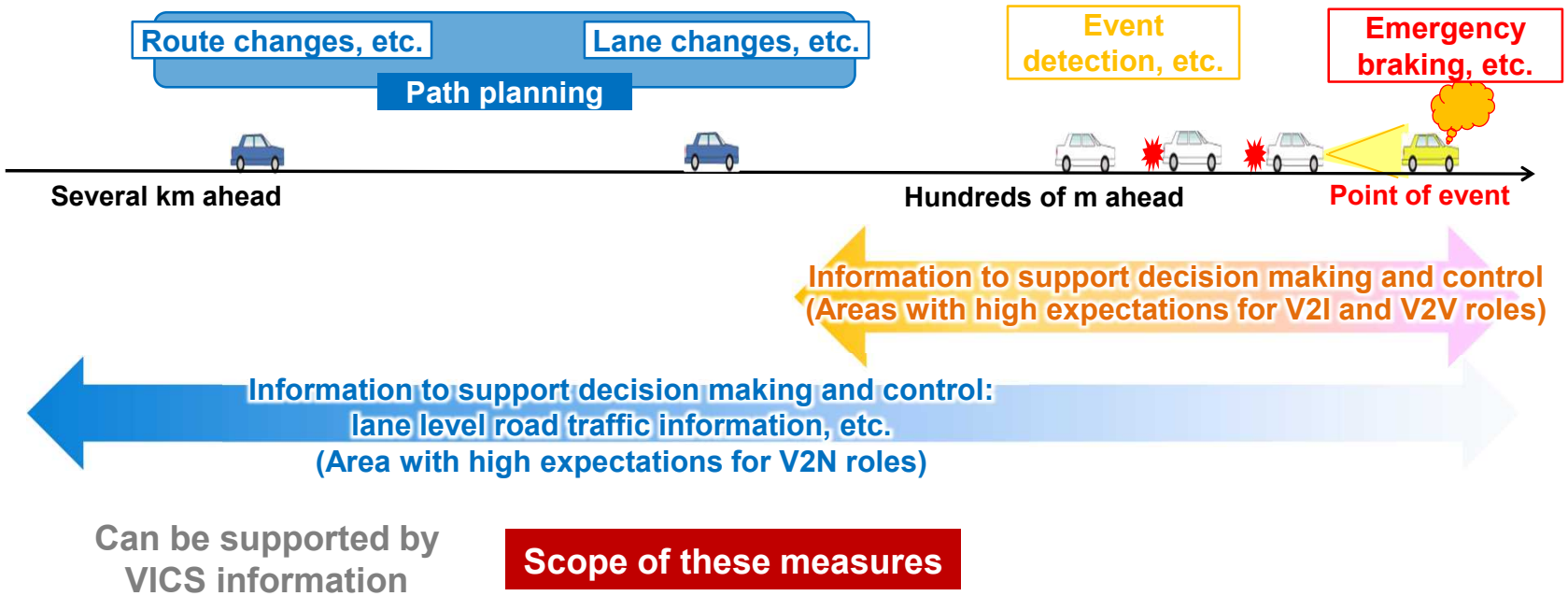
Responding to these needs

Combining of various information sources generates information effectively.

- ○ **Vehicle probe information**
  Enables precise assessment of traffic conditions and position over areas.
- ○ **Information from road and traffic authorities**
  Understanding of information such as cause of incidents that cannot be learned from the vehicle.
- ○ **Other (emergency report information, etc.)**
  Immediate assessment of emergency information.

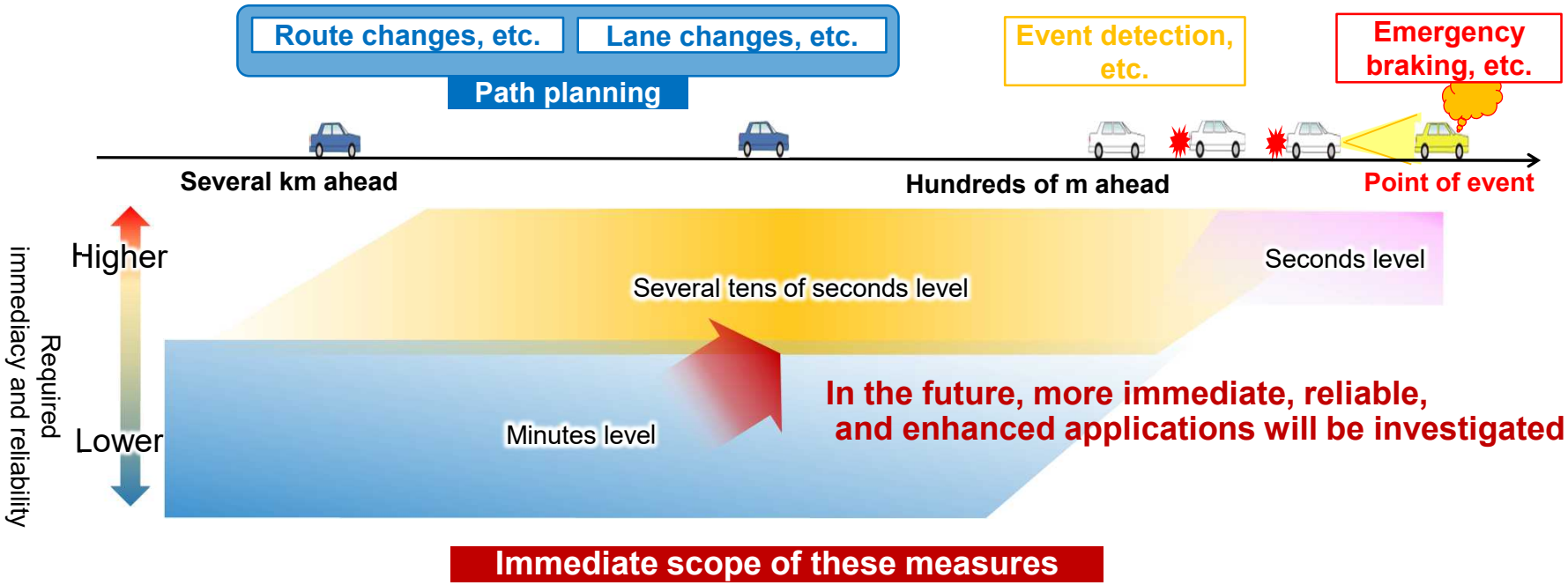
1.2. Scope of these Initiatives

- In order for a self-driving vehicle to make appropriate judgments and provide appropriate control, there are stages of control depending on the distance to where said control will be needed depending on the situation and lane level information is needed for each stage.
- Combining information obtained using various communication means in a comprehensive manner based on the characteristics at each stage is important.
- We are investigating the usefulness and usage of lane level road traffic information corresponding to the characteristics of various situations, and in these measures we are investigating the use of lane changes in path planning with a focus on lane changing.



1.2. Scope of these Initiatives

- In order to achieve early social implementation of these measures, we have started initiatives to investigate technologies for generating and providing information in real time to the extent of matching conventional road traffic information, using vehicle probe information for which there is already practical application.
- In the future, we aim to generate and provide more immediate information.

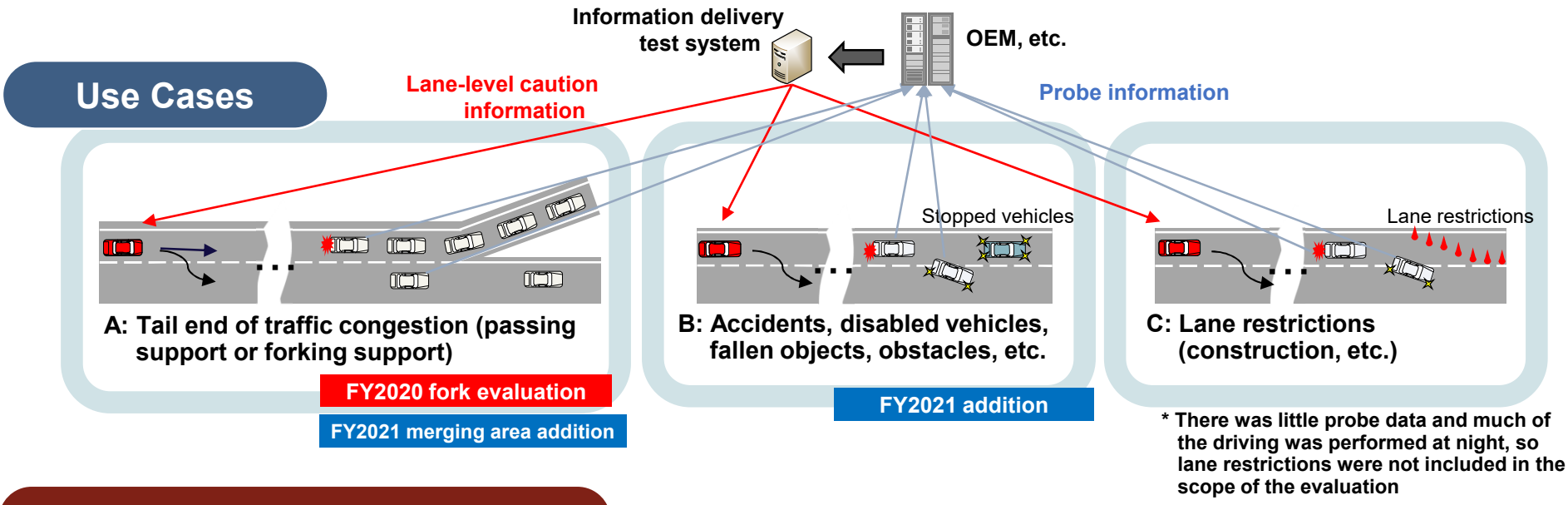


Technical deliberation using vehicle probe information that has already been put to practical application for early social implementation

1.3. Target Use Cases and Benefits of Information Provision

- In this measure, we investigated the following three use cases where lane-level information for the area ahead of the vehicle would be effective in controlling lane changes, etc., when performing path planning.

Use Cases



* There was little probe data and much of the driving was performed at night, so lane restrictions were not included in the scope of the evaluation

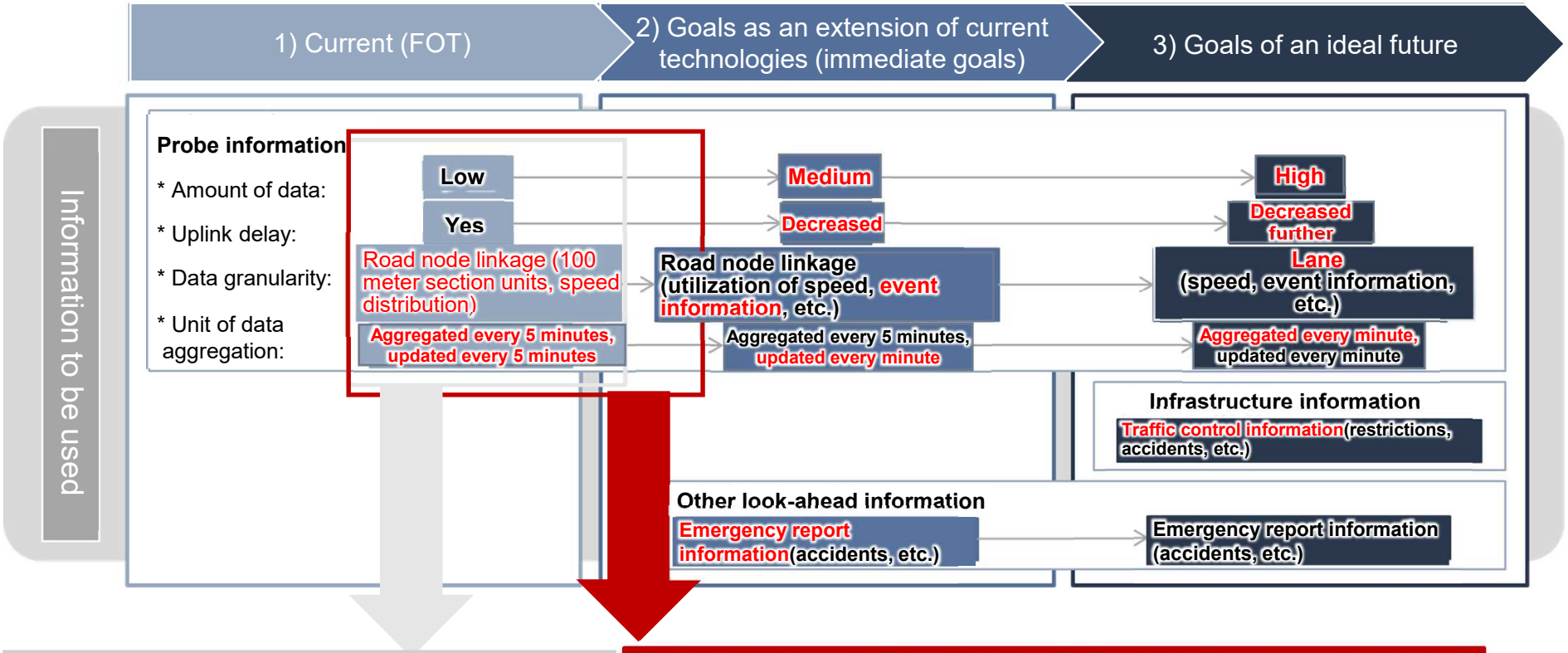
Benefits of Information Provision

- This information has the **potential to improve safety and make driving smoother** by preventing automated vehicles from having to decelerate quickly, etc., preventing rear-end collisions, and enabling lane changes to be performed at leisure when situations such as the indicated use cases occur. These outcomes can be prevented by decelerating and changing lanes, etc., far in advance based on conditions ahead of the vehicle.
- **It is also effective as support information for vehicles performing level 1 or 2 automated driving.**

Source: FY2021 4th deliberation council meeting material (created by Pacific Consultants)

1.4. Future Vision and Investigative Scope of these Initiatives

- The investigation is based on the assumption that in the future, as connected cars become more widespread, the quantity and quality of data will improve, making it possible to provide more accurate information with no uplink delay.



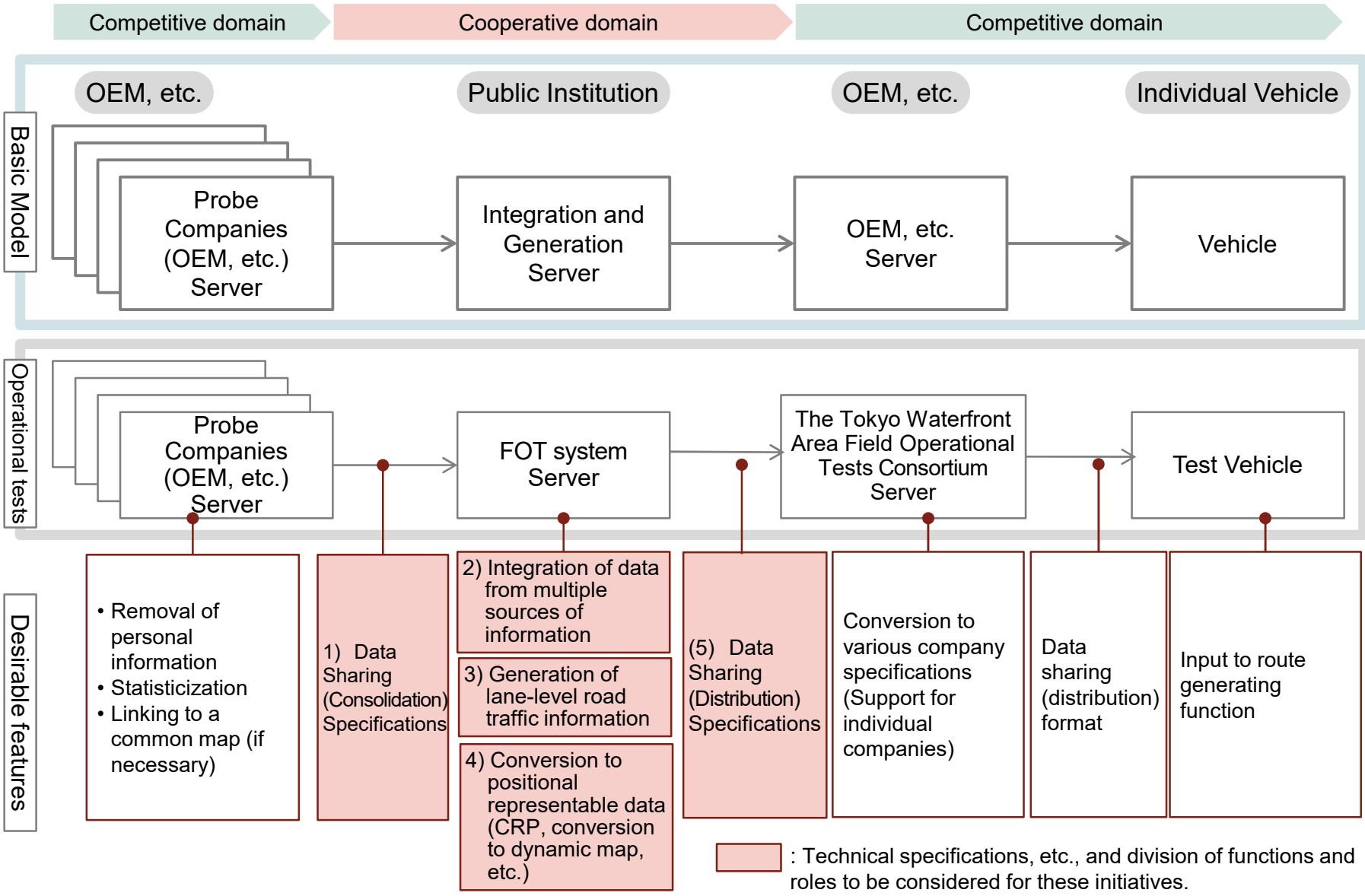
FY2020 : Conducted FOTs on two Tokyo Metropolitan Expressway routes to verify the following:

- Verification of the possibility of generating lane-level road traffic information
- Deliberation of necessary technical specifications
- Verification of the effectiveness of information

FY2021: FOTs were performed on two Metropolitan Expressway routes and technologies were established for generating information in areas other than fork areas using vehicle control event information (turn signal information, etc.)

2. Contents of Technical Deliberation

2.1. Overview of these Initiatives and Scope of Deliberation



2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Purpose

- **Consideration of technical specifications and data formats for each function related to the cooperative domain**
- **Clarification of the roles and functions of each function**

Technical Specifications

1) Specifications for data sharing (aggregation)
Data sharing specifications (data items, format, collection frequency, etc.) between centers when probe data, etc. are shared from the provider's server to the information integration and generation server

2) Specifications for data integration from multiple sources of information
Specification for integrated processing of data collected from multiple information providers

3) Specifications for generation of lane-level road traffic information
Technical specifications for generating lane-level road traffic information from available data.

4) Specifications for conversion to positional representable data
Data format and conversion specifications (conversion to CRP, dynamic map, etc.) that can express (distribute) the generated road traffic information by lane. *Investigation includes necessity of this function

5) Specifications for data sharing (distribution)
Data sharing specifications (data items, format, distribution frequency, etc.) between the centers when distributing the generated information from the information integration and generation server to the OEM, etc. servers.

Structure

Division of functions and roles
Functions of each of the functions described above that can be considered as a cooperative domain for future implementation
Consideration of how the system should be set up, such as separation of responsibilities and separation of roles

Assumptions and conditions to be considered

Related specifications, etc.
○ Data-sharing specifications between centers
- JASPAR specifications

○ Specifications for position expression
- Extended DRM-DB
- CRP

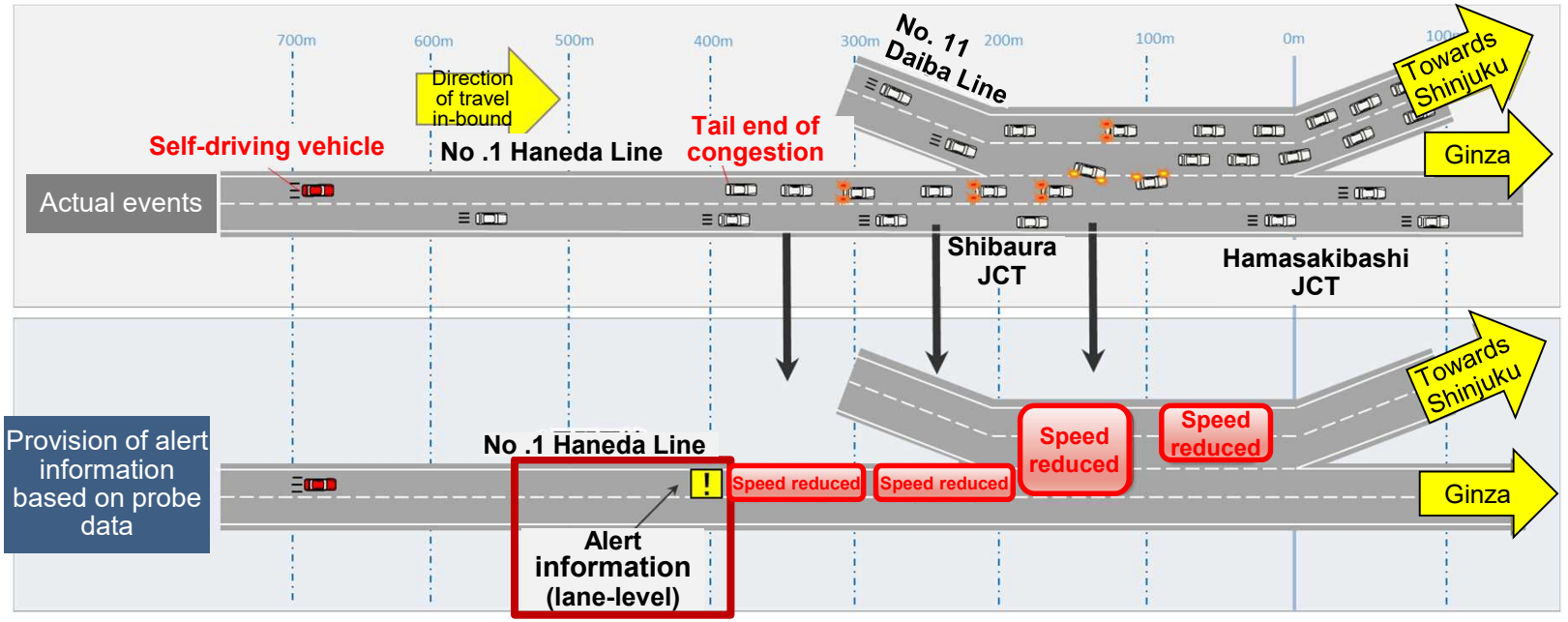
Data that can be utilized for early practical application
- Probe information available from commercial based vehicles
  → Travel time information, event information, etc. on the roadway level

*Technical specifications will be investigated regarding both:
(1) Goals for early practical application by extending current technologies
(2) Goals of an ideal future

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Information to be generated and provided: entering congestion information

- As the first effort in lane level road traffic information, implement technical deliberation necessary to generate and provide information regarding **tail end of traffic congestion**
- Congestion information is generated in 100 m units in the direction of travel.



Information to be generated and provided

Source: Eighth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Technical Deliberation on Data Sharing (Aggregation)

- The data collection format for aggregating data from probe providers is designed so that information up to 30 minutes before the collection deadline can be aggregated in five-minute increments, taking uplink delays into account.

Format Structure when Collecting Data from Probe Providers

Configuration Information			Main Information
Basic Information			Geodetic system, time zone, time of information generation
Probe information	DRM basic information		DRM link version, secondary mesh code, link number
	Layers 1 to 6		Information up to 30 minutes prior to the collection deadline is aggregated in 5-minute increments.
		DRM link unit information	Average travel speed in each direction
	Layers 1 to 6		Information up to 30 minutes prior to the collection deadline is aggregated in 5-minute increments.
		Link unit information in 100 m segments	Segment serial number, segment link distance Average speed information, speed classification information, other vehicle information, average travel speed in each direction

*The data is collected from the probe provider in JSON format and collected by file transfer using the HTTP protocol.

Source: Sixth Deliberation Council Meeting materials(prepared by Pacific Consultants)

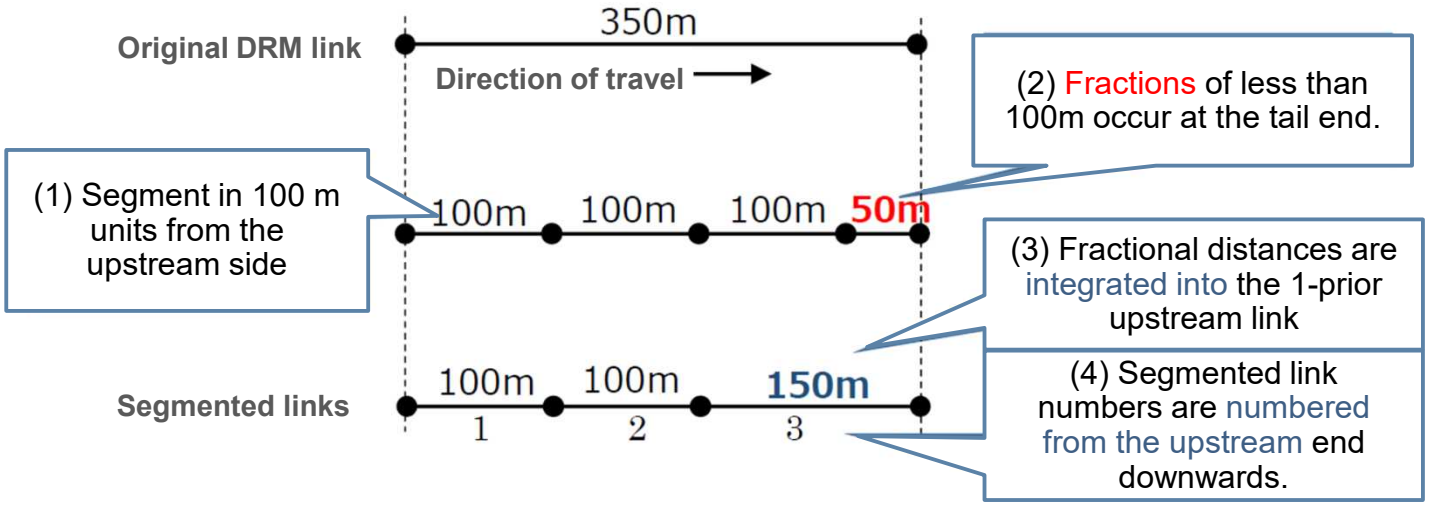
2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Technical Deliberation on Data Sharing (Aggregation)

- The unit of data aggregation when aggregating data from probe providers is based on DRM links, and the specifications are defined in a way that each link is segmented into 100 m units.

◆ How the DRM link is segmented

- The map is segmented into 100 m link units based on the link numbering system of the map databased published by the Japan Digital Road Map Association (Edition: DRM · DB3203A (March 2020 edition)).
- DRM links with a link length of 200 m or more are targeted for segmentation, and the DRM links are segmented into 100m units starting from the upstream side of the original DRM link, and the fractional distance links of less than 100m that are furthermost downstream are integrated into the 1-prior upstream link.
- The segmented link is assigned a branch number from the upstream side in relation to the original DRM link number (see FIG. 1).



Source: Sixth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

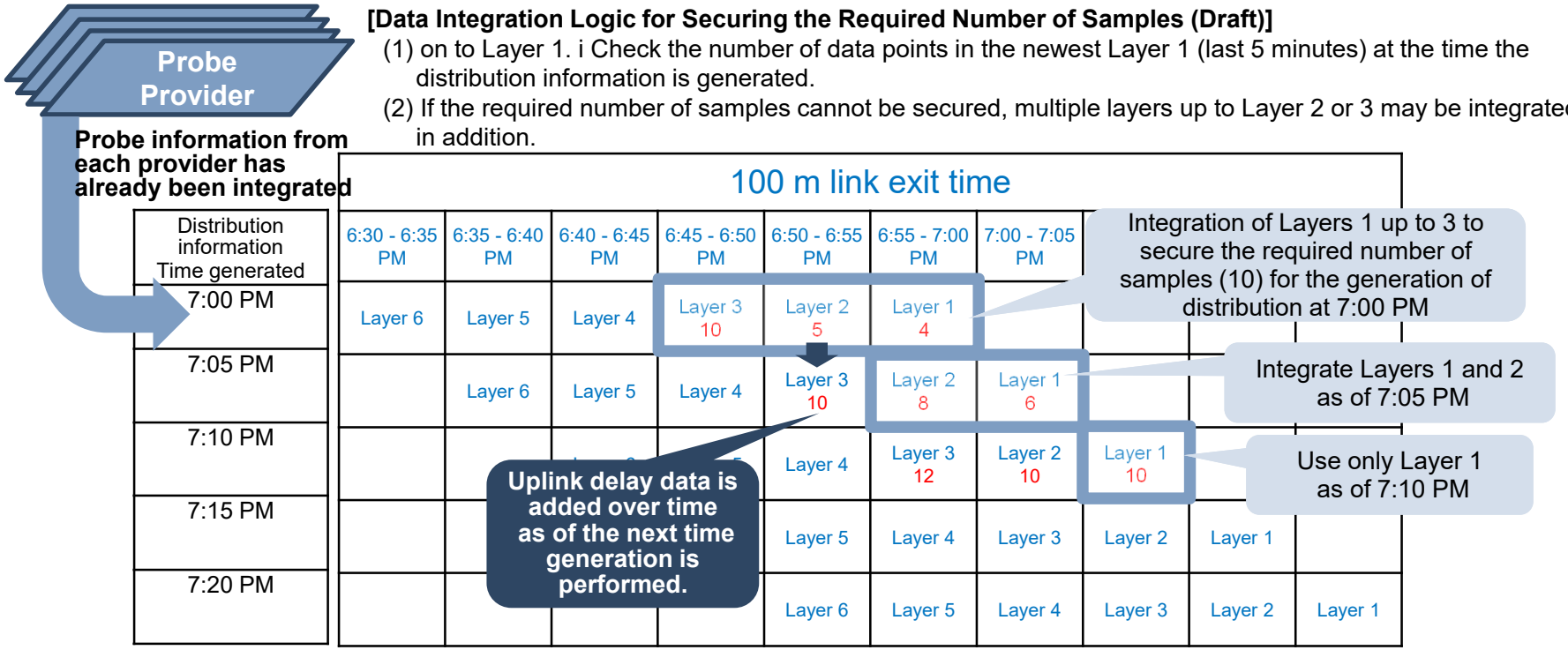
Technical Deliberation on Integrating Data from Multiple Information Sources

- Since it may not be possible to secure the required number of samples using only the most recent five minutes of data (Layer 1) due to the effects of uplink delays, the most recent historical data (Layers 2 to 6) is used with consideration of balance with ensuring the freshness of information.
  →Based on the balance between the amount of information generated and the freshness of the data, the maximum amount of historical data is the most recent 15 minutes (Layer 3).

[Data Integration Logic for Securing the Required Number of Samples (Draft)]

(1) on to Layer 1. i Check the number of data points in the newest Layer 1 (last 5 minutes) at the time the distribution information is generated.

(2) If the required number of samples cannot be secured, multiple layers up to Layer 2 or 3 may be integrated in addition.



Concept of data integration to secure the required number of samples

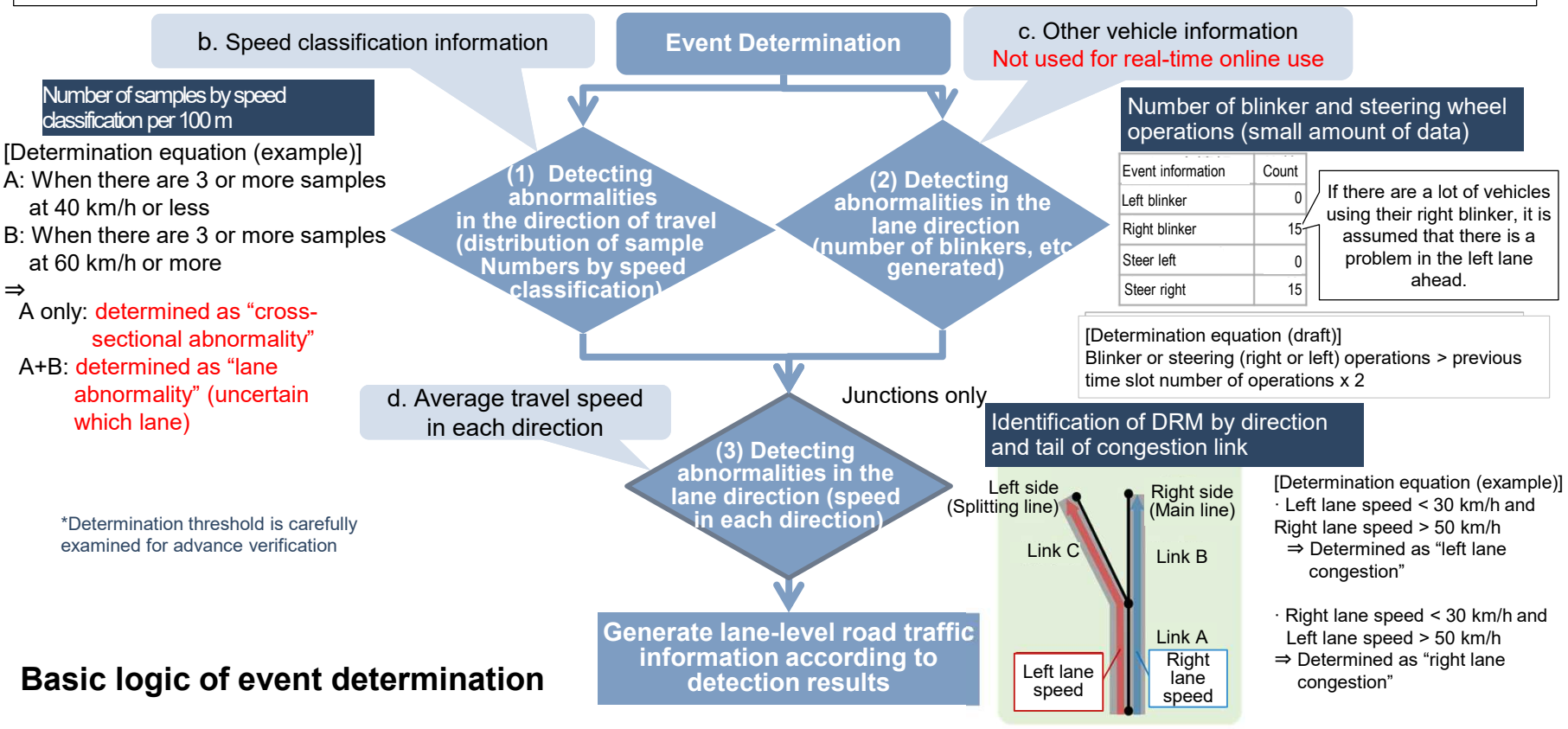
***If the required number of samples is 10**

Source: Eighth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Technical Deliberation on Generation of lane-level Road Traffic Information

- Excluding junctions, the occurrence of an event is determined based on the following two criteria: (1) abnormalities in the direction of travel (abnormalities determined on the roadway) and (2) abnormalities in the lane direction (frequent lane changes, etc.)
- At junctions, use of (3) abnormality in the lane direction (speed in each direction) is added for determination to refine the location of tail end of traffic congestion.



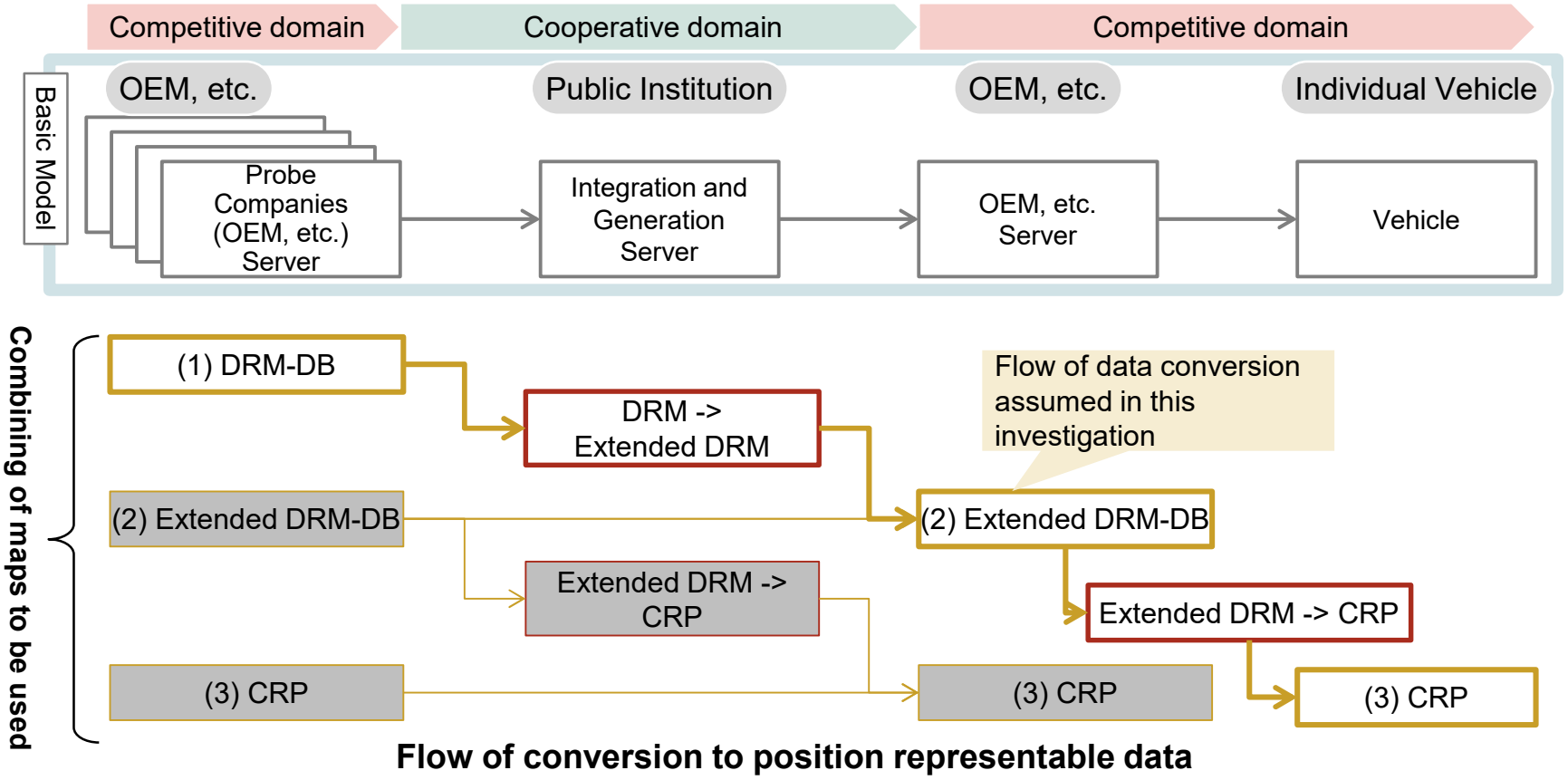
Basic logic of event determination

Source: Sixth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Technical Deliberation on Conversion to Position Representable Data

- In the data flow from the probe provider to the vehicle, the combination of maps to be used is assumed as shown in the figure below, and this shows an organized view of issues for practical application in the future in generating the necessary extended DRM and CRP system maps.



Flow of conversion to position representable data

Source: Fifth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

2.2. Deliberation of Elemental Technologies (Items to be Investigated in these Initiatives)

Technical Deliberation on Data Sharing (Distribution)

- JASPAR specification standards are applied for data sharing between the centers when generated information is distributed from the information integration and generation server to the servers of the Tokyo Waterfront Area FOT Consortium (assuming future OEM telematics centers, etc.).
- The message set referenced between servers consists of “spatial information” and “content body,” where the spatial information includes valid time and latitude/longitude expressions.
- The point and lane section where the generated alert information is displayed are described using the point detail items of latitude, longitude, and lane.

Message structure concept

Administration		**Administrative Information**
Container	**Basic**	**Spatial information**
	Contents	Content body

Spatial information

Item	Name
Time	Effective time
Section	Latitude and longitude expressions

Item	Name
Beginning Point	Starting point

Time details

Item	Name
Start	Time of occurrence
Expire	Invalid time

Geographical detail item

Item	Name
Latitude	**Latitude**
Longitude	**Longitude**
OnRoad	Presence or absence on the road
Name	Road name
Lane	**Lane(s)**
Accuracy	Authenticity of information

Source: Sixth Deliberation Council Meeting Materials (prepared by Pacific Consultants

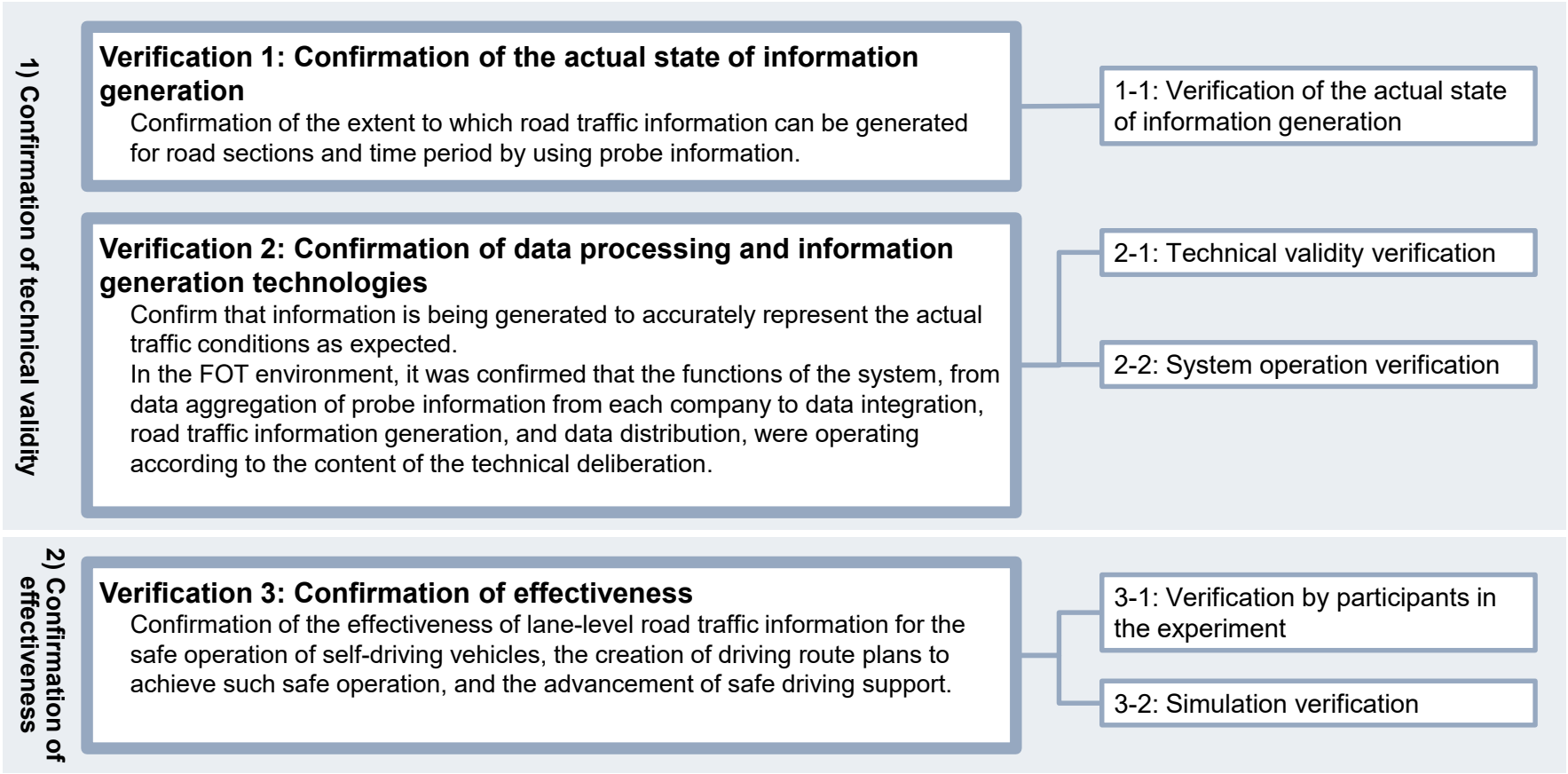
3. Technical Verification and Effectiveness Verification

3.1. Plans for Technical Verification and Effectiveness Verification

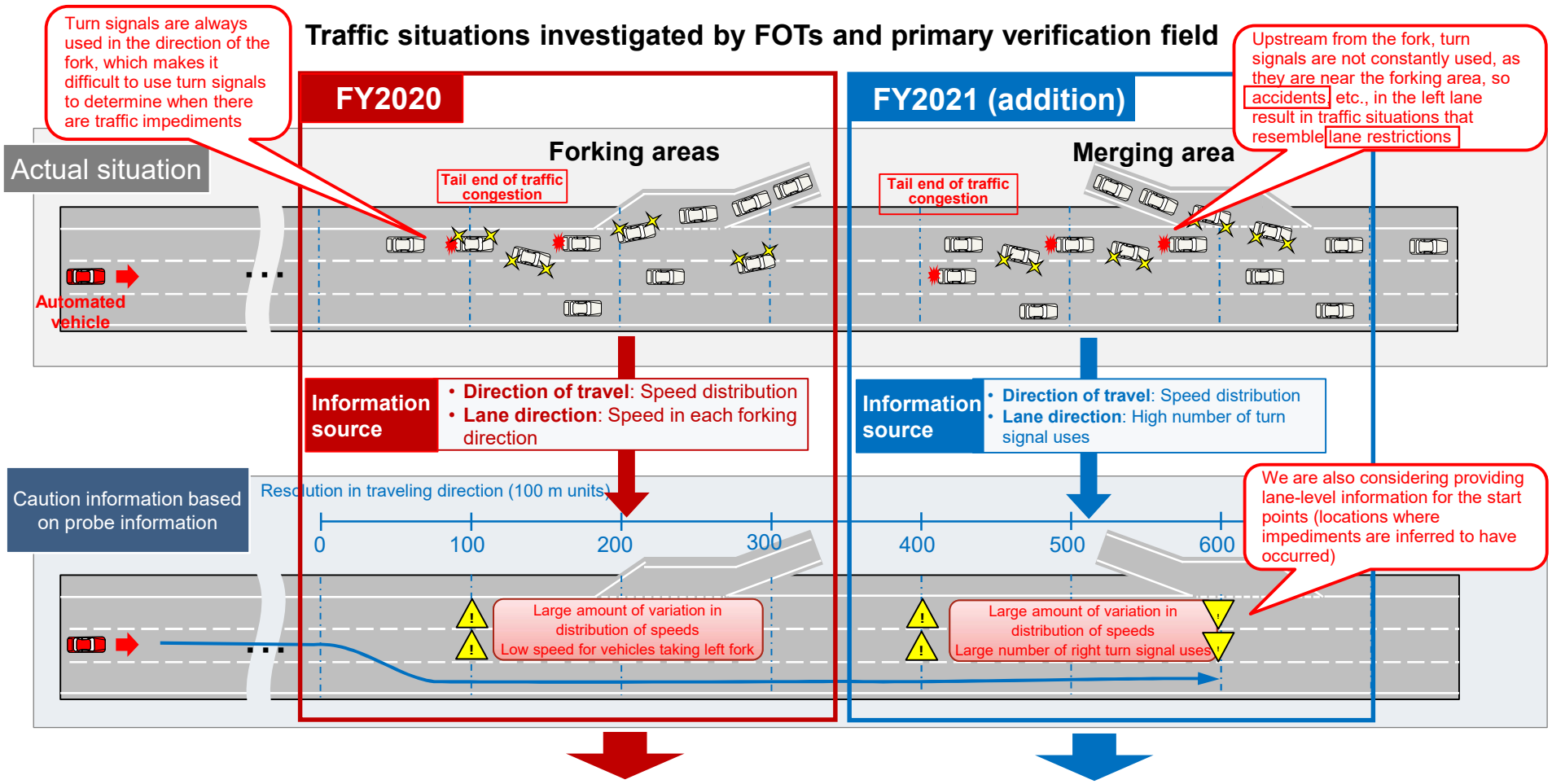
The FOTs for this fiscal year will be conducted with the following two verification objectives.

(1) Verify the effectiveness of lane-level road traffic information.

(2) To **confirm the technical validity of each elemental technology** under investigation for the practical application of generating and providing lane-level road traffic information.



3.1. Plans for Technical Verification and Effectiveness Verification

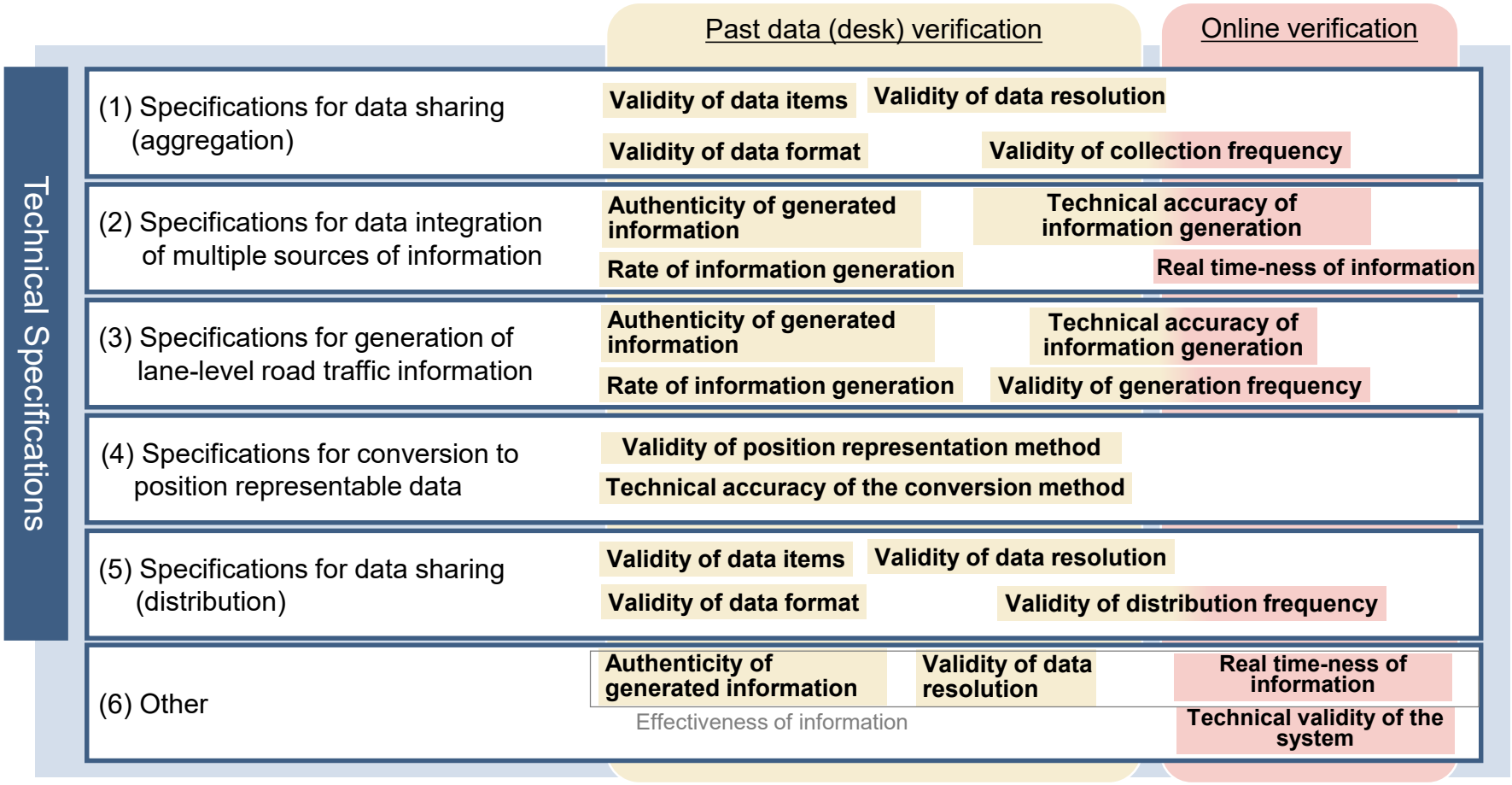


Source: Created based on FY2021 2nd deliberation council meeting material (created by Pacific Consultants)

3.1. Plans for Technical Verification and Effectiveness Verification:

Verification Items and Verification Methods for FOTs in FY2020

- In the FOTs for fiscal year 2020, the **technical specifications for data transfers between related entities and the specifications for generating lane-level road traffic information will be mainly verified using past data (desk verification). In addition, validity of delay and frequency of providing data and verification of effectiveness of information resolution will be achieved through providing data online.**

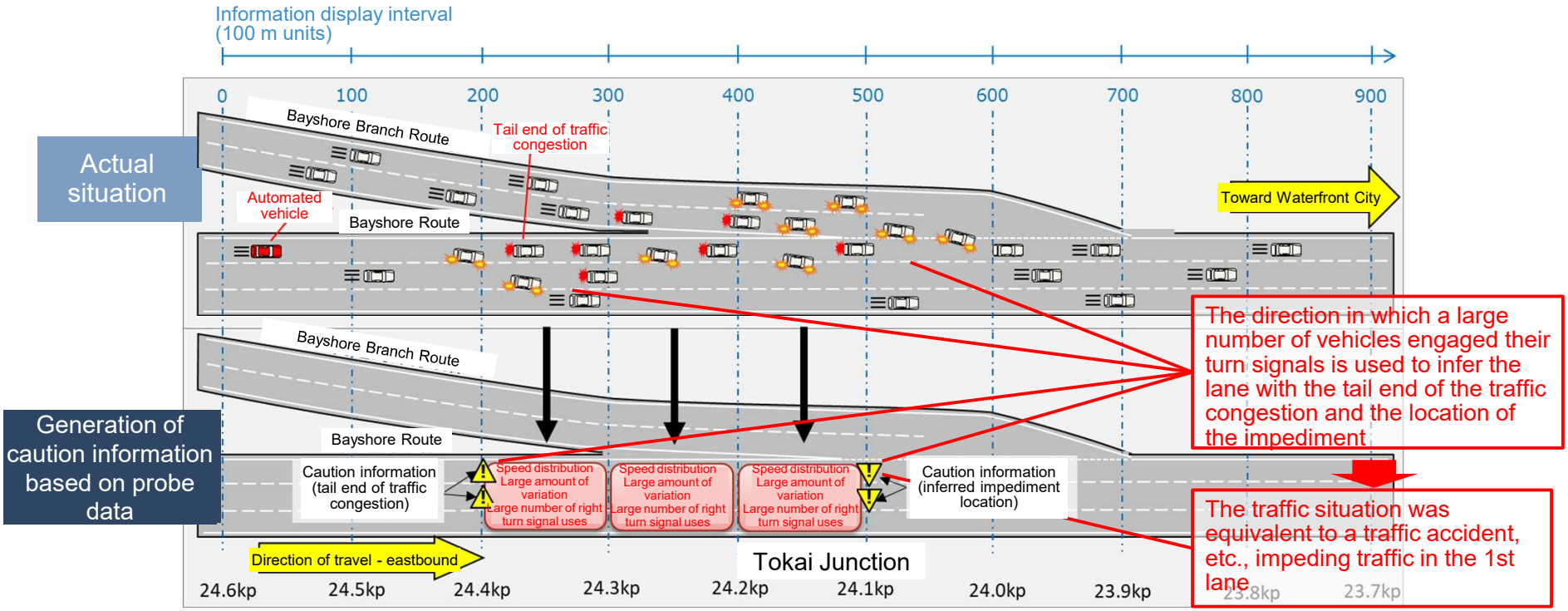


3.1. Plans for Technical Verification and Effectiveness Verification :

Verification Items and Verification Method for FOTs in FY2021

In the FY2021 FOTs, we verified the **generation of more stable and accurate information due to the increase in the number of probes from which data was collected online from two providers,** we verified the **provision of information in the directions of lanes where there were impediments, other than forks, based on the number of turn signals used,** and we **added a type of caution information indicating the location of inferred impediments.**

Conceptual image of traffic situations in Tokai Junction merging area and generation of information



Source: Created based on FY2021 2nd deliberation council meeting material (created by Pacific Consultants)

3.2. Verification Results

(1) Results of Verification of Technical Validity

(1) Data sharing (aggregation)

Amount of probe data (number of samples by speed class)

- Penetration rate of probe vehicles was approximately 3% during daytime hours (equivalent to 6 cars/5 min. on the Tokyo Metropolitan Expressway Haneda Line).
- A certain level of accuracy can be maintained at 5 vehicles/5 min. in about 50% of two-lane sections and about 80% of three-lane sections.
- During nighttime hours, there are many time periods when there are not 5 cars/5 min.
- The number of probes that could connect online increased in comparison to the FY2020 FOTs (from one company to two), so the percentage of information with a freshness of 15 minutes or less rose dramatically, from under 20% to over 90%.

Number of samples of link travel time for each diverging direction.

- A sample number of more than 2 vehicles/5 min. was obtained at the major junctions, etc. in the section under investigation.

Blinkers and steering

- Confirmed that blinkers and steering is measured according to the linearity of curves, diversions, and merges.

Validity of link aggregation units (100 m)

- Confirmed that when detecting congested sections on the expressway, there are no differences with 100 m sections up to a resolution of around 200 m.

(2) Data integration from multiple sources of information

Relationship between information freshness and rate of information generation

- The rate of information generation (daytime hours) at 5 vehicles/5 min. or more, where a certain level of accuracy is maintained, is shown below.
  Using only data from Layer 1 (last 5 min.): 10%
  Using data up to Layer 2 (last 10 min.): 60%
  Using data up to Layer 3 (last 15 min.): 80% or more
- We took measures to address the disparities in the information provision times of multiple probe information providers.

Source: Created based on 10th deliberation council meeting material (created by Pacific Consultants)

3.2. Verification Results

(1) Results of Verification of Technical Validity

3) Generation of lane-level road traffic information

Event detection method using speed information

- The event detection rate and positive detection rate with the current penetration rate of probe vehicles is 50 to 60% at the tail end of traffic congestion and about 50% when details are included.

Event detection method using vehicle event information

- Confirmed the possibility of detecting both abnormalities in the lane direction and abnormalities in the direction of travel using vehicle event information. On the other hand, an abnormality may not be detected if there is only a small amount of probe data.
- Confirmed that the use of “blinkers” is useful information for detecting abnormalities in the lane direction and the use of “brakes” is useful for detecting abnormalities in the direction of travel.
- In FY2021, we developed logic for determining the directions of lanes with traffic impediments in areas other than forking areas and developed logic for inferring the locations of impediments (the start points of traffic congestion). This made it possible to identify lane-specific traffic congestion in areas other than forking areas.

(4) Conversion of positional representable data

Development of data infrastructure for representing lane level road traffic information

- For the integration and generation process of traffic lane level road traffic information, a road level map (DRM-DB in the FOT) and a high-precision 3D map are used as source data to generate the data for organized for the number of lanes in the section every 100 m.
- It is necessary to develop a database that can represent lane level positions and establish a system for continuous updates.

Source: Prepared based on Tenth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

3.2. Verification Results

(1) Results of Verification of Technical Validity

(5) Data sharing (distribution)

Data sharing (distribution) format (JasPar specification)

- Through the FOTs, we sorted out the issues with the current JasPar specifications when distributing alert information.
- While current specifications do not specify “tail end of traffic congestion” as alert content, in the FOTs, the “99: Other” marking number was used to explicitly distribute information regarding congestion.
  → Moving forward, consider assigning a special marking number for distributing congestion information, if necessary.

Data distribution processing time

- The server side of the Tokyo Waterfront Area FOT Consortium acquires road traffic information at the lane level in arbitrary one-minute cycles and distributes it to the experiment participants.
- To achieve 1-minute distribution, we implemented an API that can be processed in about 3 seconds.

Source: Prepared based on Tenth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

3.2. Verification Results

(2) Verification Results of Effectiveness

(1) Verification by participants in the Tokyo Waterfront Area FOT 2020: received responses from 11 companies.

Effectiveness of information

- The majority of organizations responded that lane-level information regarding tail end of traffic congestion was effective.
  Reasons cited for the effectiveness of the system include “smooth driving by implementing lane changes, etc. in advance.”
- The majority of organizations also responded that congestion tail information that is not lane-level was also effective.

Timing of providing information

- The responses were 200 m to 2 km ahead for intra-city highways and 500 m to 5 km ahead for inter-city highways.

Positional accuracy of information

- The most common response was 100 m. Opinions came back that high positioning accuracy is necessary for intra-city highways due to the many curves and diverging/merging areas.

Information distribution cycle

- The most common response was 1 min.

Necessity of information

- About 80% of respondents answered that information regarding tail end of congestion is necessary.
- About 70% of respondents answered that information regarding congested sections (starting and end points) is also necessary.

(2) Verification by traffic simulation

Traffic facilitation

- Confirmed that automated vehicles in traffic flow has a rectifying effect and also has the effect of reducing journey time by providing lane-level road traffic information.

Safety improvement

- Confirmed that the provision of lane-level road traffic information reduces the rate of hazardous event occurrences.

Source: Prepared based on Tenth Deliberation Council Meeting Materials (prepared by Pacific Consultants)

3.2. Verification Results

(2) Results of effectiveness verification

● Expected to be fully or partially addressed in the spring FY2022 FOTs
▲ Response is currently under deliberation

(3) Verification by participants in the FY2021 Tokyo Waterfront Area FOTs

Degree of conformance between traffic congestion tail end information and actual situation

- Roughly 25% of the responses indicated that the location in the direction of travel "closely matched" or "roughly matched" actual traffic conditions (7 cases).
- Roughly 44% of the responses indicated that the lane experiencing the traffic congestion "closely matched" or "roughly matched" actual traffic conditions (7 cases).

Breakdown of cases where provided information deviated from actual conditions and reasons for deviation

Situation 1. Location deviation in direction of travel ⇒ Factor a (●)

(1) The location of the tail end of the traffic congestion and the location of the impediment did not match their respective actual locations.

Situation 2. Mismatch in lane information (left or right lane) ⇒ Factor b (●), factor d (▲)

(1) The traffic congestion was lane specific, but the tail end information indicated was shown as the tail end of traffic congestion affecting all lanes.

(2) The traffic congestion affected all lanes, but the tail end information indicated was shown as the tail end of either the left or right lanes.

(3) The indicated lane location for the impediment (left or right lane) was opposite of the actual lane.

Situation 3. Erroneous information provision ⇒ Factor a (●), factor c (●)

(1) Information was displayed, but there were no actual traffic abnormalities.

Situation 4. Information not provided

(1) There was traffic congestion, but no traffic congestion tail end or impediment location were displayed. **⇒ Factor a (●)**

(2) The tail end traffic congestion was not displayed paired with an impediment location (start point of the traffic congestion).
⇒ Factor d (due to system design)

Factor a. Due to situation identification cycle length/update cycle length (5 minutes) or lack of data (real-time nature of probe data)
⇒ Information is not updated before situation is resolved, situation is not identified by the time the vehicle arrives, the tail end of the traffic congestion moves closer/further, etc.

Factor b. Due to insufficient lateral direction information (turn signal information)

Factor c. Believed due to erroneous matching of probe data ⇒Due to real-time processing, short link length, etc.

Factor d. Due to complex road structure or traffic characteristics, or due to current information generation logic

⇒ There are plans to increase the number of probe information providers from two companies to four, and to revise the logic, changing the way data is overlapped based on the freshness of the information.

Source: Created based on FY2021 5th deliberation council meeting material (created by Pacific Consultants)

4. Technical Specifications Considered for these Initiatives

Technical Specifications Considered for these Initiatives

- Based on the results of technology verification and effect verification through the FOTs in FY2020, the results of the elemental technologies investigated in these initiatives are summarized as the following **five technology specifications (draft)**.

A set of technical specifications for the generation and provision of lane level road traffic information (2020 version)

Technical specifications

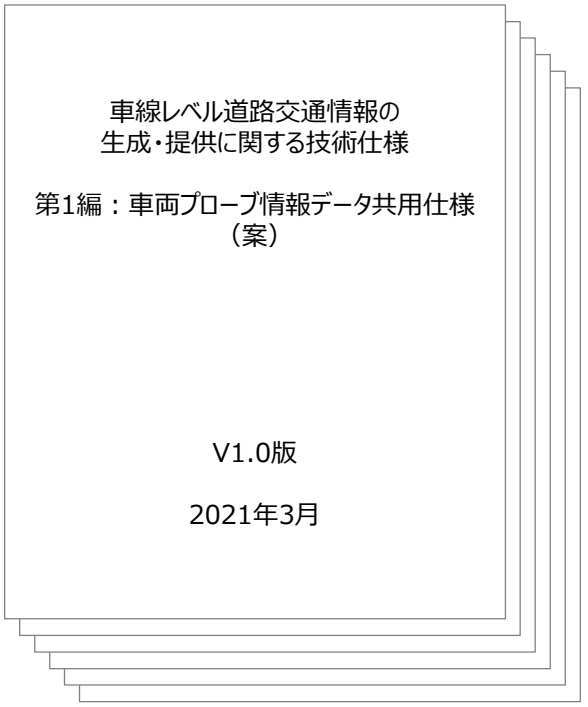
Part 1: Specifications for Vehicle Probe Information Data Sharing (Draft)
Specifications for data sharing between centers when vehicle probe information is shared from the provider's data server to the information integration and generation server

Part 2: Specifications for Data Integration (Draft)
Specification for integrated processing of data collected from multiple information providers

Part 3: Specifications for Generating lane-level Road Traffic Information (Draft)
Technical specifications for generating lane-level road traffic information from various collected data.

Part 4: Specifications for Position Expression (Draft)
Specifications for expressing the position of generated lane-level road traffic information.

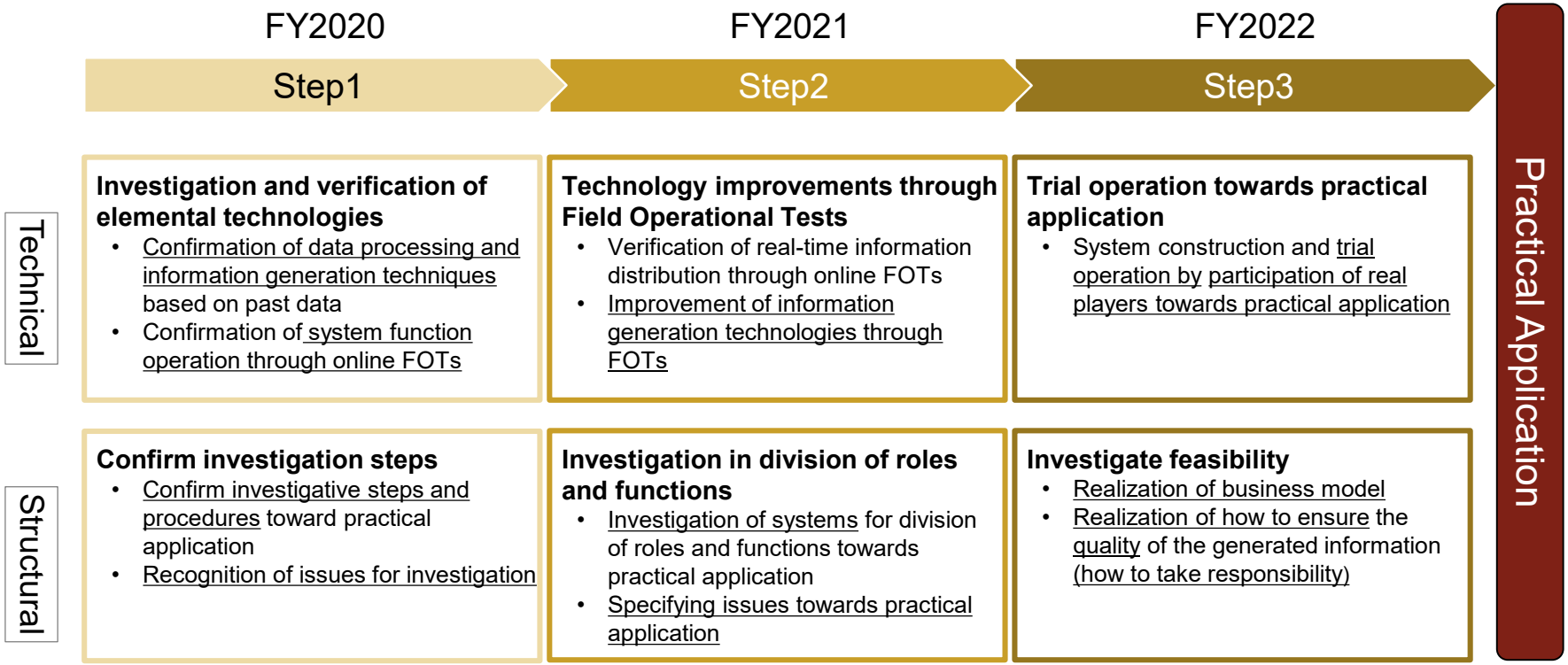
Part 5: Specifications for Data Distribution (Draft)
Specifications for data sharing between centers
when generated information is distributed from the information integration and generation server to the OEM, etc. servers.



5. Courses of Action and Challenges for Practical Application

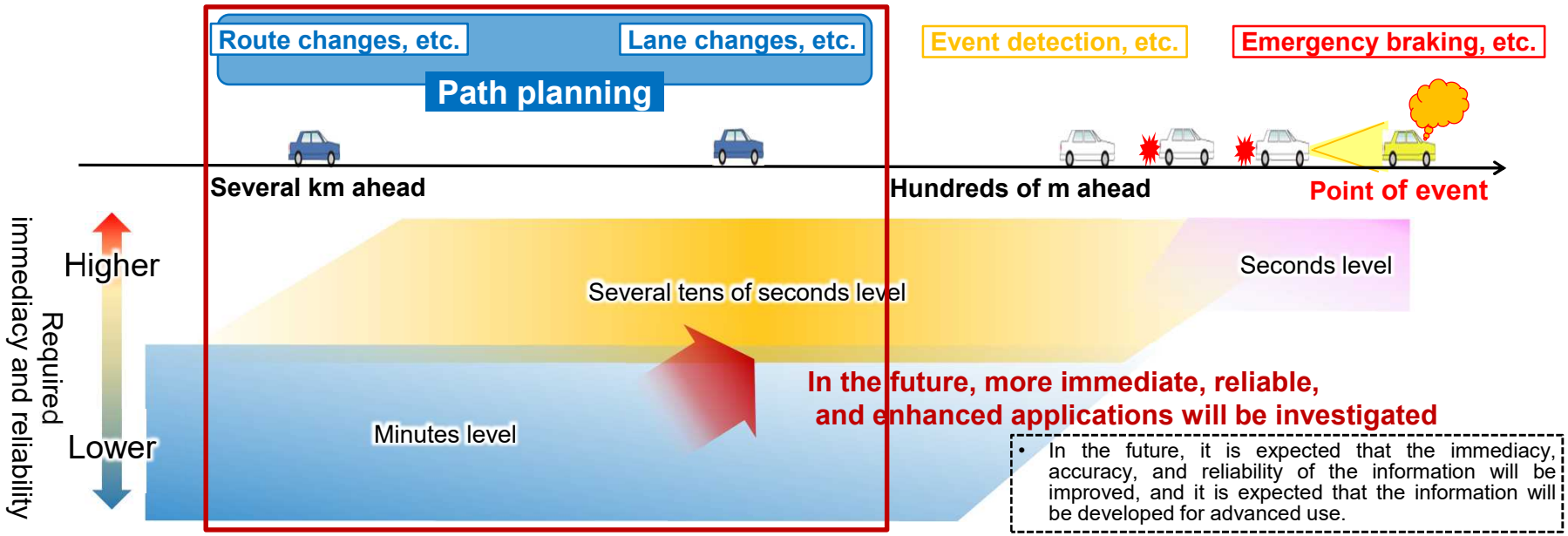
5.1. Investigative Steps and Procedures Toward Practical Application

- In parallel with the technical deliberation for the generation and provision of lane-level road traffic information through technical verification towards practical application, investigations and various adjustments will be implemented to clarify the business structure and establish a business model by the end of FY2022, when the second phase of SIP is completed.



(Reference) Immediate Service Scope for Practical Application

- The research and development operations for SIP, in **order to achieve early social implementation,** have started initiatives to investigate technologies for generating and providing information in **real time to the extent of matching conventional road traffic information, using vehicle probe information for which there is already practical application.**
- Seeking **early practical application** after the completion of the SIP **and the expression of a wider range of effects based on the spread of self-driving vehicles**, the service scope for the time being is assumed to be the **use in path planning such as route changes and lane changes** for **both self-driving and non-self-driving** vehicles.



Current scope of services (immediately after the end of SIP)

- During the transitional period to widespread use of self-driving vehicles, information will be provided to both self-driving and non-self-driving vehicles with the aim of achieving a wider range of effects (providing information to a wider range of road users).
- Considering the immediacy of the lane level road traffic information that can be generated, etc., it is assumed that this information will be used for path planning such as route changes and lane changes.

5.2. Investigative Issues Towards Practical Application

For practical application, it is necessary to clarify the division of functions and roles, build a sustainable operation system, establish a system for developing and maintaining the data infrastructure, and clarify the roadmap for service expansion.

(1) Clarifying the division of functions and roles

- The current scope of services is the enhancement of current road traffic information provision services, and it is considered possible and realistic to follow and utilize existing organizations and conventional information provision frameworks for early practical application.

(2) Clarification and detailing of needs

- Have envisioned users (OEMs, road administrators, members of the private sector, etc.) indicated an intent to use lane-specific road space information? (Conduct deep investigation of needs compared to other V2X and investigate effectiveness in usage situations)

(3) Establishment of a sustainable operation system

- Based on the envisioned services, how do we capture the value of information and what business model do we build?
  (Clarification of the beneficiary of the services, clarification of the added value, and arrangement of a cost-sharing relationship)
- How do we price the cost of purchasing data from probe providers?

(4) Establishment of a system to develop and maintain data infrastructure

- What kind of system will be used to construct and maintain road network data (link node maps) for the provision of lane level road traffic information?

(5) Clarification of the roadmap for service expansion

- The FOT was conducted using the Tokyo Metropolitan Expressway for technical deliberation. For the time being, it is thought that the service will be provided mainly on these types of motorways. What is the plan for expanding the scope of providing information in the future and what conditions will apply to providing the information?

Item3. Holding of Deliberation Council Meetings, etc.

Status of deliberation council meetings

- A deliberation council was established and deliberation council meetings were held with the aim of discussion and coordination between **related government agencies** (Cabinet Office, National Police Agency, Ministry of Land, Infrastructure, Transport and Tourism) **and major related organizations** (Japan Automobile Manufacturers Association, Japan Road Traffic Information Center, Vehicle Information and Communication System Center) with the ultimate aim of generating and providing lane-level road traffic information based on information from probes.

Table: Status of deliberation council meetings (FY2019)

Session	Agenda
First meeting June 26, 2019	• implementation plan • Issues to consider in preparation for the 2020 FOTs • Implementation approach for interviews regarding vehicle probe information collection and processing
Second meeting August 6, 2019	• Reporting on the results of interviews • Handling approach and requirement approach for issues to consider in preparation for the 2020 FOTs
Third meeting December 25, 2019	• Data that can be used in the 2020 FOTs • Overall 2020 FOTs approach (draft)
Fourth meeting March 26, 2020	• Status of technology deliberations in preparation for the 2020 FOTs • 2020 FOTs implementation approach and system development approach (draft)

Status of deliberation council meetings

Table: Status of deliberation council meetings (FY2020)

Cession	Agenda
Fifth meeting May 28, 2020	• Deliberation regarding elemental technologies for generation and provision of lane-level road traffic information • Technology verification approach by simulation • Approach for FOT (draft) / Status of deliberation and adjustments for the development of a FOT system
Sixth meeting August 6, 2020	• Deliberation regarding elemental technologies for generation and provision of lane-level road traffic information • Implementation approach and details of the FOT, and policy on technology evaluation • How to proceed toward practical application of generating and providing lane-level road traffic information (draft)
Seventh meeting October 13, 2020	• Status of technical deliberation for the FOT • Policy on technology evaluation for FOT (draft); policy on effectiveness evaluation (draft)
Eighth meeting December 15, 2020	• Implementation status of technical validity verification • Details of effectiveness verification • Outline of the summary (draft)
Ninth meeting February 5, 2021	• Progress of the FOT • Status of technical deliberation for generation and provision of lane-level road traffic information
Tenth meeting March 18, 2021	• Implementation status of the FOT • Summary of deliberation results

Status of deliberation council meetings

Table Status of deliberation council meetings (FY2021)

Session	Agenda
First meeting of FY2021 June 30, 2021	• Results of the FY2020 FOTs • Contents of measures implemented in FY2021 FOTs
Second meeting of FY2021 September 28, 2021	• Contents of new technical deliberations in FY2021 • Approach used in deliberations of the use of information other than probe information • Contents of measures implemented in FY2021 FOTs and evaluation approach
Third meeting of FY2021 December 14, 2021	• Contents of issues pointed out in deliberation council meetings, working group sessions, and task force meetings • Status of technology deliberations regarding lane-level road traffic information • Contents of measures implemented in FY2021 FOTs and technology evaluation approach
Fourth meeting of FY2021 February 18, 2022	• Status of measures implemented in FY2021 FOTs • Approach used in summarizing results of FY2021 measures

Item4. Deliberations regarding merging support

Overview of deliberations

We have investigated the Day 2 system, a service that provides merging support information being deliberated by NILIM, with the aim of improving lane-specific traffic flow information.

1. Administration of meetings

1.1. Background and objectives

1.2. Deliberation scope

1.3 Status of meetings

1.4. Results of verification of simulations in this project year and actions to be taken in the next project year

2. Study of merging area road alignment

2.1. Study scope and study items

2.2. Features of merging areas on Metropolitan Expressways and positioning of East Ikebukuro verification

2.3. Examples of study items

1. Administration of meetings

1.1. Background and objectives of the merging support Day 2 system simulation

Background

- **The Ministry of Land, Infrastructure, Transport and Tourism and NILIM are conducting joint public and private sector cooperative research regarding cooperative systems. One type of service offered by these systems that has been selected as being of particular note is merging support services.**
- **A technology study was performed from the perspective of the technical feasibility of merging support services. This study consisted of the following two steps.**

  (1) Day 1, which can be rapidly realized by combining existing technologies: Spot sensing + information provision

  (2) Day 2, which is expected to be feasible in the future: Planar sensing + information provision

- **Within the Cabinet Office's SIP-adus program, in FY2019 and FY2020 a Day 1 system was set up at the Metropolitan Expressway Haneda Airport West Entrance for the FOTs in the Tokyo Waterfront Area. Test driving and evaluation were performed. There were high expectations for the Day 2 system, as indicated below.**

<Primary evaluation results>

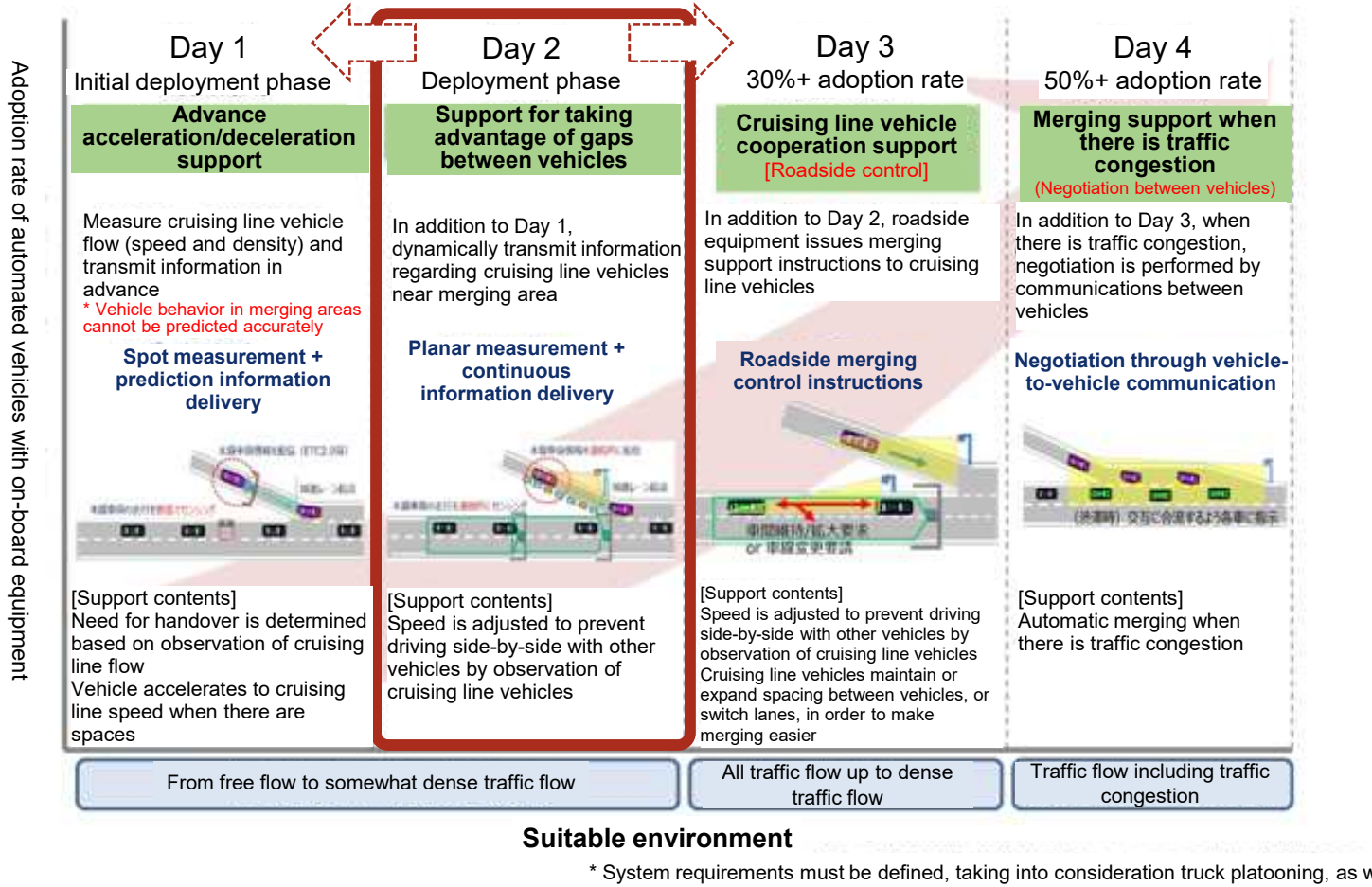
- The tests showed potential for merging support services (test participant that received information and performed HMI evaluation)
- The Day 1 system method of performing spot sensing and inferring merging point arrival times did not offer a sufficient level of inference accuracy when there is traffic congestion or heavy traffic
- Given the expectations for the Day 2 system, in FY2020, the NILIM's cooperative public and private sector research performed a technical evaluation of infrastructure sensors used to perform planar sensing

Objectives

- **Through the FY2021 and FY2022 Cabinet Office SIP-adus project, perform verification through the use of simulations in order to confirm the effectiveness of merging support services and identify issues involved in their real-world deployment with the aim of quickly deploying these services.**

1.2. Deliberation objectives and scope

- **Verification of a Day 2 system was performed using simulations during this project year in order to confirm the effectiveness of merging support services and identify issues involved in their real-world deployment with the aim of quickly deploying these services.**



* System requirements must be defined, taking into consideration truck platooning, as well

Source: Deliberation council meeting/JAMA materials regarding merging support Day 2 simulations

1.3 Status of meetings

Establishment of deliberation council

- **A deliberation council was established and met to enable discussions and coordination between related government agencies (the Cabinet Office, Ministry of Land, Infrastructure, Transport and Tourism, NILIM, etc.) and major related organizations (JAMA, the Metropolitan Expressway, etc.).**

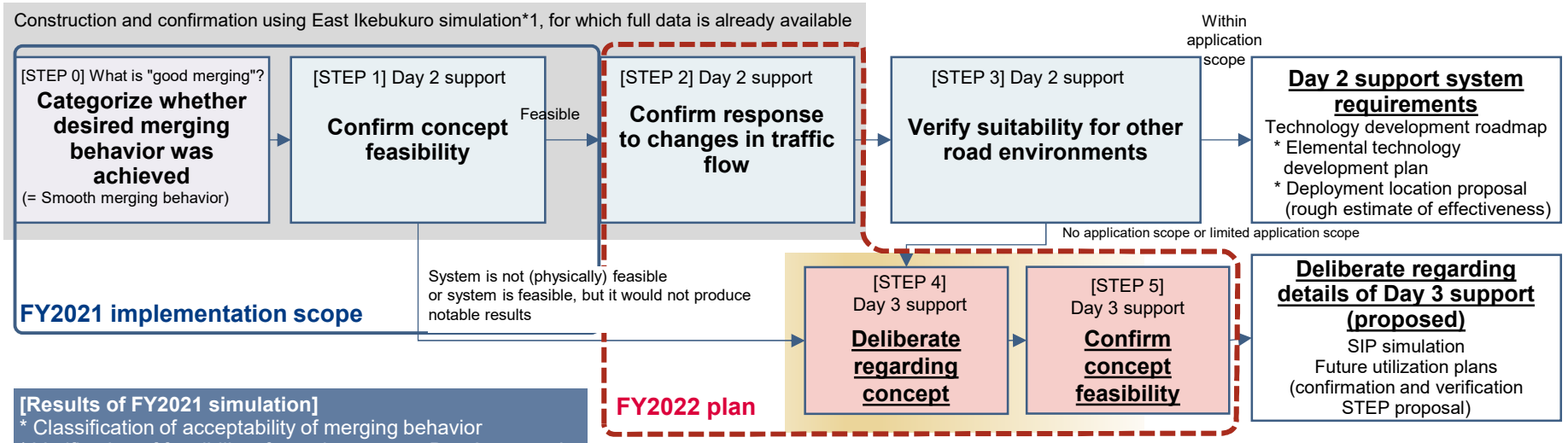
Session no.	Date	Agenda
1st	June 10, 2021	• Day 2 system deliberation schedule • Merging support system measures • Future deliberation schedule
2nd	August 5, 2021	• Day 2 system deliberation schedule (update) • Merging simulation specifications (proposed) • Plan for study of merging area road alignment (proposed)
3rd	October 7, 2021	• Explanation of proposal contents by contractor responsible for simulation operations • Merging simulation requests (proposed) • Report of results of study of merging area road alignment
4th	December 9, 2021	• Merging simulation results interim report (1)
5th	February 10, 2022	• Merging simulation results interim report (2)
6th	March 24, 2022	• Merging simulation results report

Meetings of parties performing simulations

- **Weekly operation meetings attended by related parties were held during the performing of merging support simulations as part of this deliberation project.**

1.4. Results of verification of simulations in this project year and actions to be taken in the next project year

- **The deliberation council performed Day 2 simulation verification, and during this project year, merging behavior was classified as acceptable/unacceptable, the feasibility of the Day 2 system was confirmed in East Ikebukuro, and the impact on cruising line traffic flow was analyzed.**
- **In the upcoming project year, the Day 2 system will be verified in greater depth, the Day 3 system's concept will be considered, and the Day 3 system's feasibility will be confirmed.**



*1: Results of FY2020 JAMA activities

[Results of FY2021 simulation]
* Classification of acceptability of merging behavior
* Verification of feasibility of merging support Day 2 system in East Ikebukuro
  - Sensing area
  - Transmission area
  - Sensor detection accuracy
  - Transmission delay
* Impact of Day 2 system on cruising line traffic flow

[Remaining issues with Day 2 East Ikebukuro verification]
* Confirmation of reproducibility of vehicle behavior (cruising line upstream side)
* Verification of Day 2 system effectiveness when there is traffic congestion on the cruising line

[Items verified through FY2022 simulation]
<Remaining issues with Day 2 East Ikebukuro verification>
* Confirmation of reproducibility of vehicle behavior (cruising line upstream side)
* Verification of Day 2 system effectiveness when there is traffic congestion on the cruising line

<Day 3 East Ikebukuro verification>
* Verification of feasibility of merging support Day 3 system in East Ikebukuro
  - Sensing area
  - Transmission area
  - Differences in effectiveness depending on percentage of automated vehicles in traffic
  - Differences in effectiveness depending on cruising line traffic volume

2. Study of merging area road alignment

2.1. Study scope and study items

- **In order to organize information about the characteristics of the merging area at the East Ikebukuro Entrance, where the merging support simulation was performed, a study was performed of the merging area's** road alignment**.**

[Study scope]

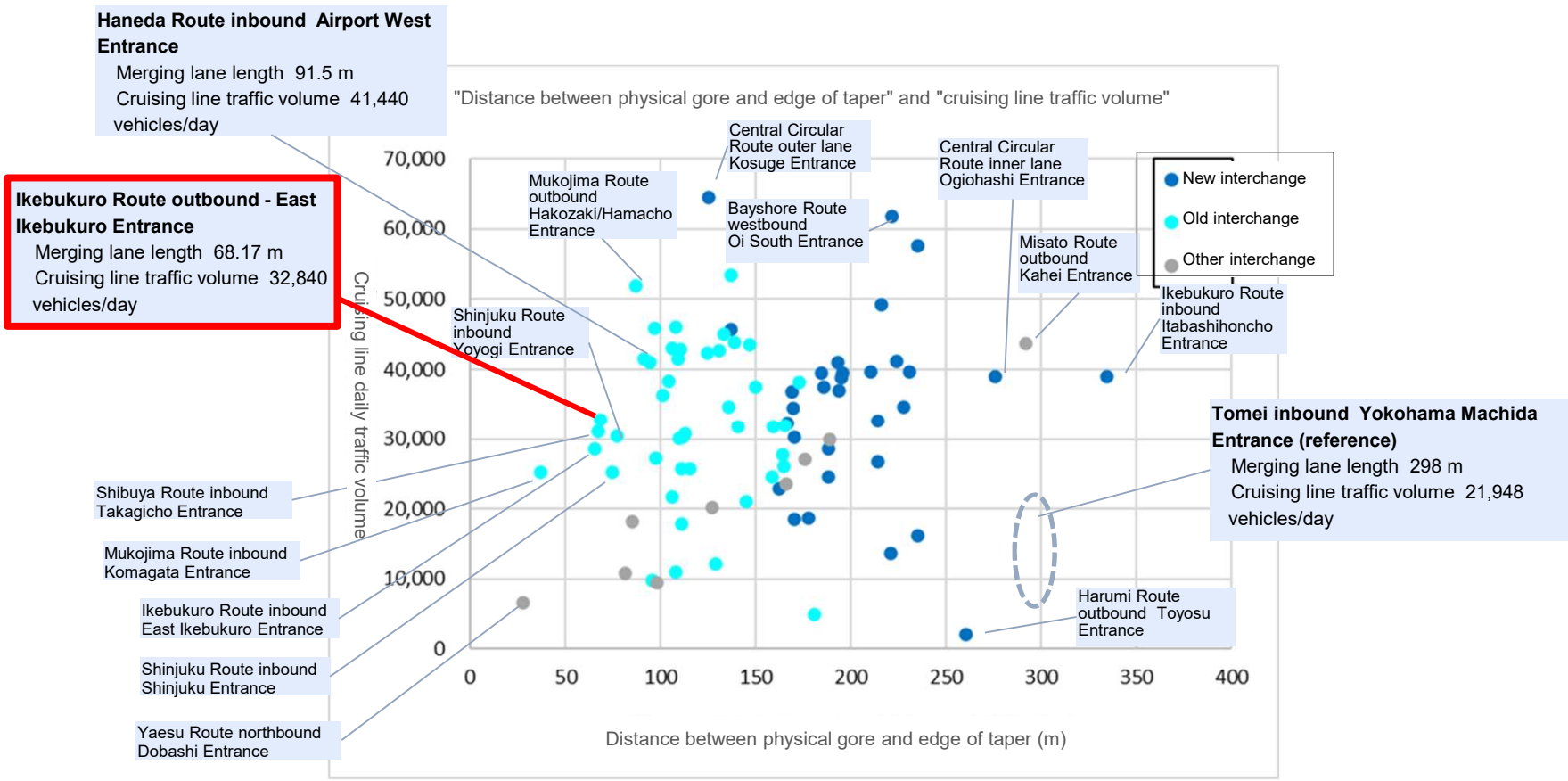
- **182 merging areas on Metropolitan Expressway routes for which distances were measurable using aerial photographs**
  - Interchanges: 108, Junctions: 63, Parking area exits: 11
  - Some parts of the Bayshore Route were excluded

[Study items]

- **Road alignment**
  - Acceleration lane length (from physical gore to edge of taper)
  - Section where merging is possible (from theoretical gore to edge of taper)
  - From ETC toll booth to physical gore
  - Distance from point where merging lane width is 2 m to edge of taper
  - Distance between edge of obstacle such as wall to theoretical gore, separating cruising line from merging lane
  - Visibility from cruising line/merging lane (* Envisioned as being visibility from driver's perspective)
  - No. of cruising line lanes
  - No. of merging lanes
- **Traffic restrictions**
  - Cruising line speed limit
  - Merging lane speed limit
- **Cruising line/merging lane traffic volume**
  - Daily traffic volume

2.2. Features of merging areas on Metropolitan Expressways and positioning of East Ikebukuro verification [1/2]

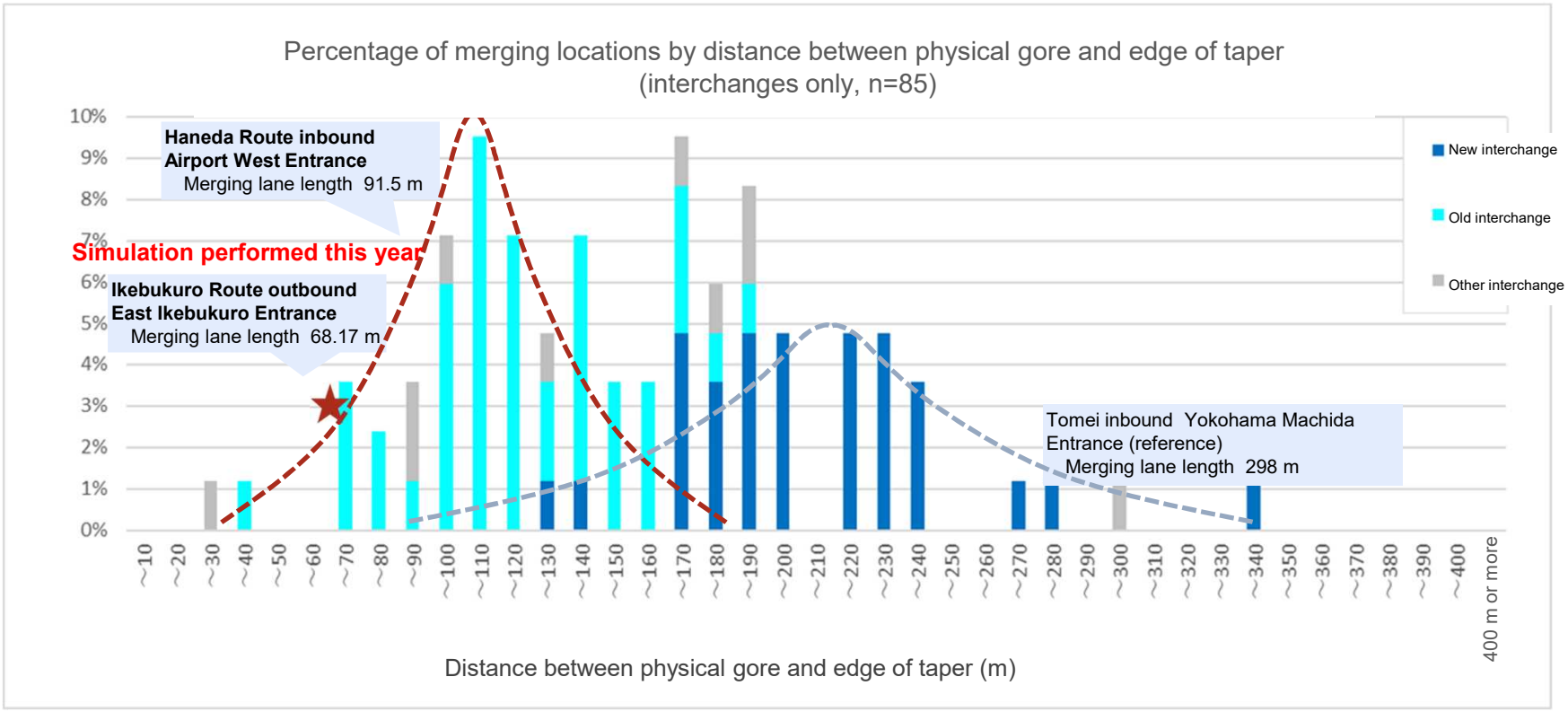
- **A study was conducted of the road alignment of merging areas in Metropolitan Expressway entry points and merging lane lengths and cruising line traffic volume were investigated**
- **It was confirmed that the East Ikebukuro Entrance had a merging area with a particularly short merging lane, even among merging points designed under old road standards**



* Analysis was performed for locations where distances could be measured based on aerial photographs.

2.2. Features of merging areas on Metropolitan Expressways and positioning of East Ikebukuro verification [2/2]

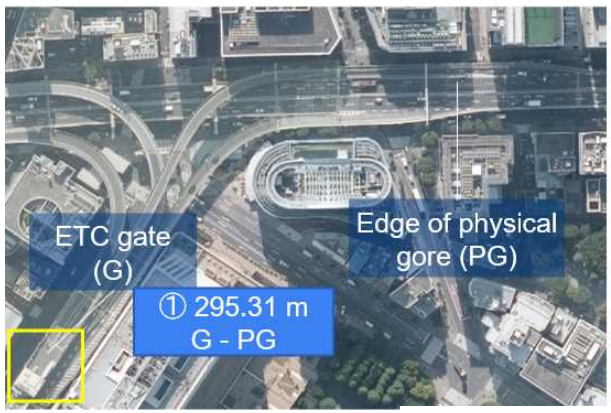
- **It was confirmed that the distribution of Metropolitan Expressway merging lane lengths had two peaks, corresponding to the old and new standards**
  - Locations with short merging lanes (old standard), including East Ikebukuro, had short distances between merging start points and merging completion points, so there appear to be many potential situations in which merging support would be effective
  - For locations with relatively long merging lanes (new standard), merging may be possible during automated driving without merging support

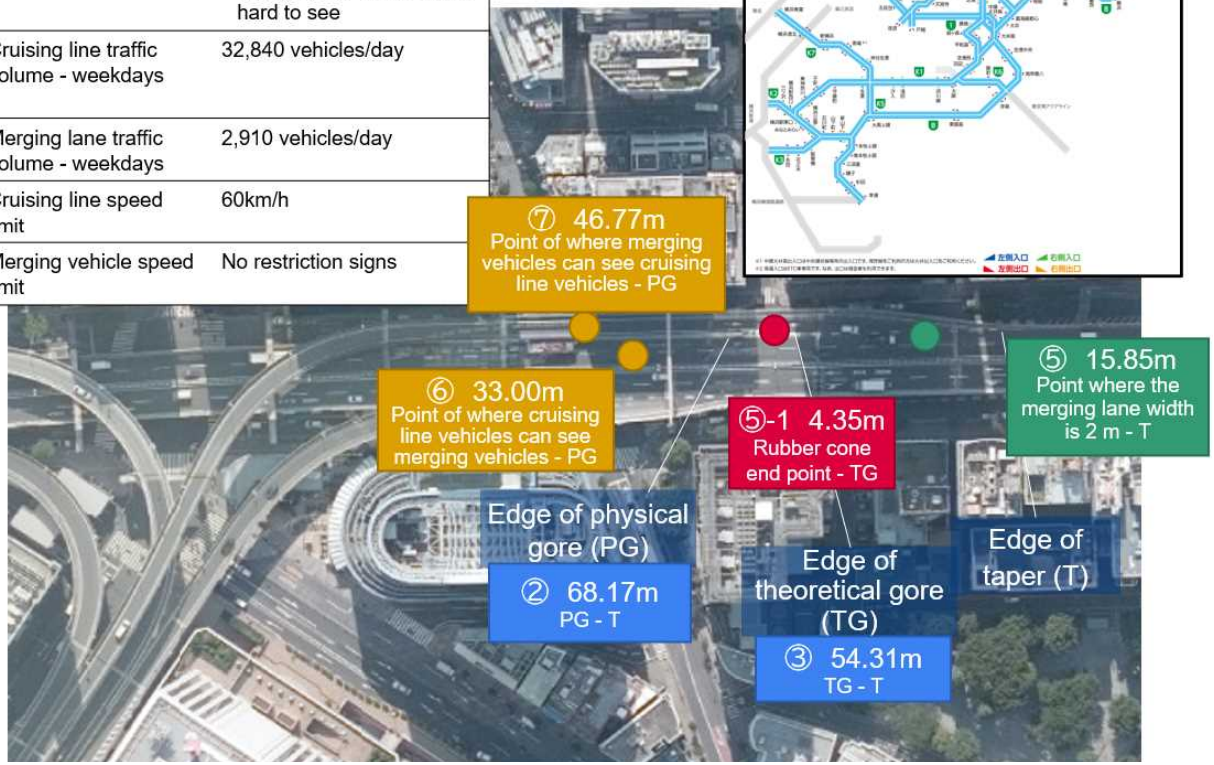


* Analysis was performed for locations where distances could be measured based on aerial photographs.

2.3. Examples of study items (East Ikebukuro Entrance (Route 5 Ikebukuro Route, outbound))

①	ETC gate to physical gore	295.31m	⑥	Point where merging vehicles can be seen from cruising line	33.00 m to PG
②	Physical gore to edge of taper	68.17m	⑦	Point where cruising line vehicles can be seen from merging lane	46.77 m to PG
③	Theoretical gore to edge of taper	54.31m	⑧	Visibility from merging lane/cruising line	• The merging lane is higher than the cruising line, so both cruising line vehicles and merging vehicles are hard to see
④	Point where the merging lane width is 2 m	15.85 m to T	⑨	Cruising line traffic volume - weekdays	32,840 vehicles/day
⑤-1	Rubber cone start and end points	4.35 m to 15.22 m to TG	⑩	Merging lane traffic volume - weekdays	2,910 vehicles/day
⑤-3	Concrete wall end point	32.72 m to TG	⑪	Cruising line speed limit	60km/h
	(only curb between concrete wall and rubber cones)		⑫	Merging vehicle speed limit	No restriction signs





Photographs courtesy of the Geospatial Information Authority of Japan
Metropolitan Expressway map: Metropolitan Expressway website, Metropolitan Expressway Mikata - Metropolitan Expressway Entrance and Exit Map
https://www.shutoko.jp/ss/mikata/map/index.html

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