戦略的イノベーション創造プログラム

Cross-ministerial Strategic Innovation Promotion Program (SIP)/Automated Driving for Universal Services/Technical Study and Evaluation of Automated Driving Control Using Lane-specific Probes or the Like

FY2020 Annual Report

Summary

Pacific Consultants Co., Ltd.

March 2021

1. Study Outline

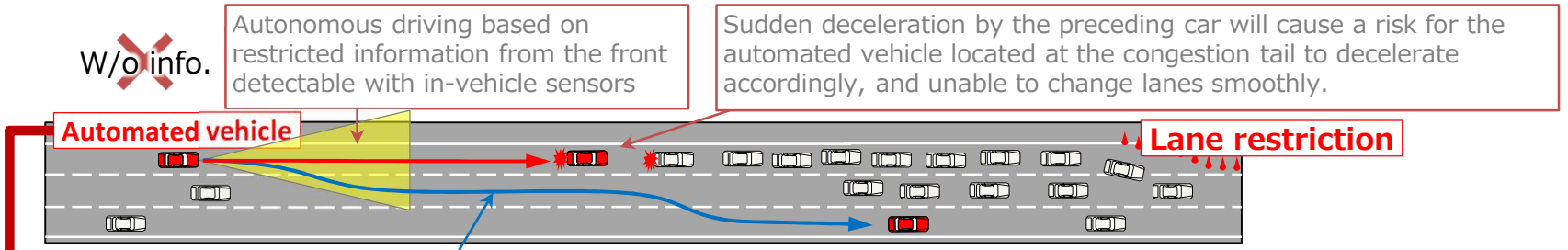
1.1. Project Goals

In automated driving on expressways, there may be cases where it is difficult to change lanes smoothly from the traveling lane to the deceleration lane due to the insufficiency or inaccuracy of information available in advance, such as when there are stopped vehicles or fallen objects ahead or there is congestion at the exit. One way to solve such cases is to allow automated vehicles to obtain lane-specific road traffic information, which will enable early lane change and consequently safe and smooth automated driving.

1.1. Project Goals

Necessity of Lane-level Road Traffic Information

- Lane-level road traffic information is necessary to achieve safe and smooth driving by obtaining the status at the front that cannot be detected by in-vehicle sensors, and changing lanes early, or other means.
- To generate lane-level road traffic information, it is effective to use vehicle probe information that can obtain traffic conditions in areas, and further sophistication of information by adding information from road/traffic controllers or others is expected.



Needs by vehicle
- What lane should be used?
- When to change lanes?

→ **Lane-level road traffic information is necessary** to determine the above.

Respond to needs

Effectively generating information by combining information from various sources

○ **Vehicle probe information**
Can obtain areas and positions precisely

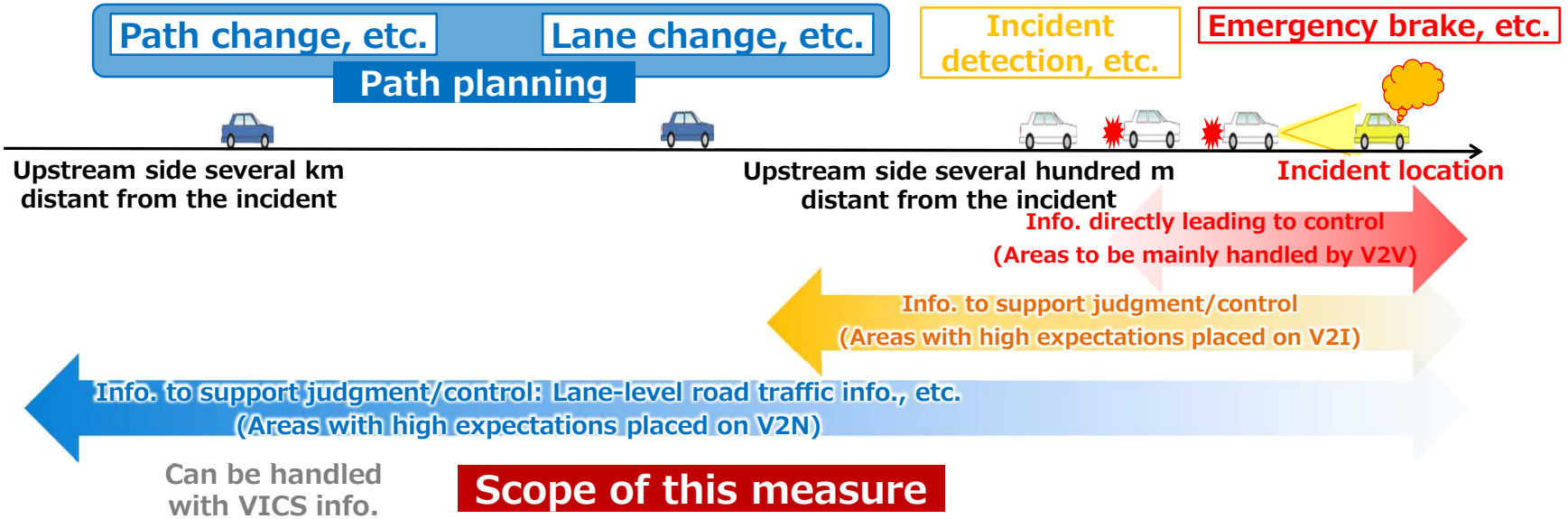
○ **Road/traffic controller information**
Can obtain information such as incident causes that cannot be obtained through vehicles

○ **Others (emergency information, etc.)**
Can obtain emergency information immediately

1.1. Project Goals

Scope of This Measure

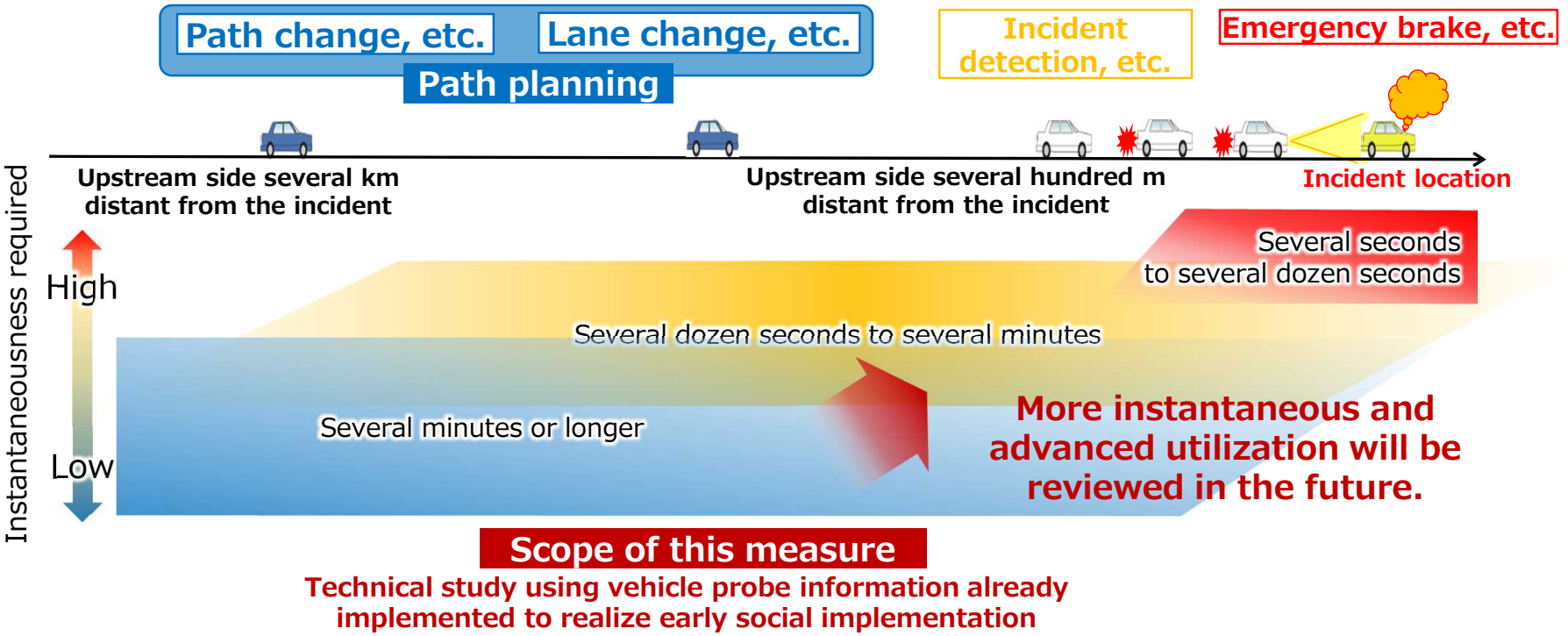
- There are multiple stages for automated vehicles to appropriately control or make judgment, depending on the distances to the point to perform controls necessary for individual scenes. Thus lane-level information is required for each stage.
- It is important to use various communication measures depending on the characteristics of each stage, and integrally combine obtained information.
- Lane-level road traffic information according to characteristics of scenes is being reviewed for the effectiveness or use, and this measure first reviews use of path planning mainly for lane change.



1.1. Project Goals

Scope of This Measure

- This measure utilizes vehicle probe information already implemented to realize early social implementation and starts activities from reviewing technologies to generate/provide information in real time similar to conventional road traffic information.
- It also aims to generate/provide further instantaneous information in the future.

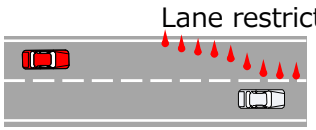


1.1. Project Goals

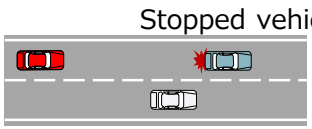
Target Use Cases and Advantage of Information Provision

Target use cases Targets **<u>three use cases</u>** being studied by Japan Automobile Manufacturers Association

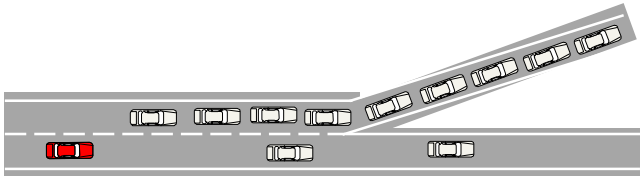
A: Lane restrictions (due to construction work or the like)



B: Traffic accidents, disabled vehicles, fallen objects, and other obstacles



C: Congestion tail



Requirement	Target sections	Communication	Control application (vehicle control or information provision, etc.)	Quick response (response from vehicle after obtaining information)
	Expressways	V2I, V2N	Lane change, traveling plan change, speed adjustment, stop	Not required

Note) Set based on the SIP Cooperative Automated Traveling Use Cases (1st Edition, September 3rd)

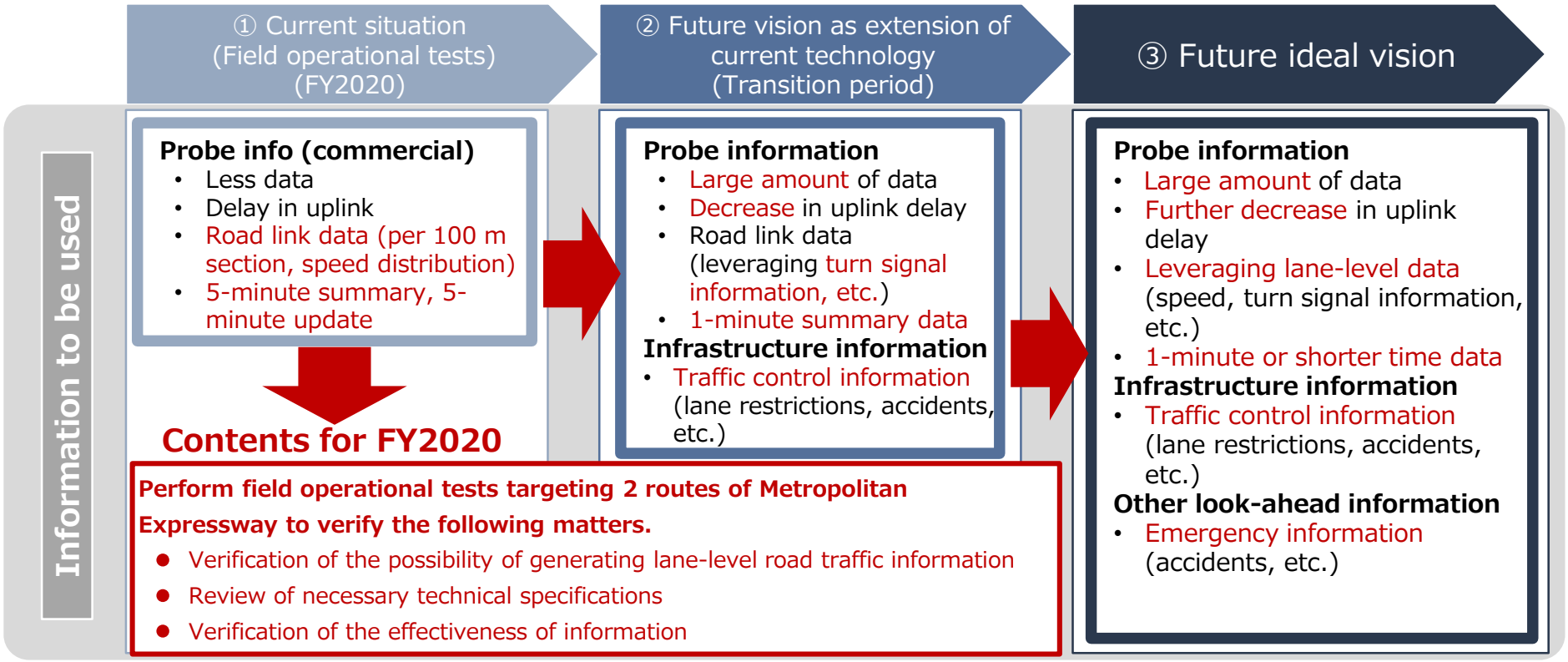
Advantages of info provision

- **Improvement on safety and smoothness, etc. is expected** thanks to smooth lane change and prevention of impact collision by the following car, as well as sudden deceleration of the automated vehicle when meeting an event shown in use cases by changing the lane in an early stage based on the situation of the front area.
- **<u>Effective as support information for vehicles with automated driving levels 1 and 2.</u>**

1.1. Project Goals

Future Visions and Scope of Study of FY2020

- In the future, data amount will be increased in line with widespread use of connected cars, so we will proceed with the study assuming that latest information will be provided thanks to collection of data without uplink delay.



1.2. Project Outline

To put the above into practice, this study and evaluation project examines the technologies to collect lane-specific congestion information, parked vehicle information, fallen object information, and incident/restriction information (hereinafter collectively referred to as "lane-specific information") and provide them to automated vehicles. Specifically, this study conducts a demonstration experiment on the Metropolitan Expressway Haneda Line and Bayshore Route (hereinafter referred to as "demonstration experiment") in the course of the Tokyo Bay Area 2020 Demonstration Experiment. The above measures are examined not only for the automated driving system, but also for the Level 1 and Level 2 driving support systems.

To achieve the above research and development objectives, the following research and development items are conducted.

a. Technical study on each element
    1) Study on lane-specific information generation technology
    2) Study and evaluation of lane-specific probe processing technology required for generating lane-specific information
    3) Study and evaluation of data integration technology for generating lane-specific information
    4) Study and evaluation of lane-specific information distribution technology

b. Demonstration experiment

c. Study and verification of elemental technologies using quasi-dynamic level look-ahead information

In FY2020, among the above research and development items, "a. Technical study on each element", "b. Demonstration experiment" and "c. Study and verification of elemental technologies using quasi-dynamic level look-ahead information "were partly conducted.

1.2. Project Outline

Study Flow of This Research and Development

Study on requirements and specifications (a. Technical study on each element (1) Technical study)

a1) Study on lane-specific information generation technology

Probe data information obtained from vehicles

Incident information (restriction information, information on fallen objects and disabled vehicles)

→ Study on requirements for data processing technology
- Lane-specific information generation technology
- Probe information processing technology
- Data integration technology

a2) Study and evaluation of lane-specific probe processing technology required for generating lane-specific information

a3) Study and evaluation of data integration technology for generating lane-specific information

a4) Study and evaluation of lane-specific information distribution technology

Link with high-precision 3D maps
- Setting Common Reference Points (CRP)
- Data generation based on the lane-level position reference method

c. Study and verification of elemental technologies using quasi-dynamic level look-ahead information

Reflection on experiment and development ⇄ Feedback

b. Demonstration experiment

Demonstration experiment planning →

1) Creation of node link maps of the demonstration experiment sections

2) Construction of an experimental system based on the technologies and specifications examined

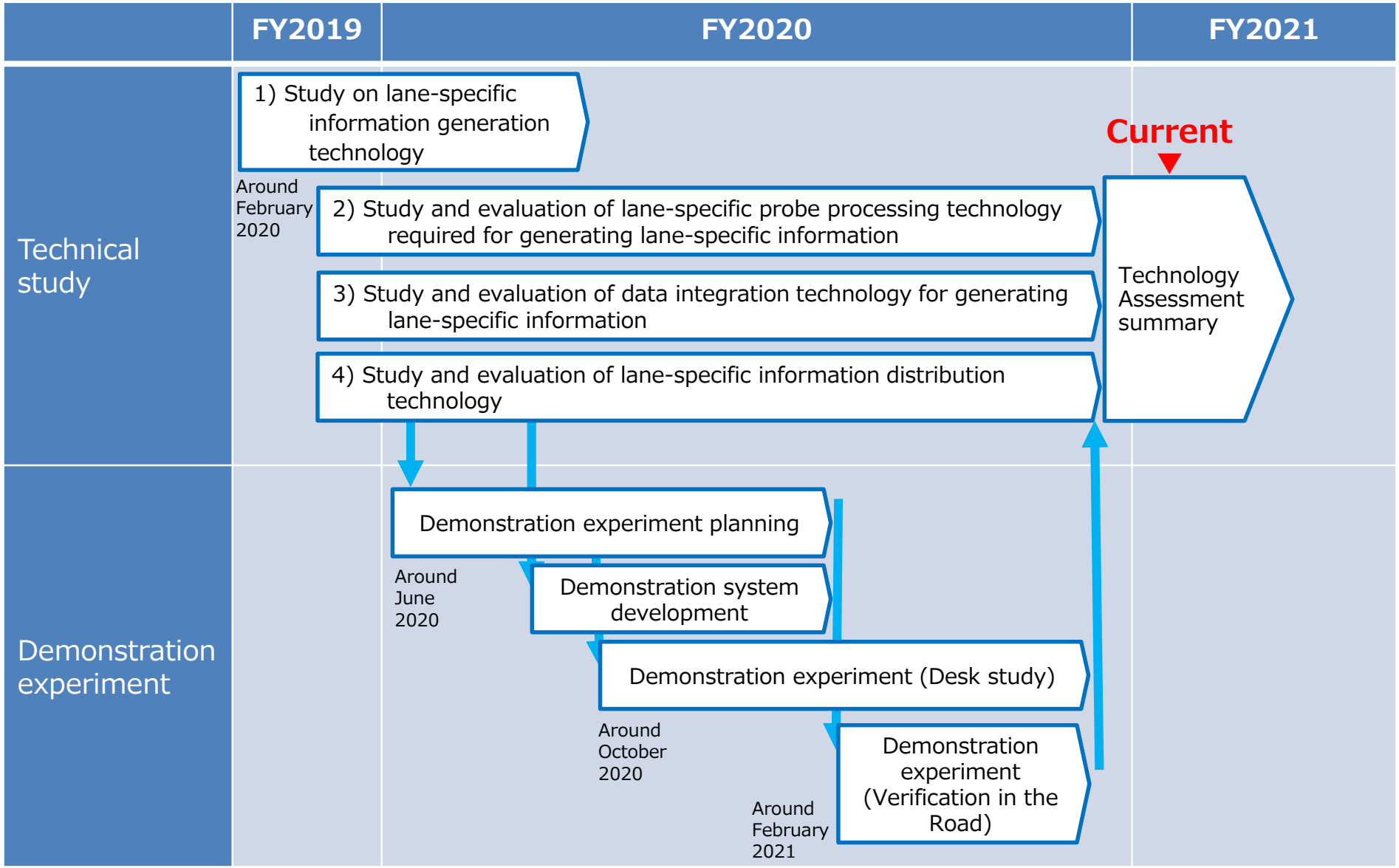
3) Demonstration experiment
- Evaluation based on the use cases of lane-level road traffic information
- Evaluation of the certainty of information and position expression

(2) Technical evaluation

* The demonstration experiment is assumed to be conducted mainly by the Demonstration Experiment Consortium.

1.2. Project Outline

Implementation Schedule of This Research and Development



2. Technical Study on Each Element

2.1. Study on Lane-specific Information Generation Technology

- This project examines how to generate lane-specific information using
  (1) Statistical data of probe information (e.g. travel speed by link) collected from each company's vehicles, and
  (2) Lane-specific fallen object information, incident/restriction information, and others

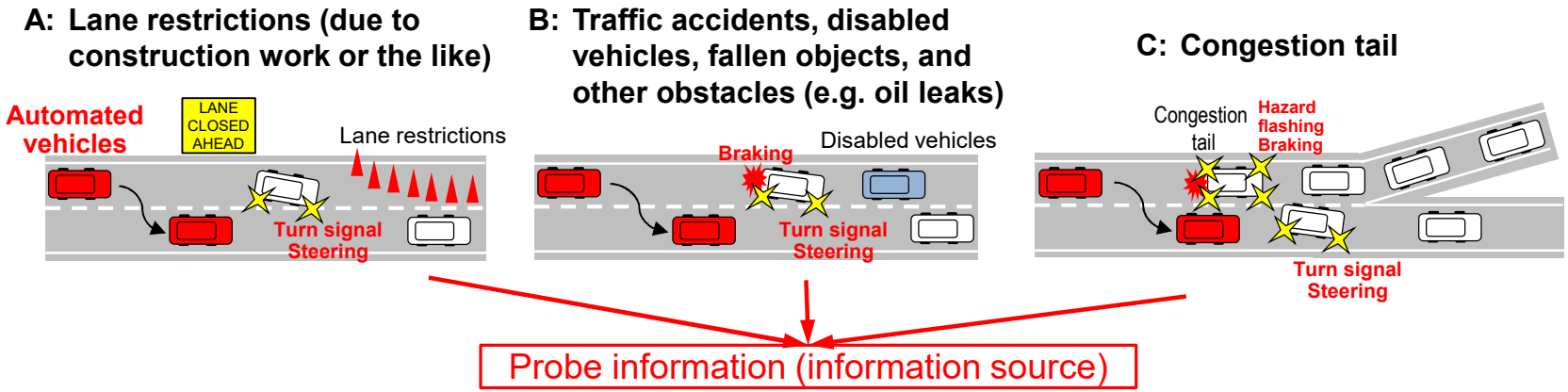
  with regard to expressways and motorways.
- This project uses available data (i.e., data obtained not from automated vehicles but from existing vehicles) in order to achieve early commercialization.
- In FY2020, a basic study was conducted on how to generate lane-specific information. Also, probe suppliers were interviewed about available data.

2.1. Study on Lane-specific Information Generation Technology

(1) Basic Study on How to Generate Lane-specific Information

■ Target use case incidents and concept of detection based on probe information

- The following are three use cases where automated vehicles use lane-level road traffic information.
- Study how to detect incidents by using available probe information depending on the use case.



Target use cases and how to detect relevant incidents based on probe information

Use Case	A: Lane restrictions (due to construction work or the like)	B: Sudden incident (traffic accidents, disabled vehicles, fallen objects, and other obstacles (e.g. oil leaks))	C: Congestion tail (e.g. directional congestion)
Information obtained by automated vehicles	Lane-specific road traffic information * Quasi-dynamic information (1-minute level)		
How to detect location of incident at lane level (Information source)	● Frequent turn signals ● Frequent steering	● Frequent turn signals ● Frequent steering ● Frequent braking	● Low speed points in lane-specific probes (directional probes at junctions) ● Frequent hazard flashing/braking ● Frequent turn signals/steering
Behavior of automated vehicles	Early avoidance (e.g. lane change)		Early avoidance (e.g. lane change) or following the congestion tail

2.1. Study on Lane-specific Information Generation Technology

(1) Basic Study on How to Generate Lane-specific Information

■ Concept of generating lane-specific road traffic information required for automated driving

- Determine the location of the incident (where lane change should be completed) using available probe information depending on the use case and provide it to automated vehicles.

Image of generation of lane-specific road traffic information to be provided to automated driving vehicles and matters to be clarified

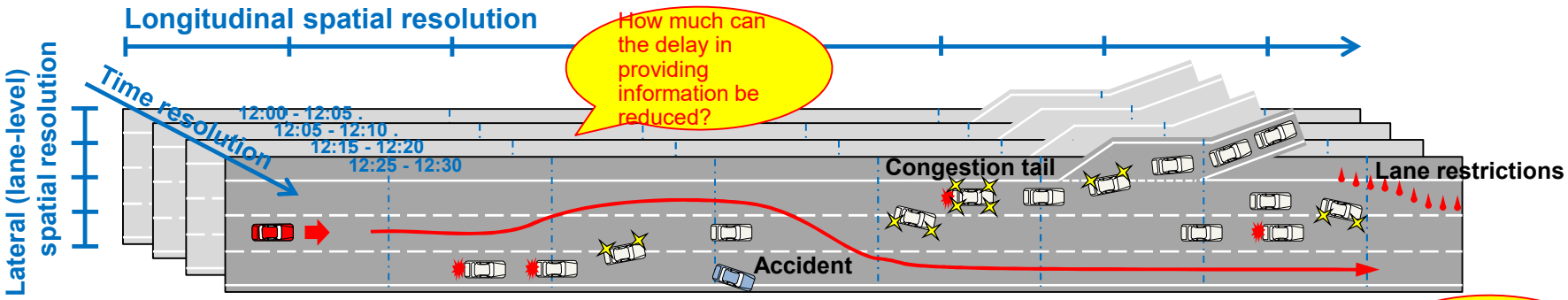


Image of the (lane-specific) probe information to be collected

What data is useful for incident determination?

Turn signal			Frequent (left)		Frequent (right)		Frequent (right)	
Braking		Frequent	Frequent		Frequent		Frequent	
Hazard flashing					Frequent			
Steering			Frequent (left)		Frequent (right)		Frequent (right)	
Sample frequency by speed range		Frequent in low speed range	Frequent in low speed range		Frequent in low speed range		Frequent in low speed range	
Speed by branch direction		See supplementary explanation on page 26	See supplementary explanation on page 26		Low speed on the left	Low speed on the left		

Image of lane-specific road traffic information to be generated ← **Data integration**

What resolution is effective as support information?

Lane-specific road traffic information			Obstacle ahead in right lane		Congestion ahead in left lane		Obstacle ahead in left lane	

2.1. Study on Lane-specific Information Generation Technology

(1) Basic Study on How to Generate Lane-specific Information

■ How to pre-verify information generation method (draft)

○ Verification using actual data

- Obtain the actual probe information and verify the certainty of the information generation method, regarding lane restrictions (due to construction work or the like), which are announced in advance, and congestion starting from Route No.1 Haneda Line inbound Hamazakibashi JCT, where lane-specific traffic congestion constantly occurs, among the target use cases.
- The target incidents and vehicle behavior are checked with CCTV video images.

○ Verification using dummy data

- The certainty of the information generated is desirable to be verified based on the actual probe information. However, it is difficult to obtain lane-specific probe or turn signal information at 100-m intervals at an early stage, and only limited video images can be used for verification. Therefore, dummy data is also created and verified by reproducing use case incidents by means of traffic simulation and presuming the amount of probe information to be obtained.
- The verification clarifies the spatial variations in the points of turn signal indication with regard to the location of lane obstruction, the amount of data obtained at 100-m intervals, and the relationship with the sample frequency by speed range.

2.1. Study on Lane-specific Information Generation Technology

(2) Interviews with Probe Suppliers

- Interviews were conducted with multiple probe suppliers in order to organize the data format and information items regarding the available information obtained from vehicles and required for generating lane-specific information.

Interview period

・Late February to early March 2020

Interview method

・Send an interview sheet in advance and conduct an interview on the day.

Interview items

- Cooperation in providing probe information in the data format desired in this project
- Cooperation in providing information on-line during the demonstration experiment
- The cost, contract method, and coordination required to cooperate with this project, and more

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

i. Basic technology for generating lane-specific probes

- Among the methods discussed in 2.1, probe processing technology will be examined for those that are feasible to conduct demonstration experiments.
- In FY2019, the data format and information items were organized regarding the available information obtained from vehicles and required for generating lane-specific information.
- In FY2020, the information items, data aggregation definitions, and collection format (Json format) for collecting probe information from probe providers were organized. In addition, a hierarchical data format that takes into account the delay in uplinking from probe vehicles will be organized.

ii. Output format of lane-specific probes

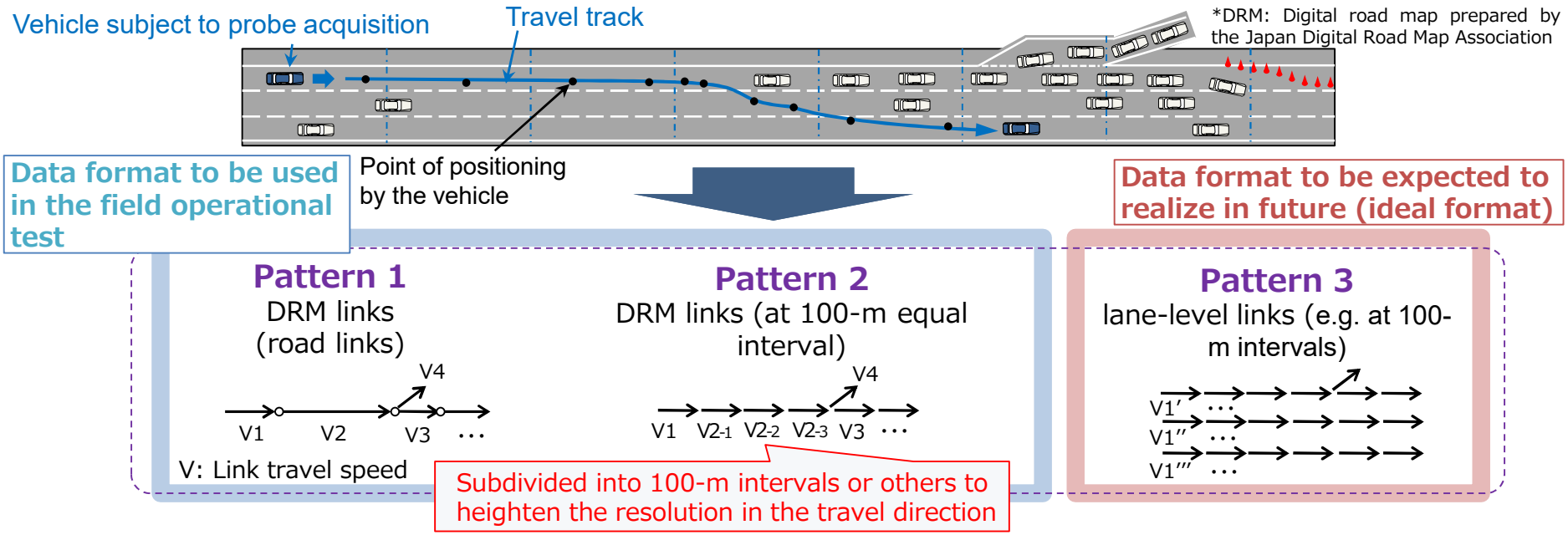
- As for the output format of lane-specific probes, we will verify whether the proposed interface specifications developed by JASPAR (Japan Automotive Software Platform and Architecture) can be used, and if this is difficult, we will create a proposed output format to achieve the purpose of the demonstration experiment.
- In FY2020, based on the interface specification draft developed by JASPAR, a draft of the output format was created to achieve the purpose of the verification experiment.

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

■ Available probe information

- The spatial aggregation unit of probe information (such as speed) is generally a link aggregation such as DRM*. (Pattern 1)
- It is desirable to use lane-level probe information (Pattern 3) to generate lane-level road traffic information, but in real terms commercial-base data (data obtained by commercial vehicles) are road-specific linked information (Patterns 1 and 2)
- Therefore, using probe information of Patterns 1 and 2 to generate lane-level road traffic information is being studied.



2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

■ Details of Probe Information to be Used

- Uses of probe information obtained from probe operators are roughly divided into desk study to evaluate the reliability of information generated with the established method, and verification of experiment system by actually distributing information to experiment participating vehicles during the 2020 field operational test.
- Probe information will be totaled every 5 minutes, considering current data collecting status or other factors.

Probe information to be used in field operational test

Unit of links for data collection	Data item		Field operational test: Desk study (using past data)	Field operational test: Verification with experiment system (online/real-time data)
Pattern 1 In DRM links	Speed by branch direction (5-minute interval)	Speed by branch direction at links before junction	○	○
Pattern 2 In DRM links (100-m interval)	**Link speed** (5-minute interval)	Average speed	○	○
		No. of vehicles by speed range(1)	○	○
	Frequency on vehicle events (5-minute interval)	Brake	○	Expected to be used in the following fiscal year and thereafter
		Turn signal		
		Steering		

Scope of data to be used in verification with experiment system

Note 1) Image of data format on No. of vehicles by speed range

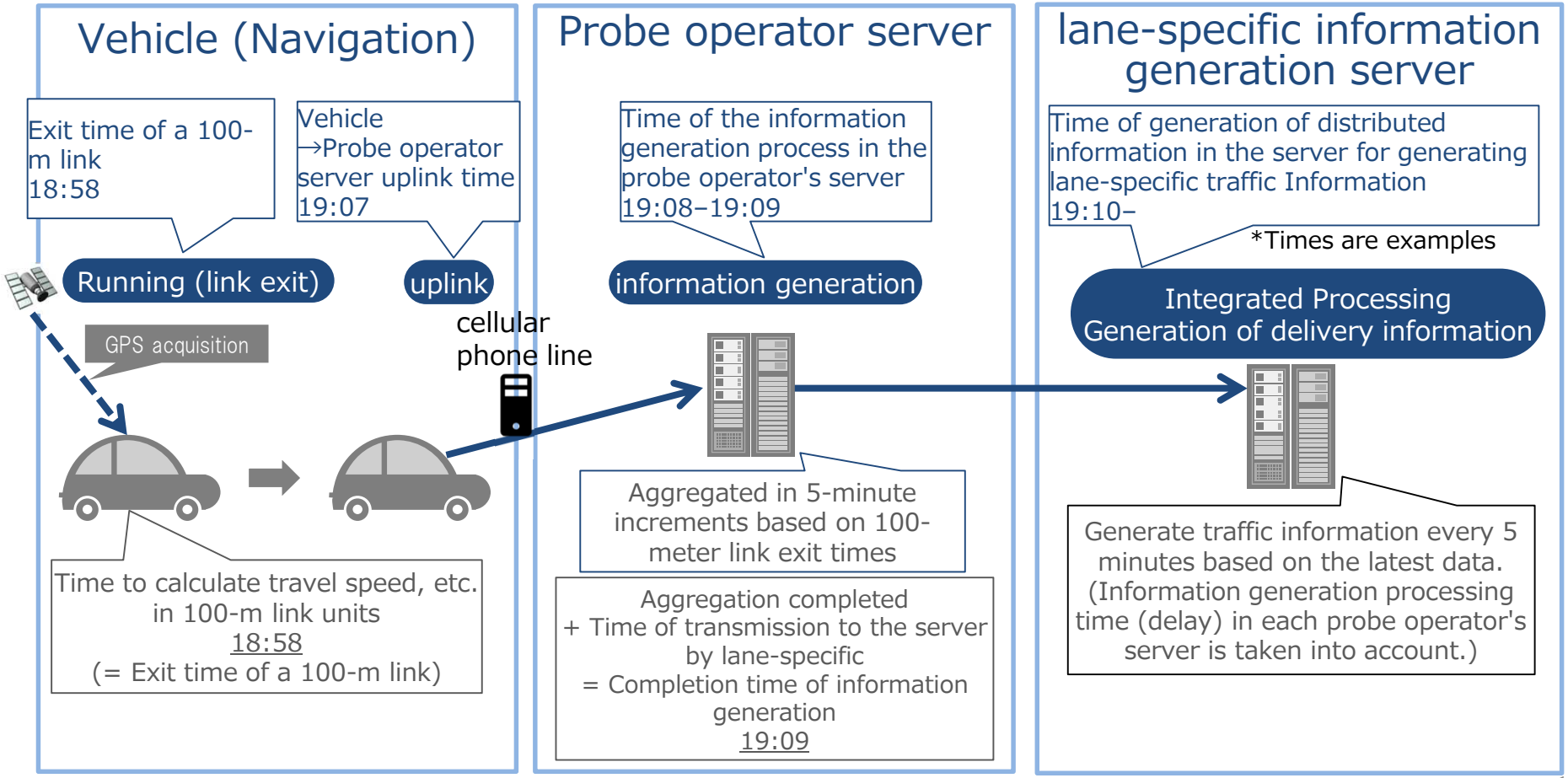
Speed category	No. of vehicles
0＜V≦10km/h	
10＜V≦20km/h	
:	
110＜V≦120km/h	
120＜V	

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

■ Data sharing (aggregation) (occurrence of uplink delays)

- It is assumed that there will be a certain amount of time before the driving information of the probe vehicle is uplinked to the information generation server of the probe provider, and this should be kept in mind when collecting probe information.



Flow from data acquisition to information collection at the vehicle

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

■ Data sharing (aggregation) (occurrence of uplink delays)

- It is assumed that there are many data that are uplinked late in the probe information, and it is possible that the required number of samples cannot be obtained only from the latest data.
- Therefore, the following should be considered in the data sharing (aggregation) phase.
  - Aggregation in 5-minute increments (called "class") based on probe vehicle travel times
  - Consolidates the most recent past data at each class (class 6). Class 1 consolidates data for the last 5 minutes, and class 6 for the last 30 minutes.
  - Examine the generation logic while checking the data acquisition rate of each hierarchical frame.

Verification items
・Data acquisition rate (occurrence of uplink delays)

Exit time of 100-m link

Delivered information generation time	18:30-18:35	18:35-18:40	18:40-18:45	18:45-18:50	18:50-18:55	18:55-19:00	19:00-19:05			
19:00	class 6	class 5	class 4	class 3 10	class 2 5	class 1 4				
19:05		class 6	class 5	class 4	class 3 10	class 2 8	class 1 6			
19:10					class 4	class 3 12	class 2 10	class 1 10		
19:15					class 5	class 4	class 3	class 2	class 1	
19:20					class 6	class 5	class 4	class 3	class 2	class 1

For the generation of distribution information as of 19:00, integrate hierarchy class 1 to class 3 to ensure the required number of samples of 10.

As of 19:05, it will be integrated to hierarchy class 1 to class 2.

As of 19:10, use only class 1.

At the next generation time, the uplink delay data will be added over time.

Image of data integration to ensure the required number of samples

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

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.1 Technical Study

■ Data sharing (aggregation) (occurrence of uplink delays)

- The data collection format for aggregating data from probe providers is designed so that information up to 30 minutes prior to the collection deadline can be aggregated in 5-minute increments, taking into account uplink delays.

Format structure to be collected from probe providers

Configuration information			Main Information
Basic Information			Geodetic system, time zone, information generation time
Probe information	DRM Basic Information		DRM link version, secondary mesh code, link number
	class 1–6		Information up to 30 minutes prior to the collection deadline is aggregated in 5-minute increments.
		DRM link unit information	Average travel speed by direction
	class 1–6		Information up to 30 minutes prior to the collection deadline is aggregated in 5-minute increments.
		100m split link unit information	Split serial number, split link distance, average speed information, speed stratification information other vehicle information, average travel speed by direction

*From the probe provider, the data expression is in Json format, and the information is collected by file transfer using the HTTP protocol.

■ Data sharing (aggregation) (collected data items and definitions)

- Define uniform definitions for information items to be collected from probe providers.
- The definition of "other vehicle information (blinker, brake, etc.)" is also defined to count the number of events.

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.2 Technical evaluation

- Based on the results of the study in 2.1.1, it will be confirmed that the information necessary to create lane-specific information can be created from probe statistics (travel time by link, vehicle information by speed band, etc.) collected from probe providers. In addition, necessary improvements will be made based on the results of the demonstration experiment.
- In FY2020, we procured past probe statistics from several probe providers and confirmed the information generation rate by time zone section and the number of backward classes required for information generation.

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

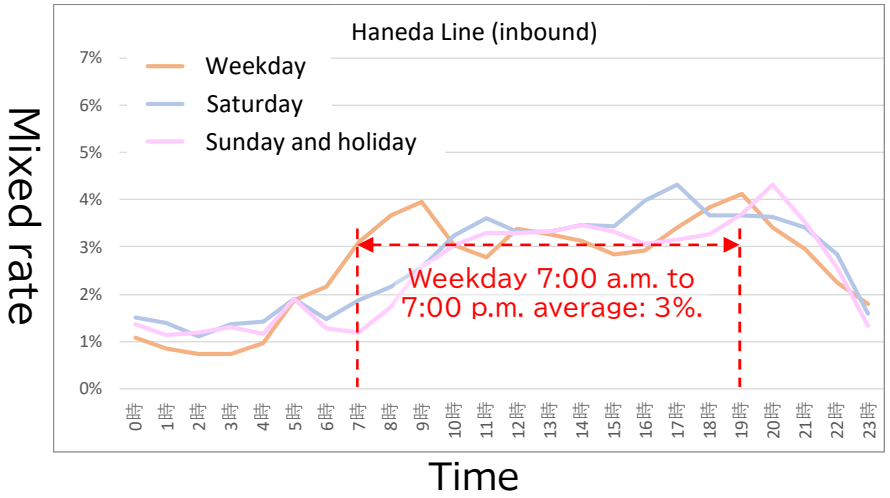
2.2.2 Technical evaluation

■Check the amount of probe information collected (contamination rate)

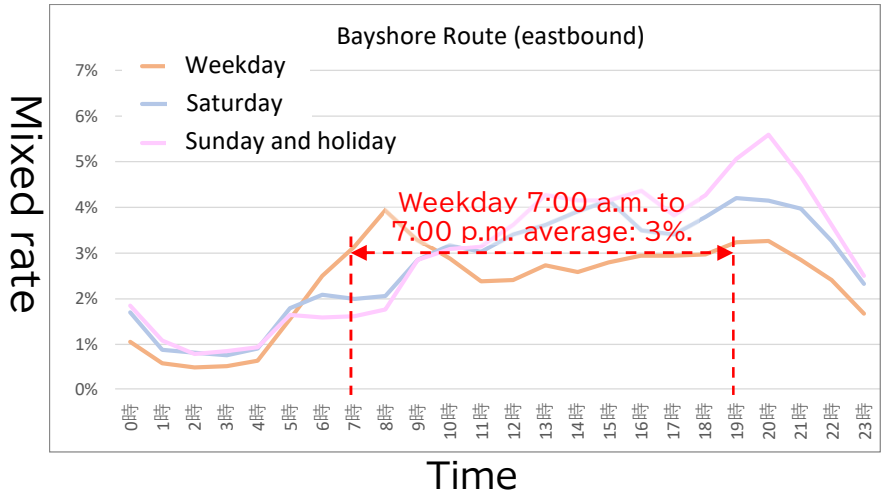
- The contamination rate of probe information (number of vehicles by speed stratification) that can be collected at present is about 3% on the Metropolitan Expressway (Route No.1 Haneda Line and Bayshore Route) (weekdays/daytime).
- Equivalent to 6 cars/5 minutes on Route No.1 Haneda Line (inbound) and 8 cars/5 minutes on Bayshore Route (eastbound).

○Number of units by speed stratum (100m section unit, mixing rate)
2020/7/8–8/7

Haneda Line (inbound)



Bayshore Route (eastbound)



*Comparison with FY2015 census traffic volume by time zone.

2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

2.2.2 Technical evaluation

■ Check the amount of probe information collected (number of units per 5 minutes)

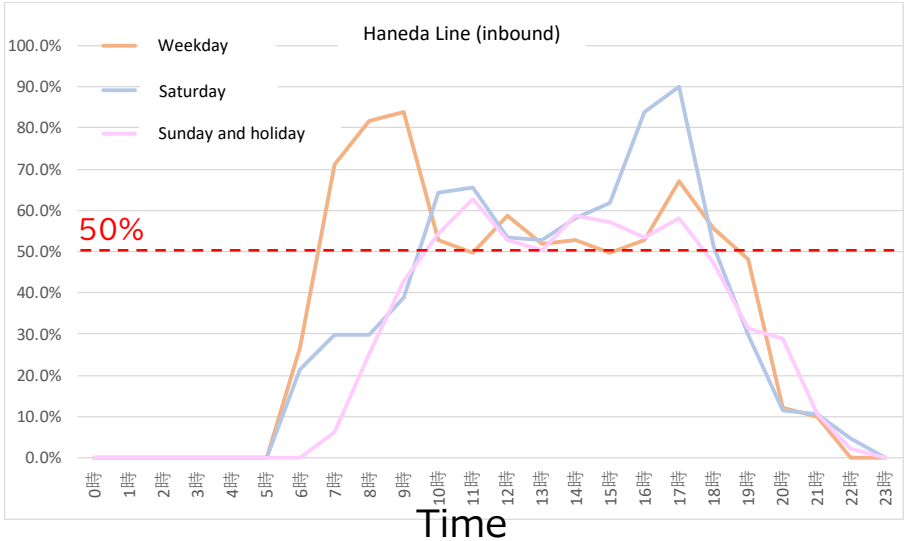
- On Route No.1 Haneda Line, regardless of the day of the week, generally more than 50% of the sections have 5 cars/5 minutes or more* during the daytime.
- On the Bayshore Route, generally more than 80% of the sections have 5 cars/5 minutes or more* during the daytime, regardless of the day of the week.
- Both routes cannot secure 5 cars/5 minutes at night.
  - ➢ In the daytime, there is a possibility of generating information with a certain level of accuracy with the current amount of collectable data.

*Number of samples for which the average travel speed can be calculated with an accuracy of ±10 km (95% confidence level) in the distribution of speeds on urban highways.

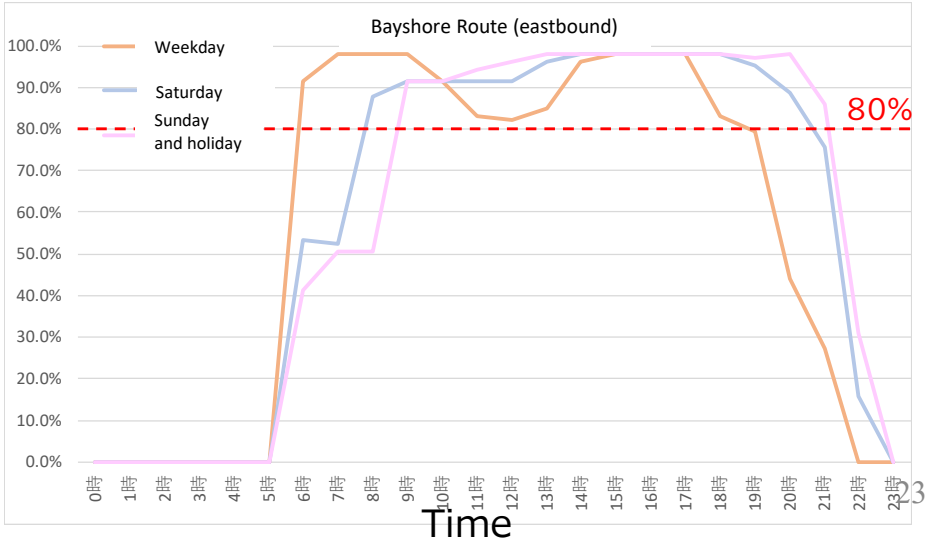
○Percentage of sections (in 100-meter increments) where the number of vehicles by speed stratum is 5 vehicles/5 minutes or more.

July 8, 2020 - August 7, 2020 Weekday average

Haneda Line (inbound)



Bayshore Route (eastbound)



2.2. Study and Evaluation of Lane-specific Probe Processing Technology Required for Generating Lane-specific Information

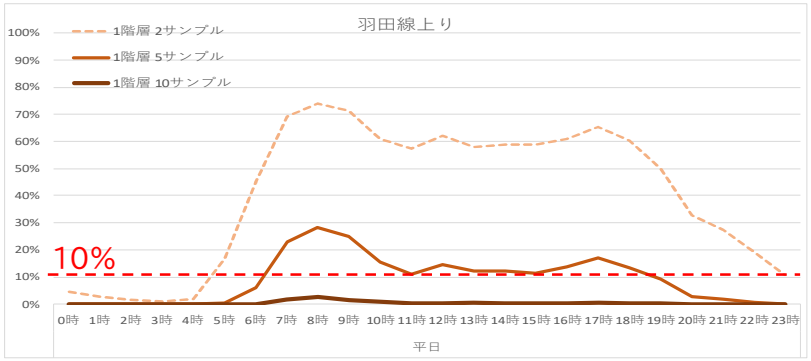
2.2.2 Technical evaluation

■ Uplink delay (backtracking time required to secure 5 units)

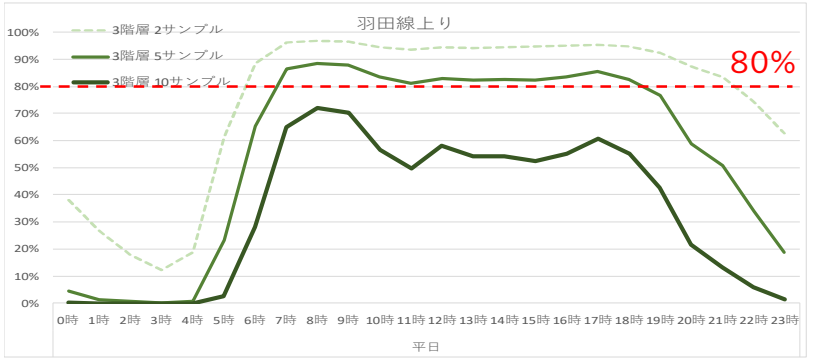
- Since there is a delay in the uplink when collecting probe information for each OEM, etc., data will be collected in 5-minute units up to 30 minutes in the past so that data collected late can be utilized.
- When trying to secure data for more than 5 units, the percentage of sections that can be collected in the last 5 minutes is 10%, 60% if you go back to the last 10 minutes, and about 80% if you go back to the last 15 minutes. (Haneda Line (inbound))
  - ➢ Taking uplink delays into account, it is expected to take about 15 minutes to collect data from five cars depending on the time of day and the segment, but this is expected to improve as the number of connected cars increases.

○Information generation rate Haneda Line (inbound) July 8, 2020 - August 7, 2020 Weekday average

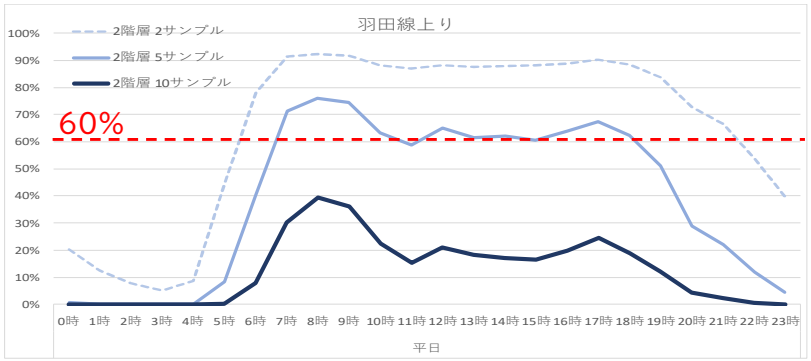
class 1 (Last 5 minutes)



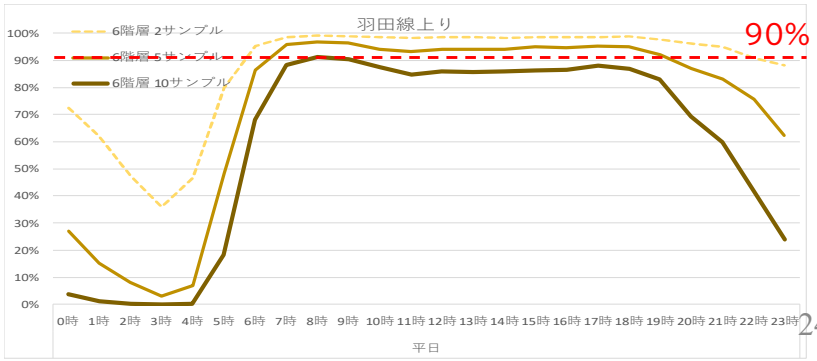
class 3 (Last 15 minutes)



class 2 (Last 10 minutes)



class 6 (Last 30 minutes)



2.3. Study and evaluation of data integration technology for generating lane-specific information

2.3.1 Technical Study

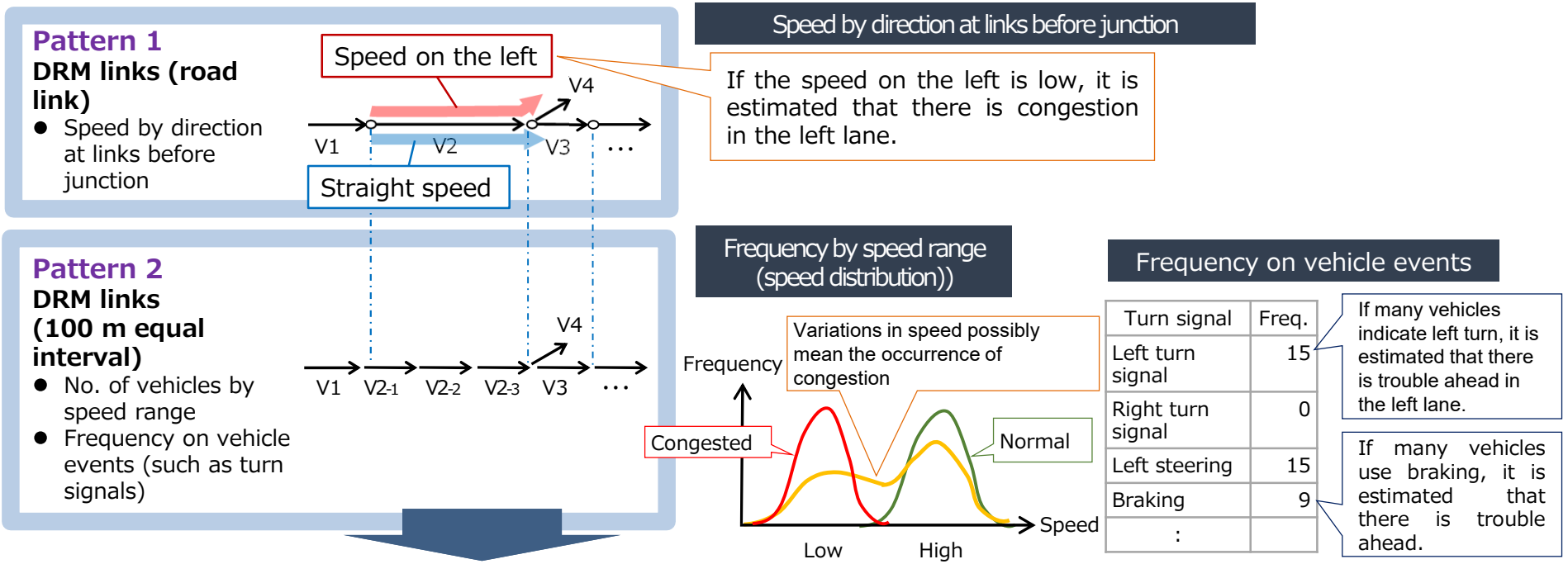
- Study how to integrate statistical data of probe information provided by each supplier into lane-specific information in consideration of the differences in the number of probe data items and accuracy while assuming the following.
- Furthermore, in the course of generating lane-specific information by the above integration process, study how to refer and utilize the data that classifies information on fallen objects, incident/restriction information, and others by lane.
- In FY2020, a basic study was conducted on the statistical processing method for integrating statistical data of probe information into lane-specific information.

2.3. Study and evaluation of data integration technology for generating lane-specific information

2.3.1 Technical Study

■ Basic concept of information held by probe information links and lane-specific information

Information held by links for probe information to be used



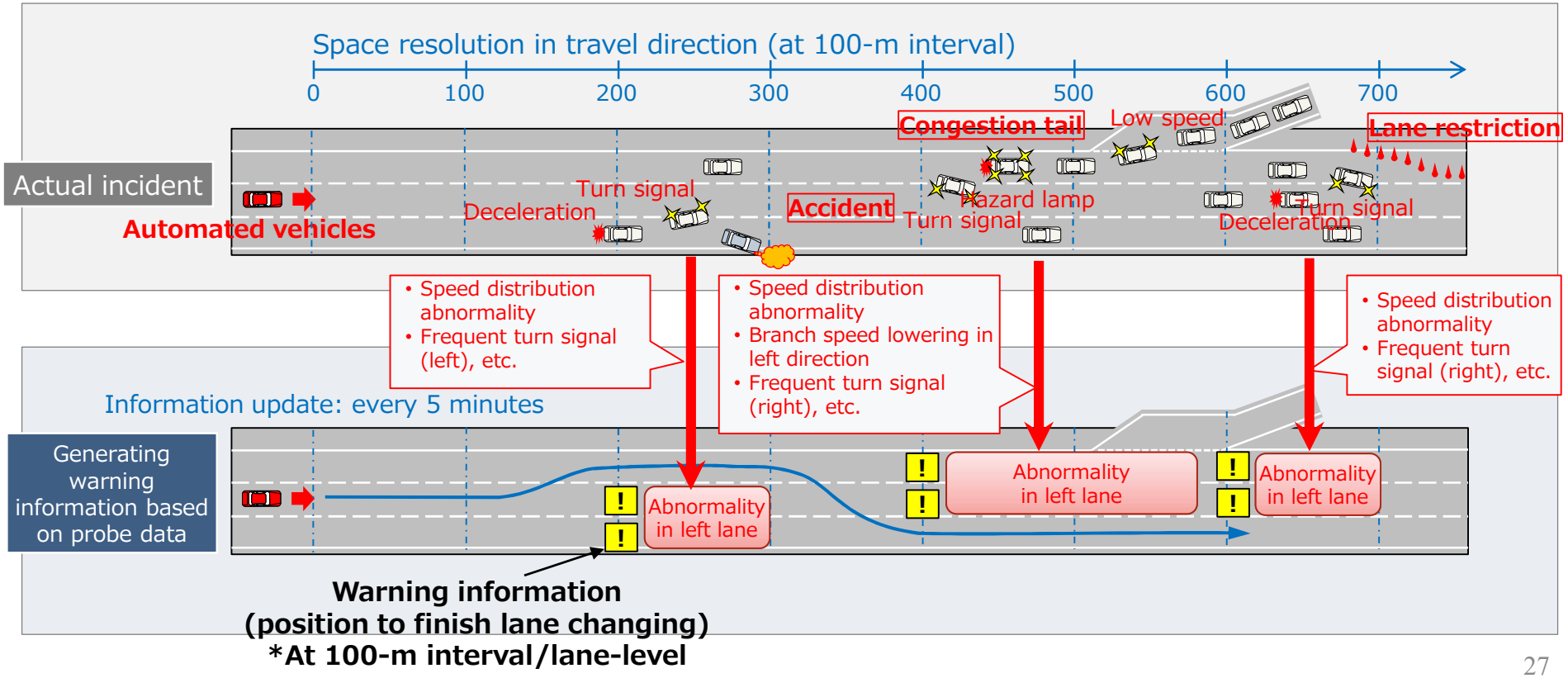
- Identifies a position where an abnormality occurs in the traveling direction at 100-m intervals from information on number of vehicles by speed range in Pattern 2.
- For lane-level abnormality, the direction (left or right) of the lane having the trouble is judged from turn signal information or the like in Pattern 2.
- At junctions, lane-level congestion status (left turn or straight) by branch direction is judged from the speed information by direction in Pattern 1.

2.3. Study and evaluation of data integration technology for generating lane-specific information

2.3.1 Technical Study

■ Lane-Level Road Traffic Information to be Generated

- Generation of the following warning information applicable to target use cases is studied.
- Since vehicle event information processing functions are not implemented in the experiment system for verification, use cases for congestion tails at the junction will be mainly verified.



2.3. Study and evaluation of data integration technology for generating lane-specific information

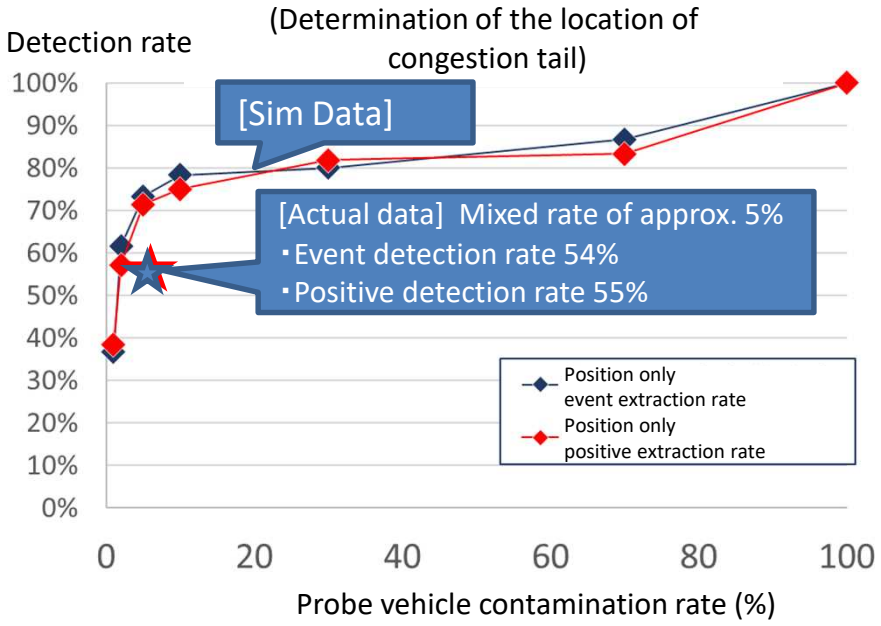
2.3.2 Technology Assessment

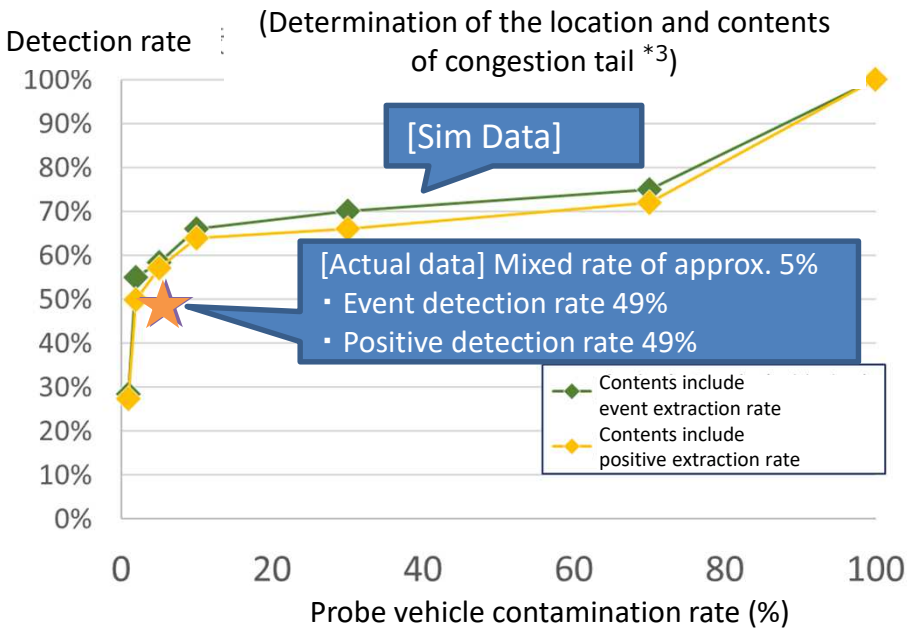
- Build a data integration server and create lane-specific information using a statistical processing method based on the technical study described in the previous section. Analyze the issues for practical use such as information accuracy of the created lane-specific information, and make necessary improvements.
- In FY2020, a data integration server was constructed and lane by lane information was generated using past probe statistics. Furthermore, the accuracy of the information was evaluated by comparing it with actual traffic conditions.

2.3.2 Technology Assessment

Preliminary verification of information generation accuracy (event detection using speed stratified volume data)

- Sorting out the accuracy of information generation according to probe vehicle mixing rate from traffic simulation results.*1
  - Information generation accuracy of about 70% is expected with a contamination rate of about 10%.
- The accuracy of information generation using the actual data collected this time*2 is 50-60% for the location of the congestion tail, and about 50% if the content (lane-specific traffic jam or cross-sectional congestion) is included.
  - Slightly lower accuracy than simulation results because uplink delay is taken into account in real data.





*1 Probe vehicle contamination rate: 1%, 2%, 5%, 10%, 30%, 70%, Number of judgment samples: 1% and 2% contamination rate ⇒ 2 vehicles, 5% and 10% contamination rate ⇒ 5 vehicles, 30% and 70% contamination rate ⇒ 10 vehicles

*2 Compared with the true value (lane-specific traffic jam and cross sectional traffic jam) confirmed by CCTV images and driving images

*3 Content judgment: Determine whether the traffic jam is lane-specific or cross-sectional.

●Event extraction rate = Percentage of congestion events detected by estimation out of actual congestion events

●Positive extraction rate = Proportion of congestion events detected by the estimation that are exactly on target

Relationship between probe vehicle mixing rate and event determination accuracy
(Before Route No.1 Haneda Line inbound Hamazakibashi JCT)

2.4. Study and Evaluation of Lane-specific Information Distribution Technology

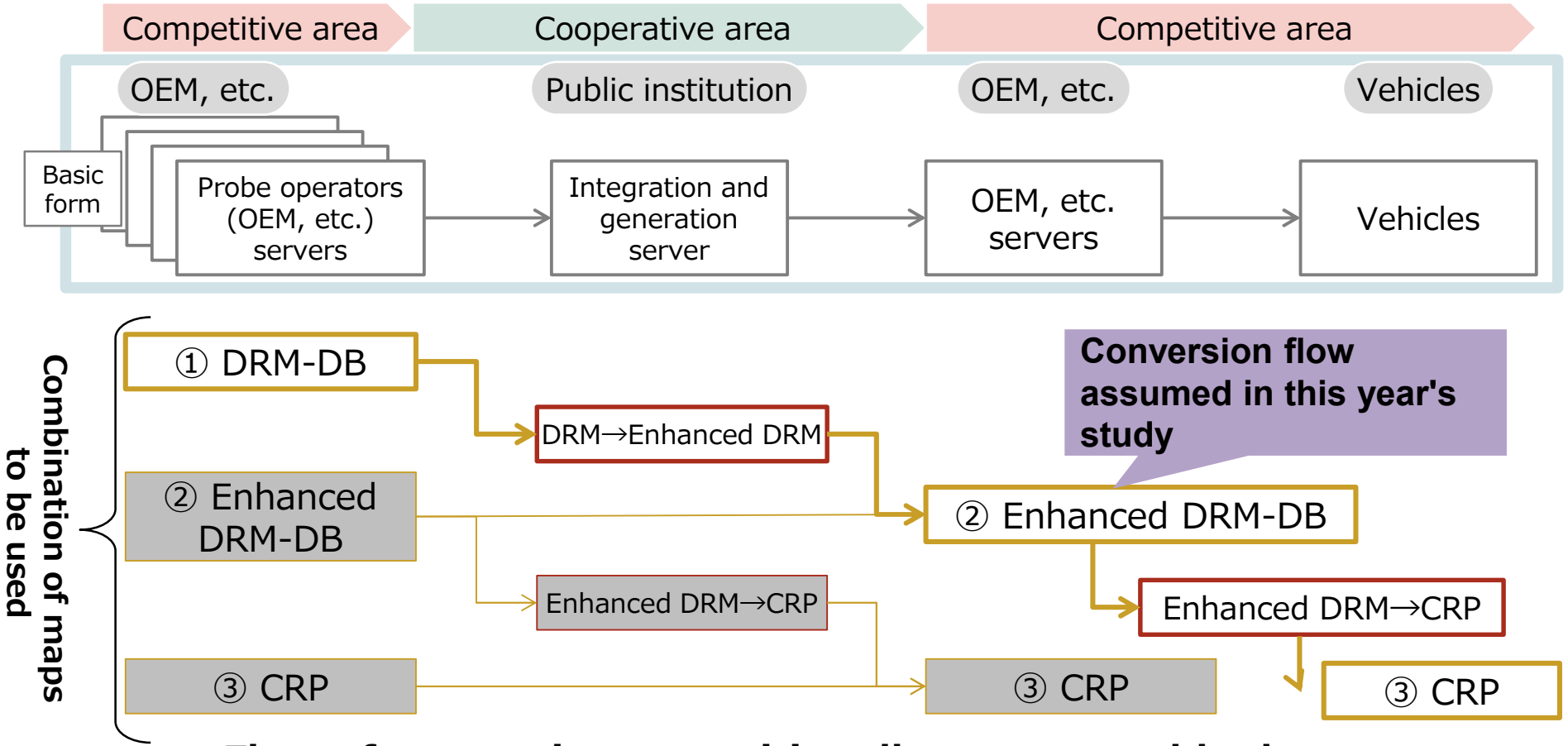
2.4.1 Technical Study

- Examine the technology for providing the lane-specific information integrated in 2.3 above to vehicles participating in the experiment or servers that relay the information (which are expected to be substituted by telematics centers of automobile manufacturers at the stage of social implementation in the future).
- Specifically, examine the message format after examining the location reference method for superimposing lane-specific information on high-precision 3D maps, lane-specific information items to be provided depending on the location, and so on. The examination will be based on other SIP measures and examinations conducted by other parties.
- Then, examine the position reference method, the contents of the lane-specific information items to be provided, the encoding scheme, and others to embody the encoding method.
- In FY2020, how to create node link maps was examined based on the position reference method for superimposing lane-specific information on high-precision 3D maps.

2.4.2 Technology Assessment

■ Conversion to positionally representable data

- In the data flow from the probe provider to the vehicle, the combination of maps to be used is assumed to be as follows.
  - ➢ This section summarizes the issues to be addressed for future practical use in generating the necessary extended DRM and CRP maps.



Flow of conversion to positionally representable data

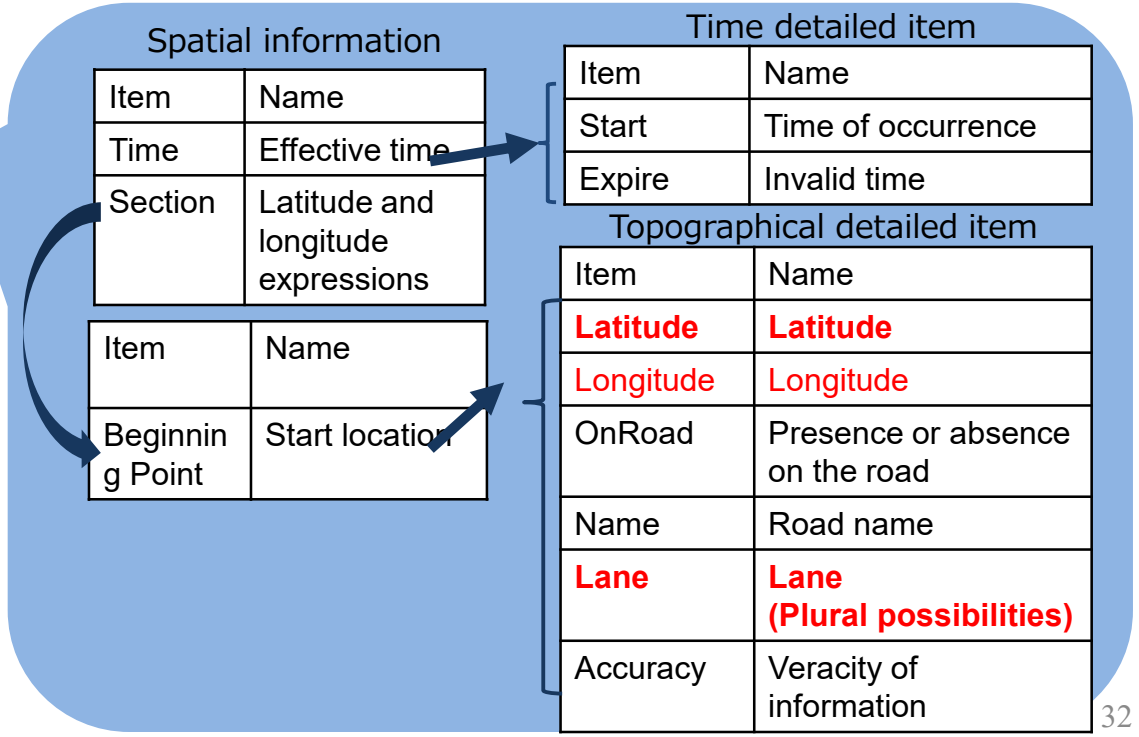
2.4.2 Technology Assessment

■ Data sharing (distribution) (Data Sharing Specification (Draft))

- JASPAR specification standards will be applied for data sharing between the centers when the generated information is distributed from the information integration and generation server to the servers of the Tokyo Waterfront Area Operational Test 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 classification for displaying the generated alert information is described by the latitude/longitude and lane of the point details item.

Image of message structure

Administration		**Management information**
Container	**Basic**	**Spatial information**
	Contents	Content body



2.4. Study and Evaluation of Lane-specific Information Distribution Technology

2.4.2 Technology Assessment

- Based on the results of the technology study, information by lane will be created using data expressions based on the definitions of the location reference method determined, and an interface will be implemented to exchange information between the probe data integration server for the verification experiment and the server for the experiment prepared by the Tokyo Waterfront Area Operational Test Consortium, and the appropriateness of using the technology will be evaluated. The details of the interface to be implemented will be decided in consultation with the Consortium.
- In FY2020, information by lane was created using data expressions based on the definition of the location reference method in accordance with the upgraded DRM, and an interface was implemented on the probe data integration server to exchange information with the server for the experiment of the Tokyo Waterfront Area Operational Test Consortium.

■Conversion to positionally representable data

○Development of data infrastructure for representing lane level road traffic information

- For the process of integrating and generating lane-specific traffic information, the road level map (DRM-DB in the demonstration experiment) and the high-precision 3D map are used as the source data to generate the data that organizes the number of lanes in the section every 100 meters.
- It is necessary to develop a data infrastructure capable of representing lane-specific positions and to establish a system for continuous updating.

2.4. Study and Evaluation of Lane-specific Information Distribution Technology

2.4.2 Technology Assessment

■ Data sharing (distribution)

○Data distribution specification

- Through the demonstration experiment, we clarified the issues with the current JASPAR specifications when distributing alert information.
- Although the current specifications do not specify the "congestion tail" as alert content, the "99: Others" marker number is used in the demonstration experiment to explicitly distribute information on the congestion tail.

→ Consideration will be given to assigning a special marker number for congestion tail information as needed.

○Data delivery processing time

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

3. Demonstration Experiment

3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

- A demonstration experiment is conducted to verify the technical study and evaluation of each element mentioned in 2 above.
- Create two types of node link maps for the demonstration experiment sections (Metropolitan Expressway Bayshore Route (from Daiba to Haneda Airport) and Metropolitan Expressway Haneda Line (from Shiodome to Airport West)), based on the definition of the position reference method representing the link map provided by the Japan Digital Road Map Association (hereinafter referred to as "DRM Association") and that provided by the Vehicle Information and Communication System Center (hereinafter referred to as "VICS Center") by lane and the definition of the position reference method based on the CRP setting specifications, which is being examined in the SIP Second Phase "Investigation and study on the Role of Common Reference Points (CRP) in High-precision 3D Maps."
- Regarding the collection of fallen objects in the relevant sections, since the existing system is in operation, develop another system for the experiment and deploy the necessary personnel so as not to affect the existing system.
- In FY2020, real-time probe information was procured through online connections from probe providers, and in cooperation with the Tokyo Waterfront Area Operational Test Consortium, a verification experiment was conducted to distribute lane by lane information to vehicles participating in the experiment in the above section. Two types of node-linked maps were prepared for the locations of the demonstration experiment, and the node-linked map based on the definition of the location reference method, which expresses the link map by lane, of the DRM Association and the Road Traffic Information and Communication Systems Center was used for the demonstration test. In addition, a questionnaire survey was conducted on the participants of the experiment to verify the effectiveness of lane-specific information.

3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

- Using probe information that can be obtained from commercial vehicles, generate and provide online alert information on congestion tails caused by the three use cases.
- Participants in the experiment will drive through the target section during the information provision period, receive and view the information, and answer a questionnaire.

***The recommended driving section begins at Route No.1 Haneda Line inbound Hamazakibashi JCT, where lane-specific congestion is likely to occur (between Heiwajima IC and Shiodome IC).**

① Information-delivery section

Range of the experimental section in the right figure

1) Sections recommended for driving

・ Route No.1 Haneda Line inbound (Heiwajima IC → Shiodome IC)

*Likely to receive alert information due to traffic congestion.

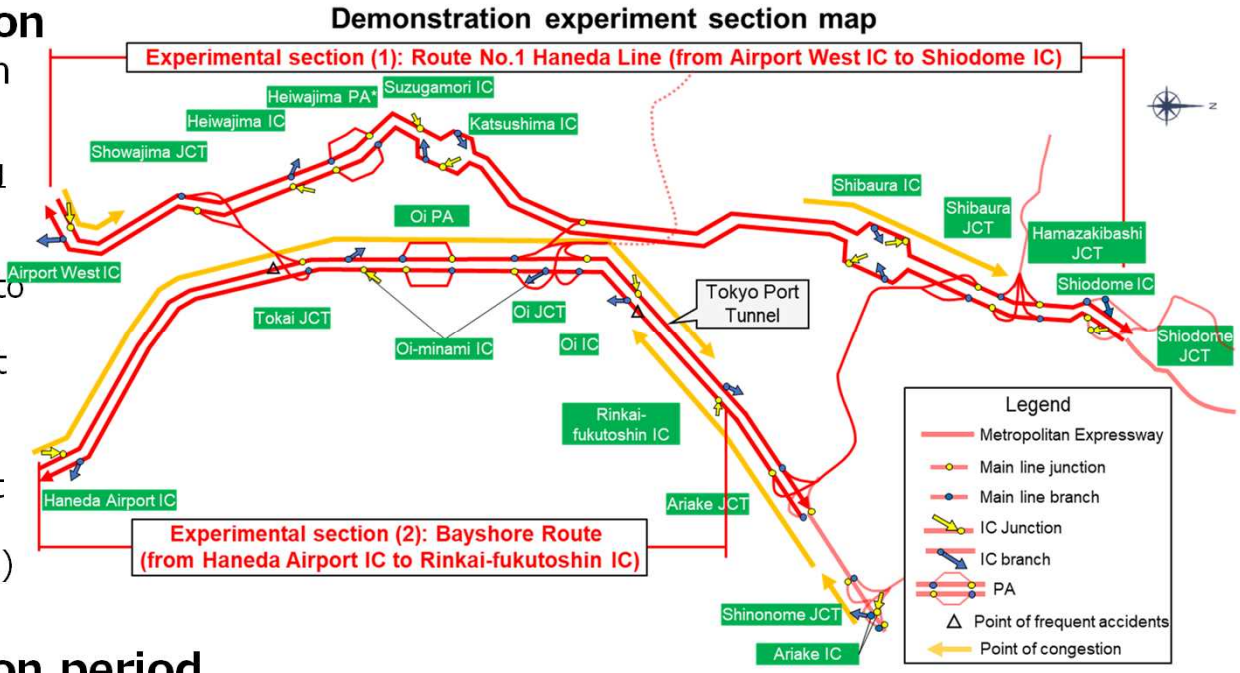
*Depending on the time of day, the alert information will be lane-specific.

2) Recommended times to drive

・The following times when you are most likely to receive alert information

Weekday morning (around 9-10 a.m.)

Weekday evening (around 3-5 p.m.)



② Online information provision period

- 10 weekdays from February 15 (Mon.) to 26 (Fri.), 2021
- **9 a.m. – 5 p.m.**

③ Information provided

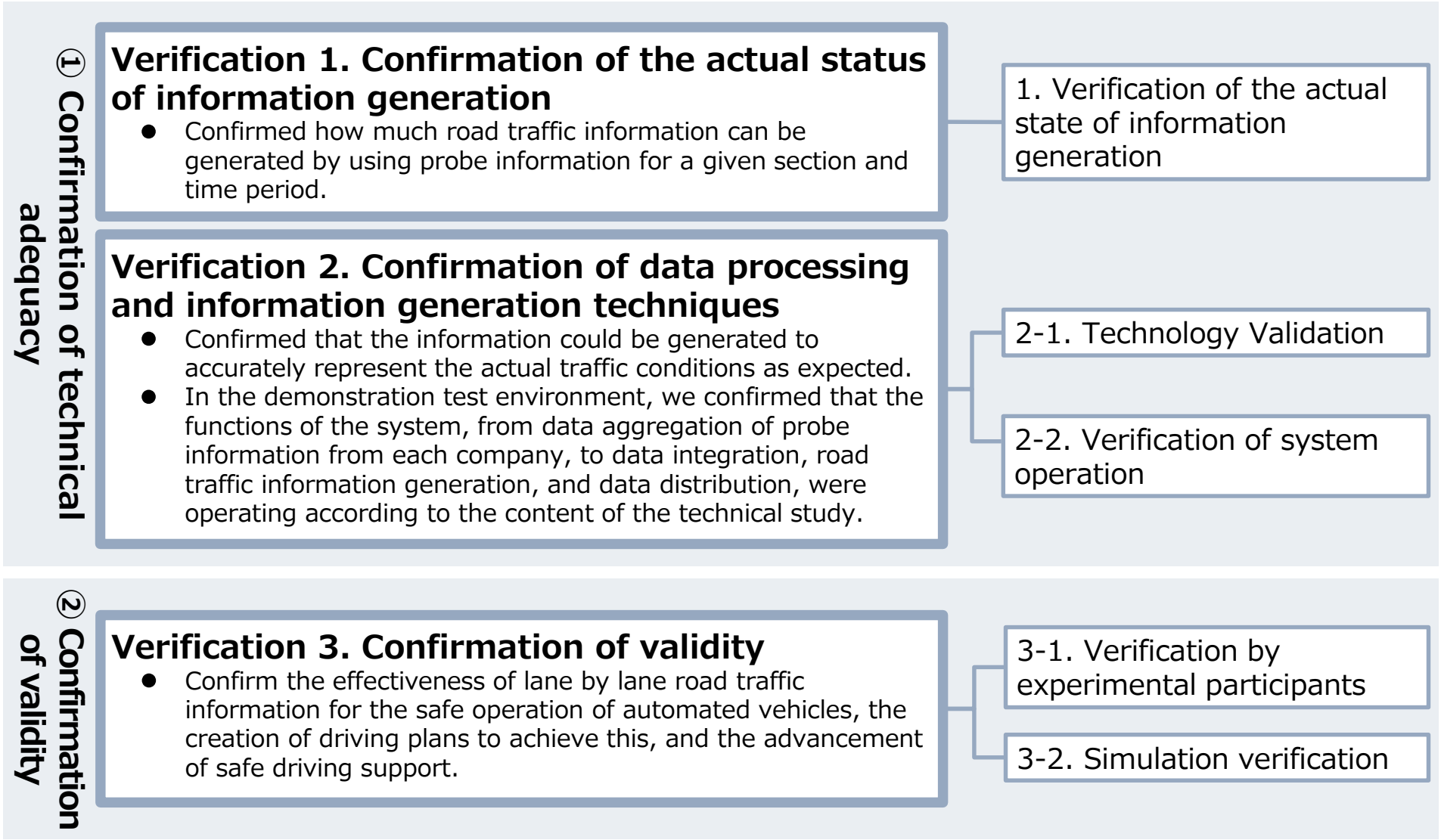
The following **alert information** is provided in **5-minute cycles**.

●"Congestion tail" position (in units of 100-m section)

*Some areas and times are **lane-specific**.

3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

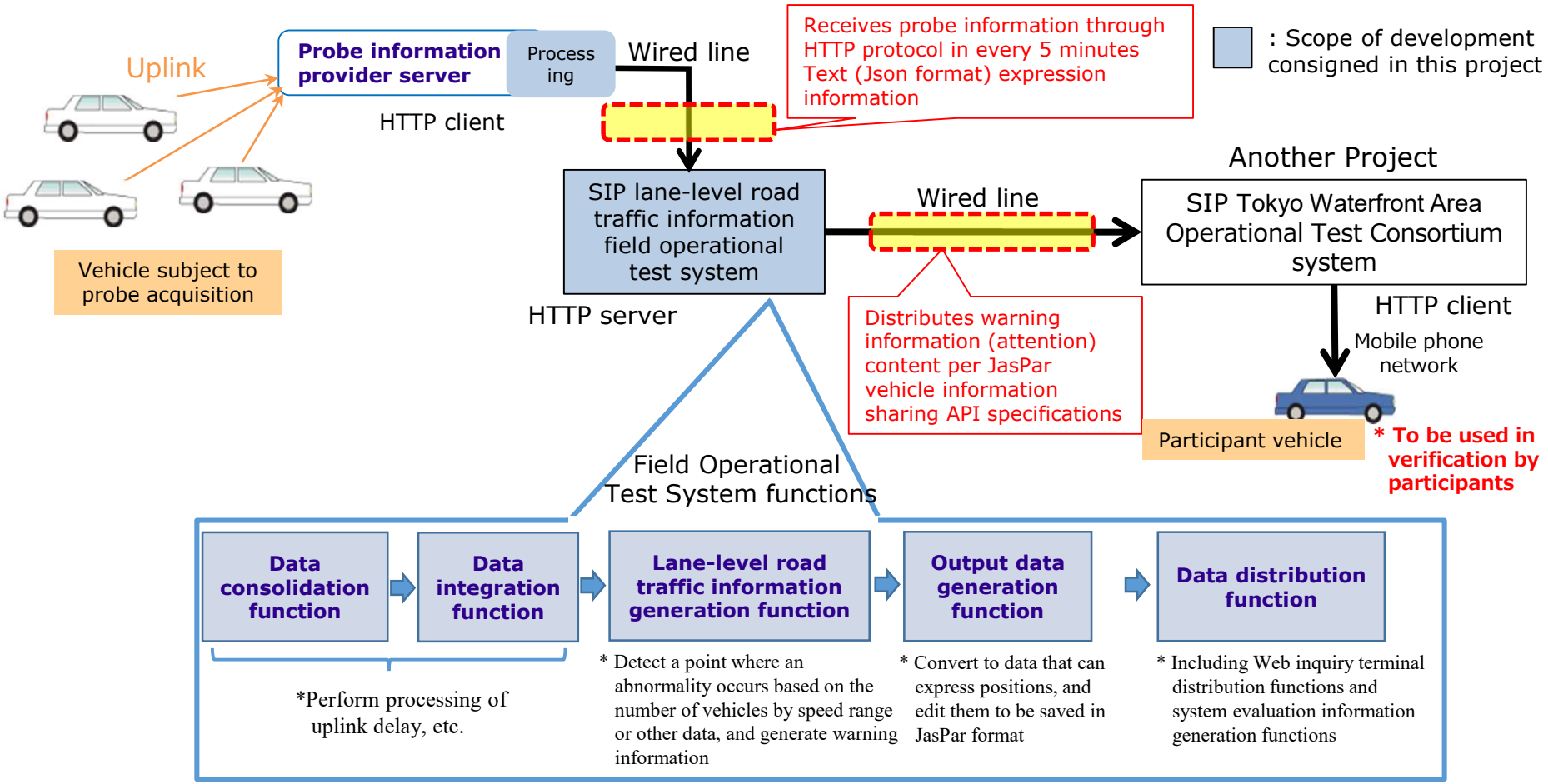
Verification policy in the demonstration experiment



3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

Configuration of Field Operational Test System

- Verify system operation, processing time, etc., and compile technical specifications.
- Participants in the experiment experienced delivery of information, and were asked to answer questions about the effectiveness and issues.

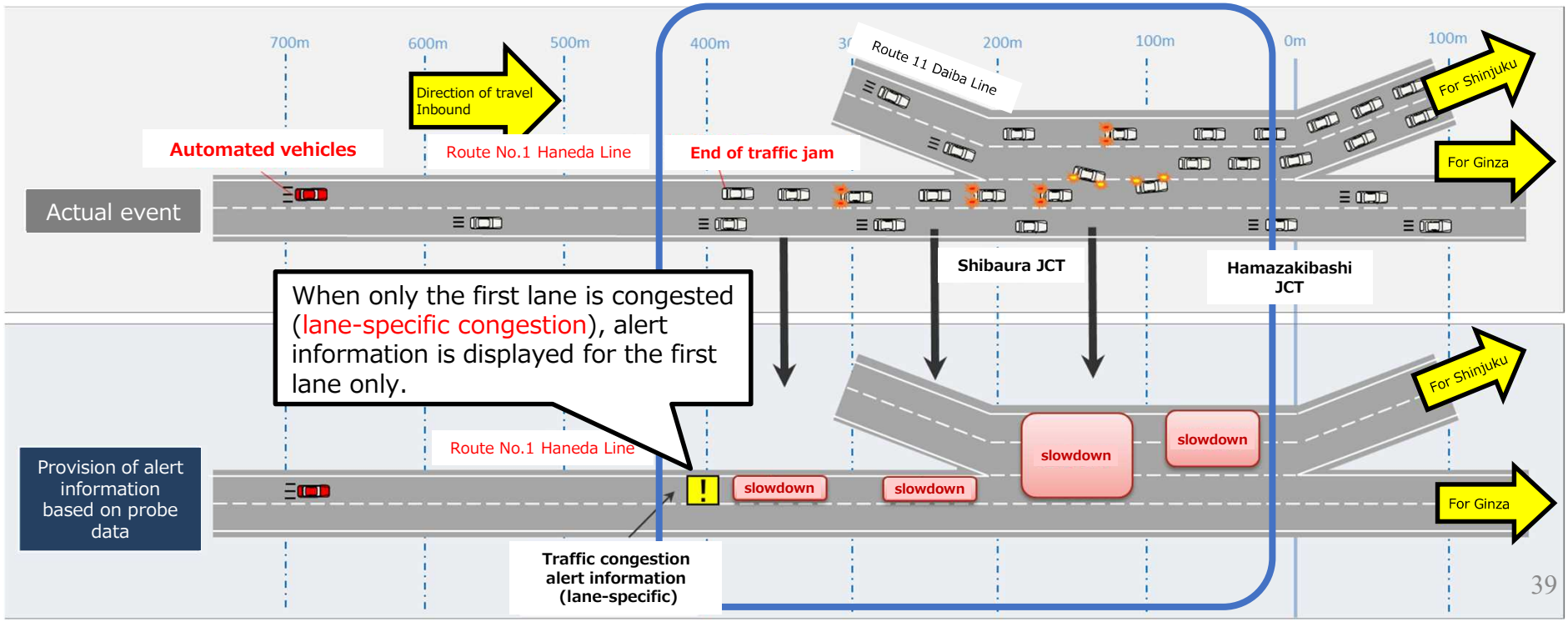


3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

Overview of traffic jam occurrence and information distribution in the main verification field

- On Route No.1 Haneda Line inbound, congestion always occurs on weekday mornings and evenings, with the Hamazakibashi JCT as the first stop.
- Because of the traffic congestion in the Shinjuku area, the congested queue overflows into the left lane of Route No.1 Haneda Line, and lane-specific congestion occurs depending on the time of day. Accordingly, it is positioned as a major verification field.
- Generate the location of the tail end of the traffic jam as alert information in 100-meter increments in 5-minute cycles.
- If the traffic jam is in the first lane only, alert information is displayed in that lane. If the traffic jam is in both lanes (cross-sectional traffic jam), the information is displayed in both lanes.

When only the first lane is congested

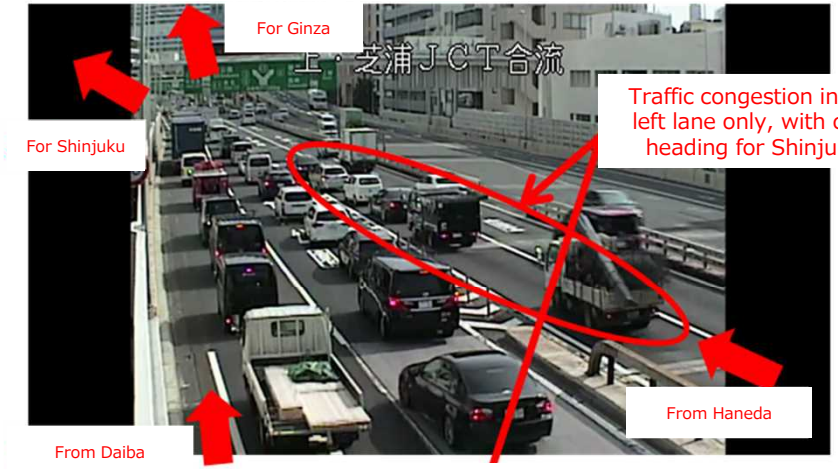


3.1. Examination of Demonstration Experiment Implementation Policy (Draft)

Traffic congestion by lane at Hamazakibashi JCT and image of information distribution

- When there is lane by lane congestion in the first lane of Route No.1 Haneda Line, the second lane is flowing with dense traffic and it is difficult to change lanes quickly when going straight toward Ginza.
- If you know the lane ahead of you in advance, you can change lanes in plenty of time.

Lane-specific traffic congestion near Shibaura JCT confluence



Running image

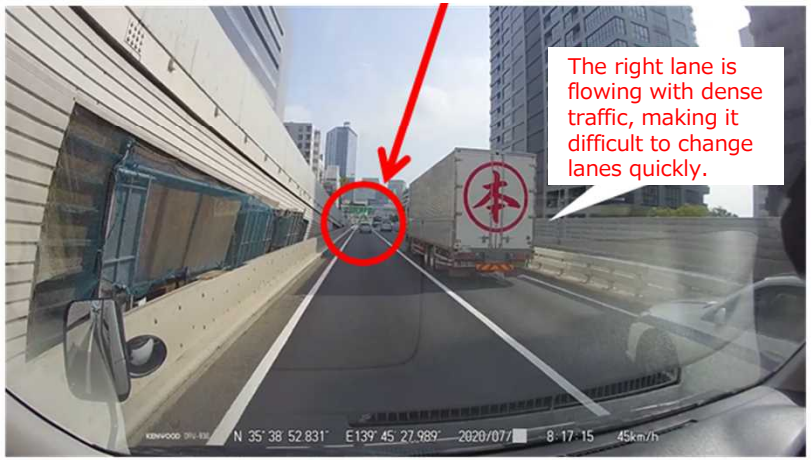
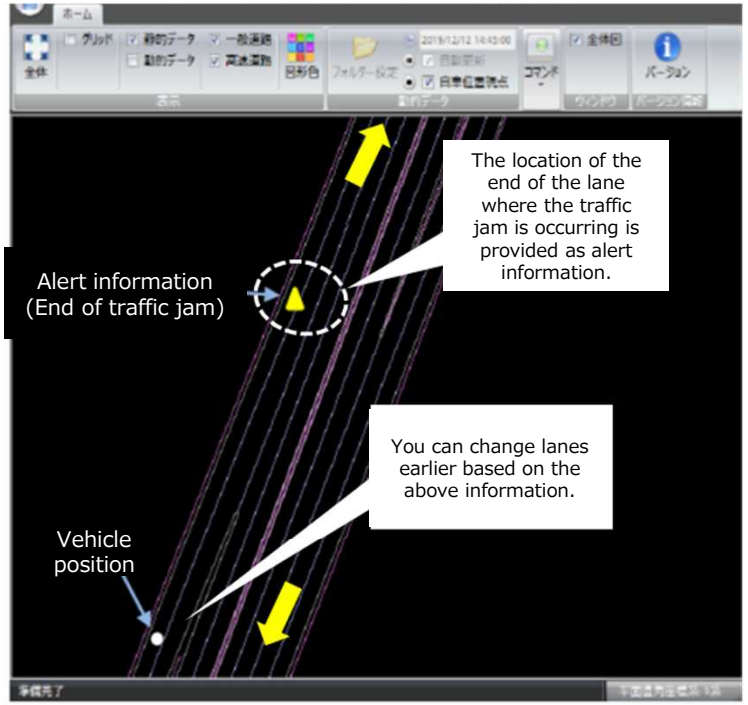


Image of displaying lane level road traffic information on a high-precision 3D map (example of in-vehicle viewer display)



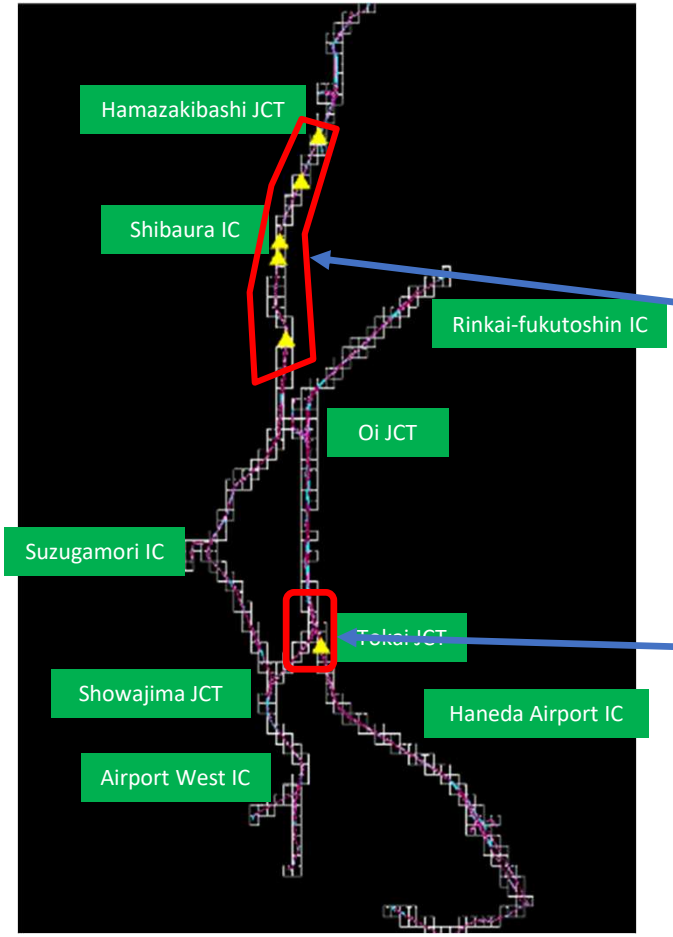
3.2. Outline of implementation of the demonstration experiment

Status of distribution of alert information during the demonstration experiment

- Morning congestion on Wednesday, February 24: The viewer display shows that the traffic situation generally corresponds to that day's traffic situation.

Wednesday, February 24, 2021 9:30

Delivery information viewer display

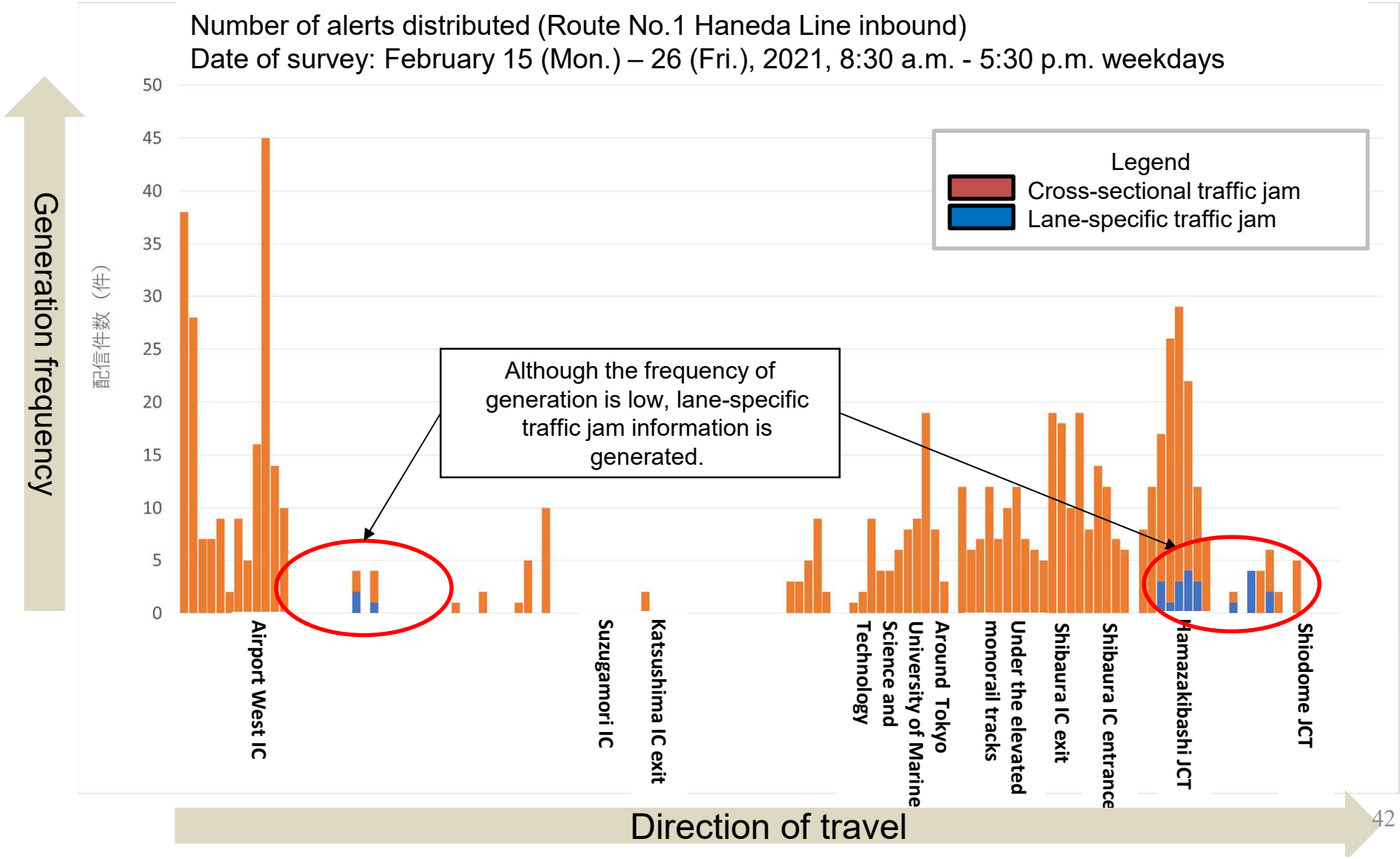


JARTIC Traffic Information

*From JARTIC website

Frequency of distribution of alert information (by content) during the demonstration experiment

- Looking at the points where alert information is generated on Route No.1 Haneda Line inbound, information is generated according to the location of the tail end of traffic congestion, and a lot of lane-specific traffic congestion information is generated near Hamazakibashi JCT.



3.3. Efficacy evaluation by experiment participants

Mode of participation in the experiment by experiment participants (questionnaire respondents)

- A total of 11 companies responded to the questionnaire regarding the evaluation of the effectiveness of delivered information.
- Five respondents received the delivered information during actual driving, and two received it in the laboratory.
- The number of times each company drove the actual route ranged from 2 to 13 times. Of these, the number of times that the delivered information could be compared with actual traffic conditions ranged from 1 to 8 times.

Participation of survey respondents in the experiment

Form of participation		Number of participants
①	Participation in online distribution experiment (Receiving during actual driving on the expressway)	5 companies
②	Participation in online distribution experiments (Reception in the laboratory)	2 companies
③	Viewing of handout video materials only	3 companies
④	Answered questionnaire only	1 companies
Total		11 companies

Driving conditions in the experimental section

Participants in the experiment	Number of days traveled	Number of trips	Number of times of checking delivered information	Number of times compared to actual traffic conditions
A	2 days	9 times	8 times	8 times
B	1 day	2 times	1 time	1 time
F	3 days	9 times	4 times	4 times
G	4 days	13 times	9 times	6 times
H	2 days	2 times	2 times	2 times

*Traveling sections were Route No.1 Haneda Line inbound and outbound.

3.3. Efficacy evaluation by experiment participants

Summary of questionnaire contents and results (preliminary report)

*In the future, the reasons for the responses will be confirmed, cross-analyzed, and cross-checked with the driving images.

Questionnaire A
(Answer for each trip)

- Date and time of travel
- Degree of agreement between delivered information and actual event

Congestion tail with lane-specific location information
⇒Match + Slight match = 44%

Questionnaire B
(Answer based on all runs)

- Regarding questions that contribute to path planning for automated vehicles (level 3 and above)

① Valid + Somewhat valid
= 54% (I'm not sure, 27%)

② How far in advance do you need the information?
⇒200m–2km
③ Location accuracy of required information (direction of travel)
⇒100–300m
④ Update cycle for necessary information
⇒1–2 minutes

*All of these answers are for intra-city highways.

⑤⑥⑦ Congestion tail position
⇒Necessary + Somewhat necessary= 82–91%
⑤⑥⑦ Congested traffic section
⇒Necessary + Somewhat necessary= 72–81%
⑤⑥⑦ Location of obstacle itself
⇒Necessary + Somewhat necessary= 63–73%

- Regarding questions that contribute to path planning for drivers (automatic driving level 2 and below)

① Validity of information

Comparison

⑧ Validity of information

Service requirements
⑨ Timing
⑩ Positional accuracy
⑪ Update cycle

Service requirements (by intra-city/inter-city expressway)
② Timing
③ Positional accuracy
④ Update cycle

Comparison

Information needed and why
⑤ Congestion tail
⑥ Traffic accident
⑦ Lane regulation

⑫ Improvements for practical use

⑨ How far in advance do you need the information?
⇒200m–2km
⑩ Location accuracy of required information (direction of travel)
⇒50–500m
⑪ Update cycle for necessary information
⇒1–5 minutes

*All answers are for intra-city highways.

Questionnaire structure and summary of results

4. Investigation and verification of elemental technologies using quasi-dynamic level look-ahead information

- The following is a summary of the information sources that may be utilized as quasi-dynamic level look-ahead information, as well as a study of the applicability to lane-specific information generation.
- In addition, we will verify whether it is possible to estimate the lane from past data of the probe statistics to be collected using the records of accidents, etc. in the traffic control information as dummy data.
- In FY2020, the sources of warning information (operators) and available information items were organized.