“Strategic Innovation Promotion Program (SIP)
Third Phase / Development of the smart mobility platform /
Research and development of a general traffic signal information provision platform using V2N”

Progress Report for Fiscal Year 2023

OMRON Social Solutions Co., Ltd.
NIPPON SIGNAL CO., LTD.
Panasonic Connect Co., Ltd.
UTMS Society of Japan

March 2024

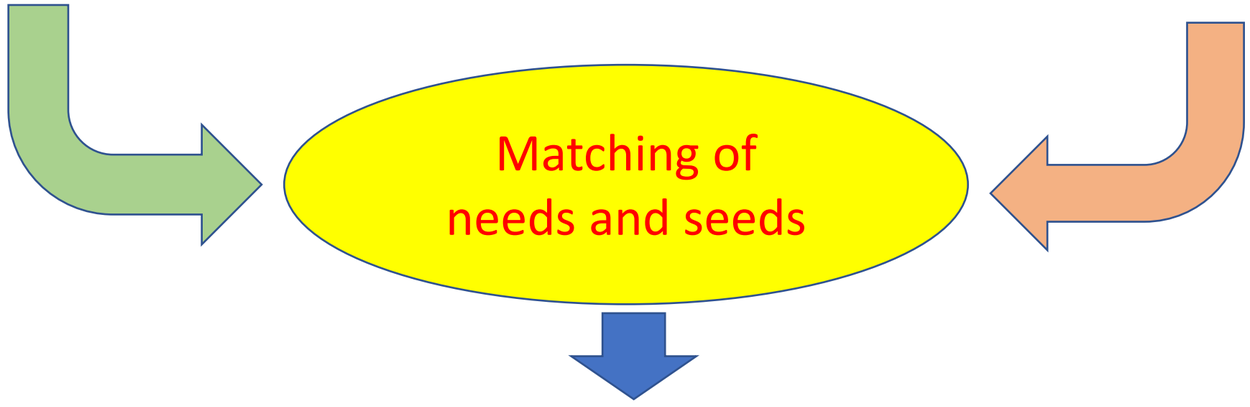
Contents

1. Background and objective

[Background]

- Many of Japan's traffic fatalities are among so-called vulnerable road users (pedestrians and bicyclists), and further strengthening of safety measures at intersections is an issue.
- From a carbon-neutral perspective, it is also an urgent need to ensure smooth passage at intersections.
- In Japan, the diversification of mobility is expected, including the spread of delivery robots and micromobility.

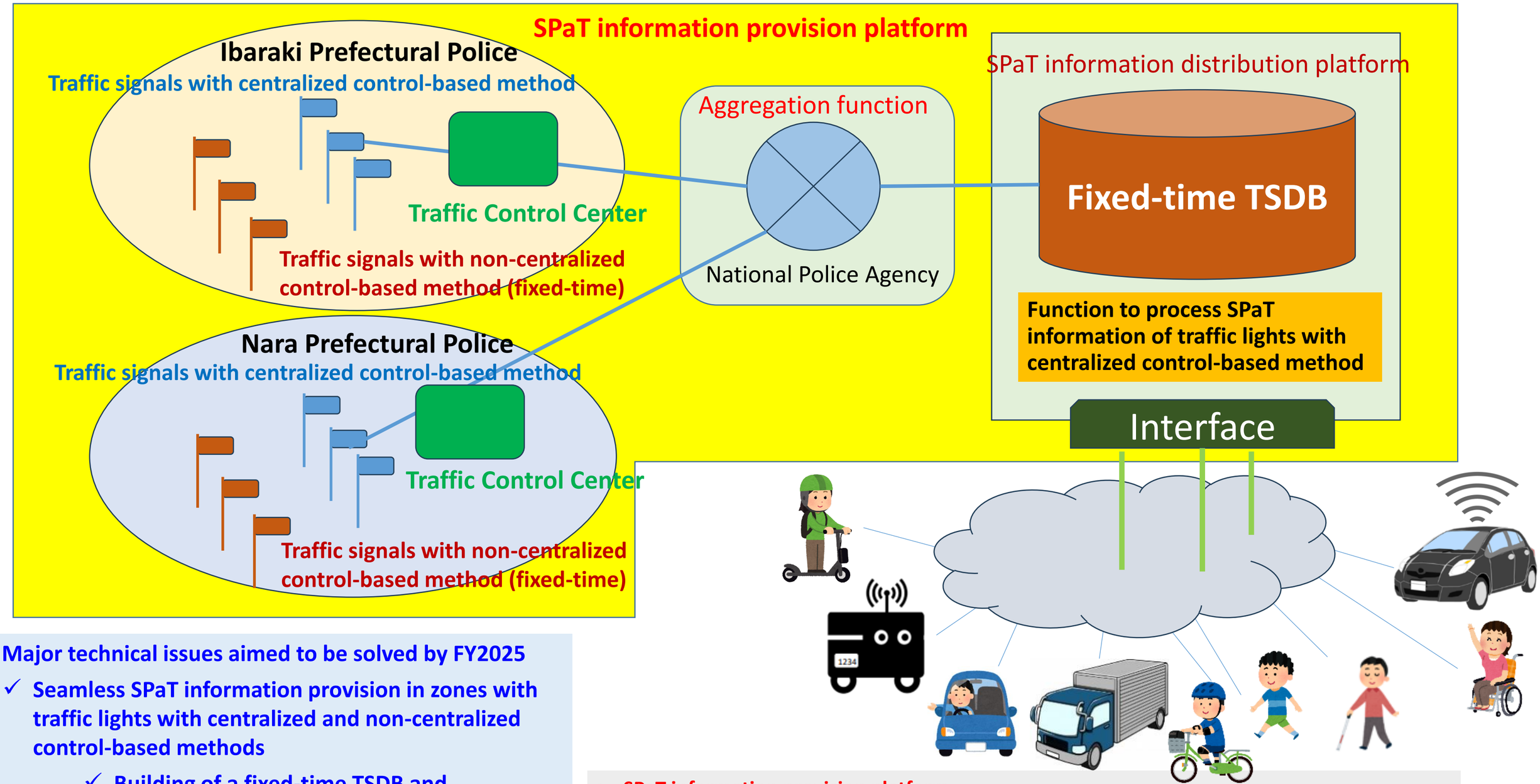
- In the second phase of the SIP Program, research and development were conducted on V2N-based traffic signal information [hereafter SPaT(signal phase and timing) information] provision technology for automated vehicles, and certain results were obtained.
- By utilizing this technology, it is possible to improve safety and smoothness of various types of mobility in addition to automated vehicles, such as driver-operated vehicles, pedestrians, bicycles, delivery robots, and micromobilities, according to their respective situations.



[Objective]

As part of the "realization of a society without a mobility divide where everyone, goods and services can move freely, independently, safely, comfortably, and in a way that is friendly to the environment, other people, and the community," which is one of the objectives of the third phase of the SIP Program, we will establish V2N-based traffic signal information provision technology in a form that can be applied to various types of mobility, and implement this technology in society by building a platform for providing traffic signal information.

2. Overall overview of the research and development



- **Major technical issues aimed to be solved by FY2025**
  - ✓ **Seamless SPaT information provision in zones with traffic lights with centralized and non-centralized control-based methods**
    - ✓ **Building of a fixed-time TSDB and development of measures to ensure its accuracy**
  - ✓ **Building of a SPaT information provision platform**
    - ✓ **Establish operations across multiple prefectures**
    - ✓ **Building of interfaces**
  - ✓ **Response to needs related to various mobility options**

- **SPaT information provision platform**

An integration of traffic lights, the control center, aggregation function, and SPaT information distribution platform

- **SPaT information distribution platform**

A system that serves as a common infrastructure for signal information distribution, equipped with a fixed-time TSDB, SPaT information processing functions for traffic lights with the centralized control-based method, and interfaces for providing such information.

- **Fixed cycle TSDB (Traffic Signal information Database)**

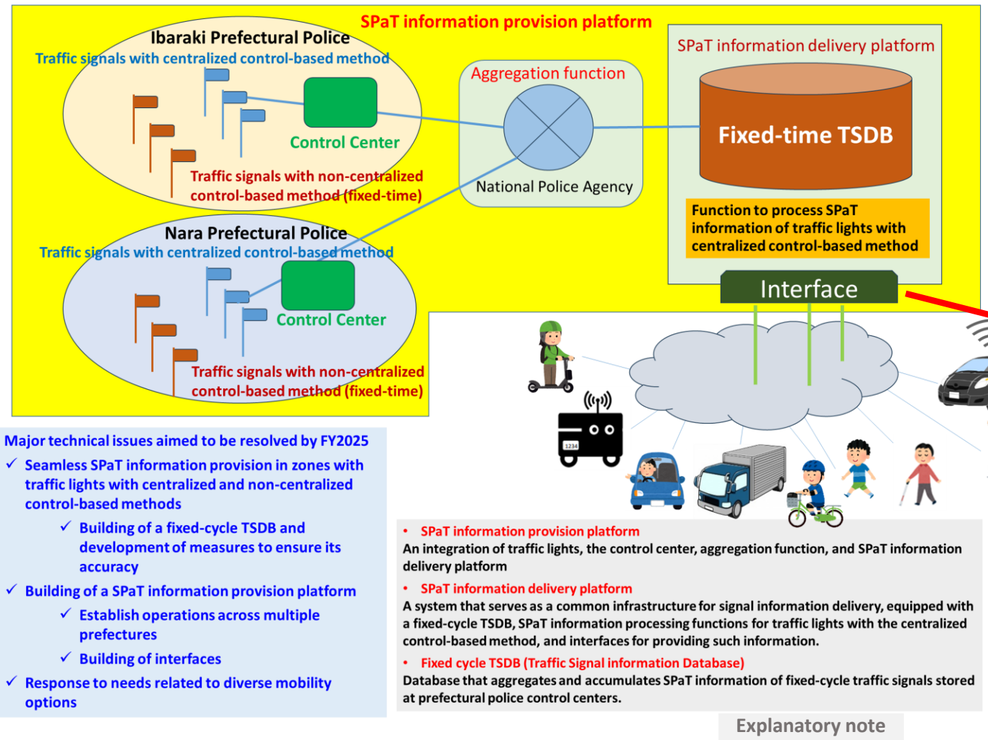
Database that aggregates and accumulates SPaT information of fixed-time traffic signals stored at prefectural police control centers.

2. Overall overview of the research and development

☐ Collaboration with other consortium (Collaboration with the Nippon Signal consortium)

Provide various types of traffic information distributed by Ibaraki prefectural police and Nara prefecture Police through collaboration between the platforms

UTMS Society of Japan Consortium Platform

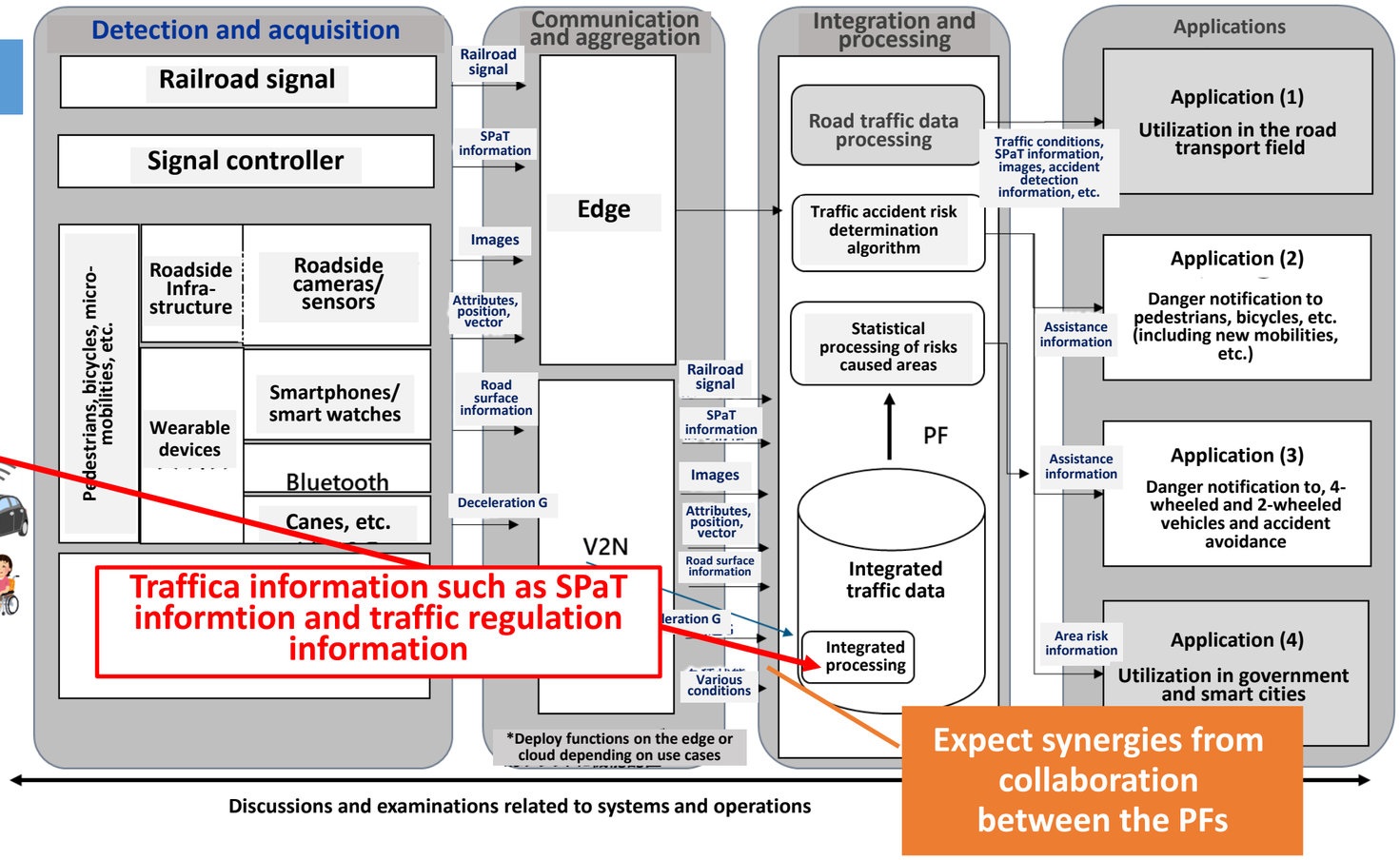


- Major technical issues aimed to be resolved by FY2025
  - ✓ Seamless SPaT information provision in zones with traffic lights with centralized and non-centralized control-based methods
    - ✓ Building of a fixed-cycle TSDB and development of measures to ensure its accuracy
  - ✓ Building of a SPaT information provision platform
    - ✓ Establish operations across multiple prefectures
    - ✓ Building of interfaces
  - ✓ Response to needs related to diverse mobility options

- **SPaT information provision platform**
  An integration of traffic lights, the control center, aggregation function, and SPaT information delivery platform
- **SPaT information delivery platform**
  A system that serves as a common infrastructure for signal information delivery, equipped with a fixed-cycle TSDB, SPaT information processing functions for traffic lights with the centralized control-based method, and interfaces for providing such information.
- **Fixed cycle TSDB (Traffic Signal information Database)**
  Database that aggregates and accumulates SPaT information of fixed-cycle traffic signals stored at prefectural police control centers.

Explanatory note

Nippon Signal Consortium Platform



[Demarcation]

(Objective Difference)

- The purpose of the UTMS Society of Japan Consortium is to confirm that reliable SPaT information can be provided using the V2N method to a wide variety of mobility and platforms.
- The purpose of the Nippon Signal Consortium is to confirm that it can support the improvement of mobility safety in specific use cases by utilizing the provided SPaT information, etc.

(Assignment of work execution)

- The UTMS Society of Japan Consortium will conduct the work related to the prefectural police, which is the source of SPaT information generated by the V2N method.
- For parts other than the above, each will be responsible for system construction within their respective platforms. The common parts, such as the cost of the line connecting the two platforms, will be divided proportionally through future discussions.

3. List of sub-themes

[Organizations in charge of each sub-theme]

No.	Name of sub-theme	Organizations in charge
1	**Research and development of low-cost SPaT information generation technology for fixed-time traffic signals**	**OMRON SOCIAL SOLUTIONS Co., Ltd.**
2	**Research and development of practical application technology for V2N-based SPaT information**	
3	**Research and development of I/F standardization that enables smooth distribution of SPaT information from the platform to various types of mobilities**	**NIPPON SIGNAL CO., LTD.**
4	**Research and development on the seamless SPaT information distribution in zones with various types of traffic signals, including those of centralized and non-centralized control systems**	
5	**Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information**	**Panasonic Connect Co., Ltd.**
6	**Research on diversified needs of the SPaT information provision platform, etc.**	**UTMS Society of Japan**

4. Roadmap

Research items will be carried out from FY2023 to FY2025 to confirm the establishment of necessary technologies through feasibility demonstration experiments. In FY2026 and FY2027, various types of mobilities will be involved as users to practically verify the effectiveness of the SPaT information provision platform in comprehensive demonstration experiments. Specifically, research and development will be carried out under the six sub-themes described in Section 5.

Fiscal year		2023	2024	2025	2026	2027
Sub-theme No.	**Overall**	Concept	Feasibility demonstration experiment preparation	Feasibility demonstration experiment implementation	Comprehensive demonstration experiment implementation	
1	Fixed-time TSDB	Technology research, design	Implementation	Verification	Improvement design	Verification of improved version
2	SPaT information practical application technologies V2N-PICS technologies	Technical issue examination, etc. Requirements examination, design	Application implementation for verification	Verification of SPaT information provision platform Verification	Improvement design	Verification of improved version
3	Requirement definition for each mobility Improvement of advanced PICS Equipment, simulated terminals	Needs survey Preparation of draft revisions of specifications and standards	Requirement definition, IF specification definition Production and on-premise demonstration	Feasibility demonstration experiments	Comprehensive demonstration experiments	
4	SPaT information provision technical issues Equipment, simulated OBU	Issue identification, experiment specification examination	Experiment preparation Production and on-premise demonstration	Feasibility demonstration experiments	Comprehensive demonstration experiments	
5	Fixed-time TSDB New provision interface Expansion of SPaT information provision destinations	Development of fixed-time SPaT information generation technology International standardization trend survey, new I/F design Examination of requirement specification for low-speed mobilities	Building of SPaT information distribution platform for various types of mobilities			
6	Needs survey Comprehensive demonstration experiments	Needs survey on various mobilities		Experiment preparations	Operation of demonstration experiments	

5. Research and development results for FY2023

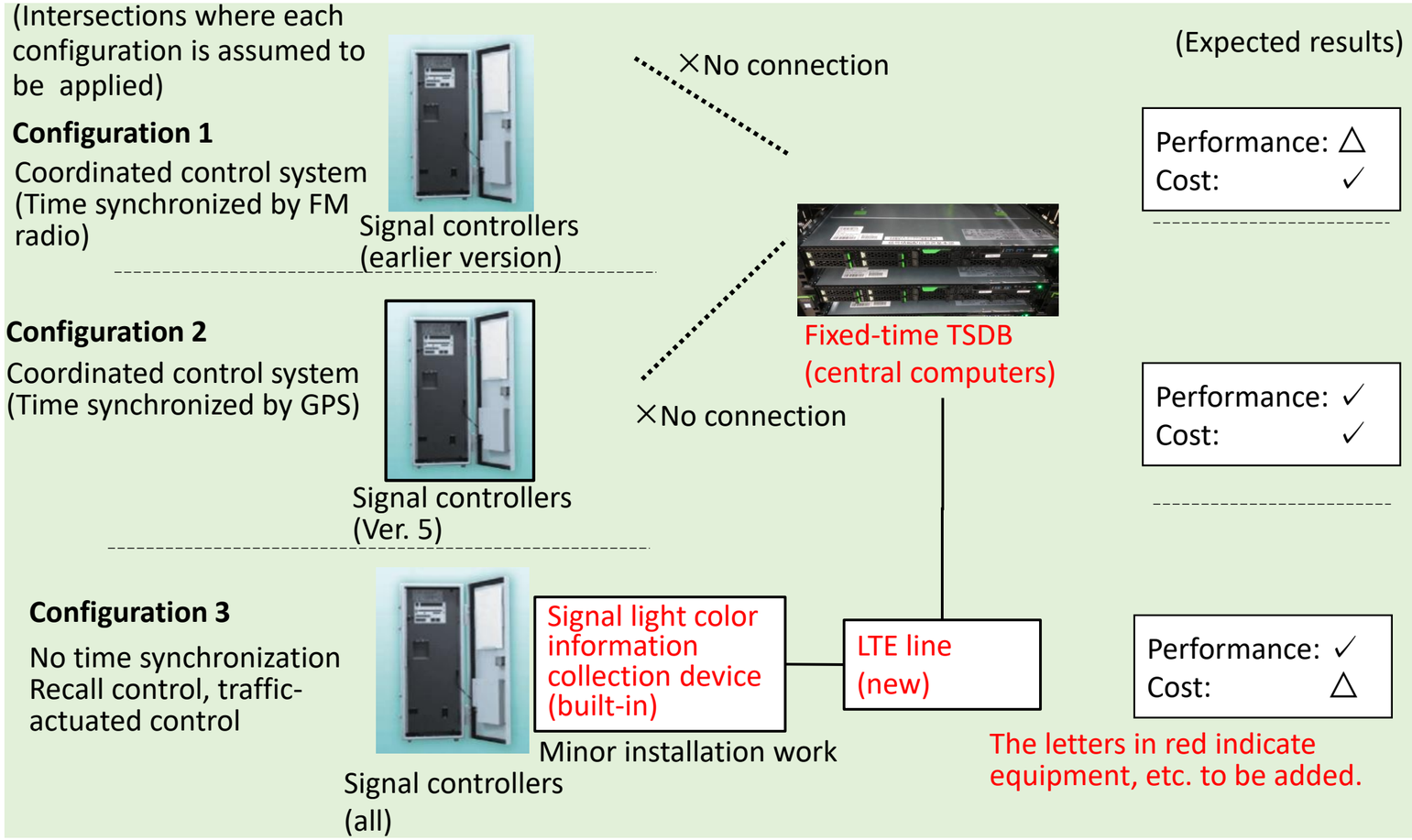
5.1. Sub-Theme 1 "Research and development of low-cost SPaT information generation technology for fixed-time traffic signals"

5.1.1 Outline

Of the approximately 210,000 traffic signal controllers installed at intersections throughout Japan, approximately 70% are fixed-time traffic signals that are not connected to traffic control centers. In the 2nd Phase of SIP, the controller-based method, which provides SPaT information of fixed-time traffic signals was examined, but cost issues have been pointed out in its practical application. Therefore, in Sub-theme 1, research and development will be conducted on a new method that can provide SPaT information at a lower cost and with constant accuracy.

Three configurations will be examined based on the type of fixed-time traffic signals and their control details. The configurations 1 and 2 are assumed to be applied at intersections that implement coordinated control and have a time synchronization function. Although there are differences in time accuracy, these two configurations have in common that a line between the signal controller and the traffic control center is not required and that the fixed-time TSDB installed at the traffic control center generates SPaT information based on predetermined information.

The configuration 3 is assumed to be applied at intersections that do not have time synchronization function or where the signal light color changes due to external factors such as recall control and traffic-actuated control. A signal light color information collection device installed at the intersection is connected to the traffic control center via a line, and the fixed-time TSDB creates SPaT information based on the collected signal light color information.



Configuration diagram of generating SPaT information of fixed-time traffic signals

<Term explanation>

Coordinated control system: A control system that provides difference in green start times at adjacent intersections to allow smooth passage through each intersection.

Recall control system: A control system in which the signal on the main road is always set to green, and the signal on the subsidiary road is turned green only when a vehicle is detected or when a pedestrian pushes the button on the signal pole.

Traffic-actuated control system: A control system that truncates or extends green time in response to changes in traffic demand during a short period of time by using vehicle detectors, etc.

The old version of the signal controller : Control is performed at 1 second intervals, and uses FM radio for time synchronization.

Signal Controller Version 5: Control is performed at 0.1 second intervals, and GPS is used for time synchronization.

5.1. Sub-Theme 1 "Research and development of low-cost SPaT information generation technology for fixed-time traffic signals"

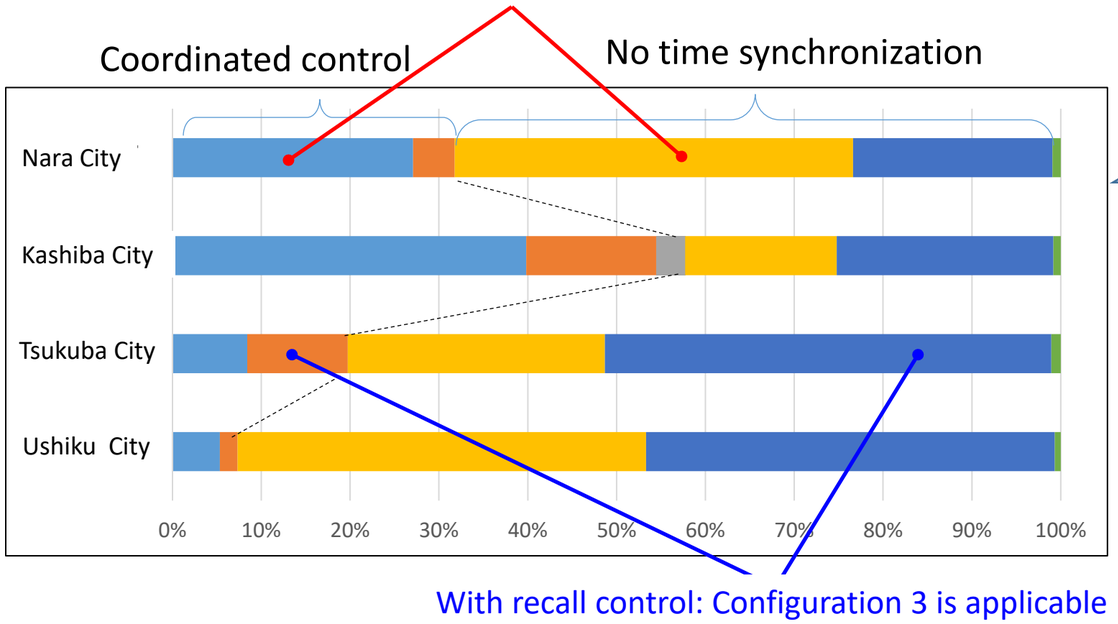
5.1.2. Results

The necessary survey for the design of a fixed-time TSDB was carried out and a draft specification for a fixed-time TSDB was prepared.

1) Results of survey on the state of installation of fixed-time traffic signals.

In order to assess the cost reduction effects of the three proposed configurations, four regions were surveyed to determine which configurations could be applied. Although there is variation between regions, it is expected that Configurations 1 and 2 will be applicable to between 37% and 72% of all fixed-time traffic lights in each region, and Configuration 3 will be applicable to between 28% and 63%.

Those with no special control system: Configuration 1 or 2 is applicable
(It is assumed that controllers that are not time-synchronized will be replaced with those with a coordinated control system and with GPS time synchronization when the signal controllers are updated).



The composition ratio varies widely by region.
→It is important to budget installation costs for each installation area, taking the composition into consideration.

Legend:
- Coordinated control, without special control
- Coordinated control, with recall control
- Coordinated control, with traffic-actuated control
- No time synchronization, no special control
- No time synchronization, with recall control
- No time synchronization, with traffic-actuated control

Results of survey on the state of installation of fixed-time traffic signals

2) Results of time accuracy survey of fixed-time traffic signals

For Configurations 1 and 2, the time accuracy of the signal controller affects the accuracy of the SPaT information. Configuration 2 is time-synchronized by GPS, and the specification stipulates that the time accuracy must be within ±0.1 second. On the other hand, Configuration 1 is time-synchronized by FM radio time signals, etc., but the specifications do not specify the time accuracy. Therefore, we surveyed nine intersections taking Configuration 1 and confirmed that the time error is as small as ±1 second or less. Based on this, we set the target SPaT information accuracy to within ±1 second for Configuration 1 and within ±0.3 seconds for Configuration 2.

5.1. Sub-Theme 1 "Research and development of low-cost SPaT information generation technology for fixed-time traffic signals"

5.1.2. Results

3) Offset tracking survey

Fixed-time traffic signals are designed to change signal cycles to a predetermined pattern depending on the time of day. At fixed-time intersections under coordinated control, the lag times between green start times (offset) at adjacent traffic signals is adjusted (offset tracking) over a maximum of five signal cycles at the timing of the signal cycle changes. However, this operation varies depending on signal controller manufacturers and signalized intersections; therefore, it was determined that it would be difficult to create a pattern based on some kind of rules in accordance with the operating principles of signal controllers. As a result, it was concluded that the past operating history should be used, on the assumption that the same offset-tracking operation is performed on the same day categories and during the same times.

4) Evaluation of methods for confirming SPaT information

In Configurations 1 and 2, SPaT information is generated based on information such as signal cycles predetermined by the fixed-time TSDB, which is not connected to signal controllers, which means this SPaT information does not reflect the actual operating status of signal controllers at that point in time. Therefore, we tried an indirect method to check whether there is any time lag between the actual signal light color information and the SPaT information, based on the consistency between the signal light color and the time when vehicles passed the stop line calculated from the probe information obtained from traveling vehicles. At intersections where probe information was obtained from a sufficient number of passing vehicles, the signal light color when vehicles passed the stop line was either green or yellow, and although it was not possible to confirm to the point where whether there is not a second-by-second time lag between the actual signal light color and the SPaT information, it was confirmed that there was a certain degree of consistency. In the future, we will continue to examine methods of confirming SPaT information at locations where probe information cannot be obtained from a sufficient number of passing vehicles.

5) Preparation of draft specifications for the fixed-time TSDB

The main functions of the fixed-time TSDB are as follows:

For intersections where Configuration 1 or Configuration 2 is applied, the fixed-time TSDB edits SPaT information immediately after the start of a cycle using the current time and various set values, and transmits the edited information to the SPaT information distributor.

For intersections applying Configuration 3, the fixed-time TSDB edits SPaT information based on the signal light color change information received from the signal light color change information collecting unit immediately after the start of the cycle and after determining that a recall phase was implemented, and then transmits the edited SPaT information to the SPaT information distributor.

The light color change information collecting unit monitors a signal light color change and transmits the time and signal light color information to the fixed-time TSDB when the signal light color changes.

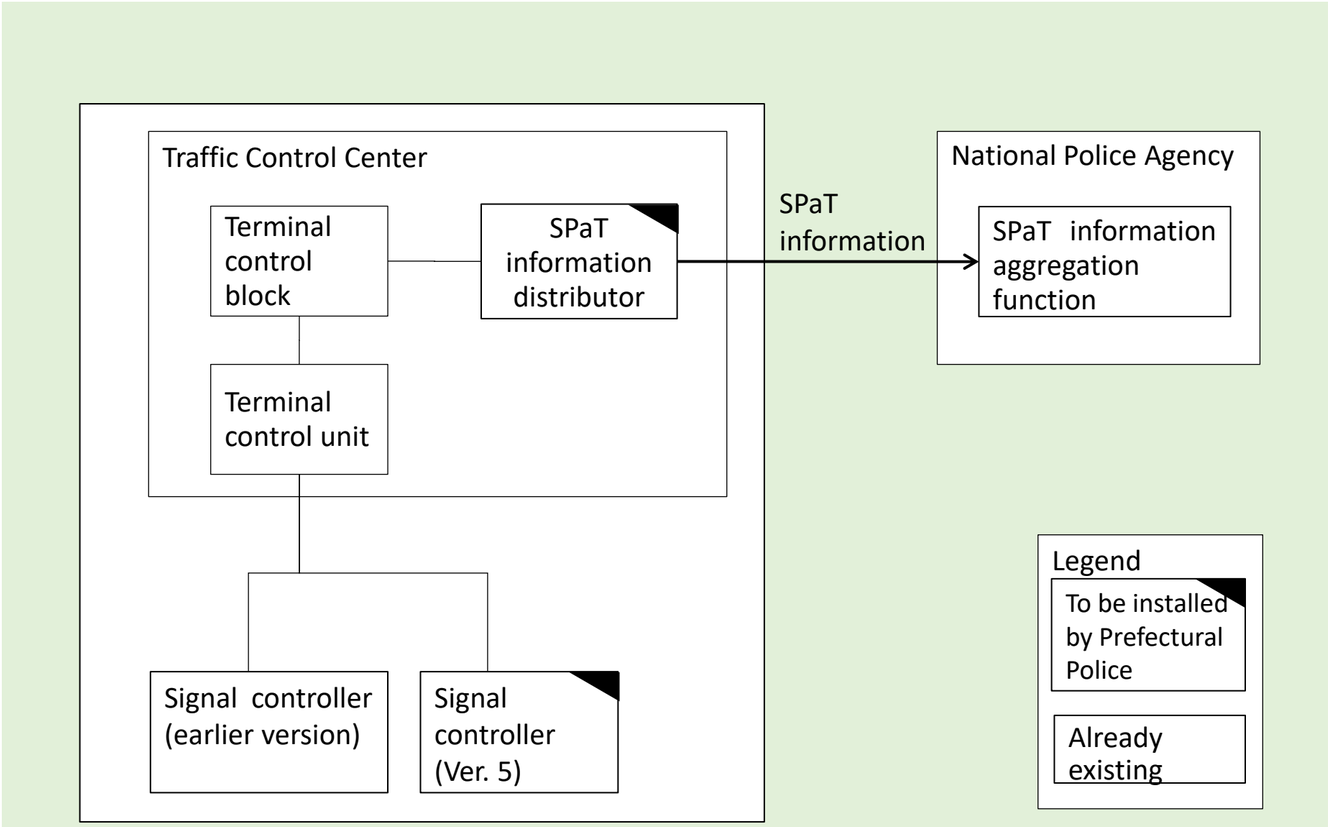
5.2. Sub-theme 2 “Research and development of practical application technology for V2N-based SPaT information”

5.2.1 Outline

Sub-Theme 2 focuses on the development of technology for generating SPaT information on the traffic control center side. Specifically, issues identified in the demonstration experiments of the SIP 2nd Phase will be addressed to revise the SPaT information distributor specifications and the SPaT information provision common message standards.

Afterwards, using these revised specifications and standards, a SPaT information distributor will be installed in the Ibaraki Prefectural Police Traffic Control Center to provide SPaT information in specific areas in order to verify its use in automated driving and new use cases in the actual field. In this Subtheme, before verifying each use case, the SPaT information itself transmitted from the traffic control center to the National Police Agency will also be verified.

As a new use case other than for automated driving, we will verify whether it is possible to use SPaT information transmitted by the V2N method to assist pedestrians in crossing the street using a smartphone, by using the advanced PICS as a reference. Through this verification, the necessary information, functions, and operational issues for new use cases of SPaT information other than for automated driving will be identified.



System configuration diagram on the Traffic Control center Side

5.2. Sub-theme 2 “Research and development of practical application technology for V2N-based SPaT information”

5.2.2 Results

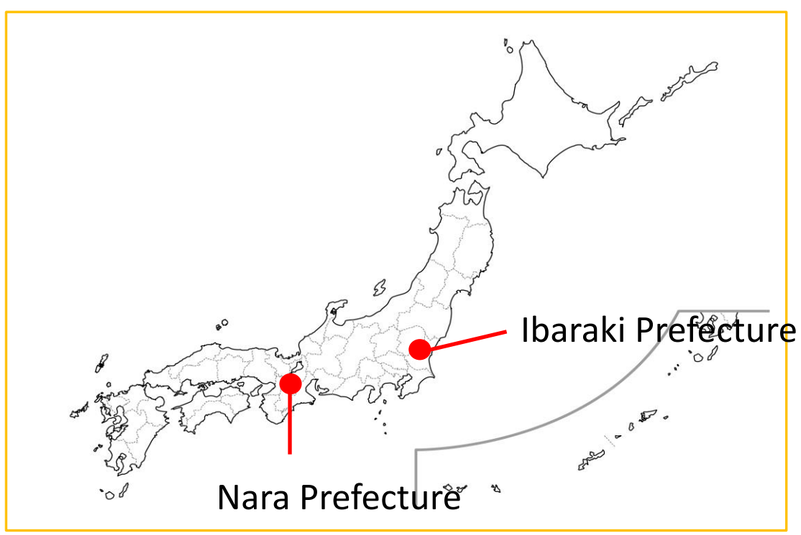
The following three items were carried out as the design phase for the building of the SPaT information provision platform.

1) Requirement definition for the SPaT information provision platform demonstration experiment

Requirement definition was conducted to verify the SPaT information provision platform itself and to select locations to conduct experiments for use cases that use SPaT information distributed by the V2N method, in preparation for the feasibility demonstration experiment and the comprehensive demonstration experiment scheduled in the SIP 3rd phase.

As tentative plans for use cases, in addition to the automated driving use case, four new use cases were selected: (1) vehicle driving assistance to drivers, (2) assistance to pedestrians in crossing signalized intersections, (3) assistance to unmanned delivery robots in passing through intersections, and (4) assistance to low-speed mobilities in passing through intersections. In each use case, requirements such as the performance required for SPaT information and the sequentiality of signalized intersections where SPaT information is provided were examined.

In addition to Nara Prefecture, where the experiment environment was built in FY2022, the testing environment will be newly created in FY2024 in Ibaraki Prefecture, where SPaT information is planned to be provided at more than 100 intersections. Candidates for intersections and travel routes that can be tested in each use case were examined in advance. It is expected that the results of this examination will be used by the participants of the comprehensive demonstration experiment in the future as a reference to examine experimental intersections.



Demonstration experiment location

<Term explanation>

- ✓ Feasibility demonstration experiment:
  Verify the establishment of necessary technologies in actual traffic scenes
- ✓ Comprehensive demonstration experiment:
  Demonstration experiments with the participation of SPaT information recipients and verification of the effects of the platform (including improvements and optimization)

5.2. Sub-theme 2 “Research and development of practical application technology for V2N-based SPaT information

5.2.2 Results

2) Examination of practical application of providing SPaT information distributed by the V2N method

Examinations were conducted to solve the issues identified in the SIP 2nd phase. At intersections where SPaT information is provided by the control-based method and recall control is implemented (e.g., push-button traffic signals), the signal on the main road changes to yellow when a push-button is pressed, but the SPaT information distributed by the V2N method remains green, although this is an extremely rare occurrence. This was due to the fact that information indicating that the push-button was pressed did not reach the SPaT information distributor due to packet loss in the section using UDP/IP communication. As a countermeasure, a method of providing SPaT information was examined, giving priority to not providing incorrect SPaT information, although the SPaT information becomes temporarily indeterminate.

3) Technical examination of V2N-PICS

As a use case other than in automated driving, technical verification will be conducted to see whether it is possible to assist pedestrians in crossing using a smartphone application (V2N-PICS) that uses SPaT information distributed by the V2N method. A draft specification for a smartphone application was prepared for a feasibility demonstration experiment using the advanced PICS (see page 13) as a reference. The main functions are as follows:

- Determination of the start of service when a pedestrian approaches an intersection
- The receive request and receive processing of SPaT information distributed by the V2N method
- Update of display of a pedestrian signal light color and the number of remaining seconds as time elapses.

SPaT information distributed by the V2N method includes pedestrian SPaT information, but does not include static information required by pedestrians (intersection name, pedestrian crossing information, etc.); therefore, these types of information were examined as intersection definition information. The method of distributing intersection definition information will be examined in FY2024.

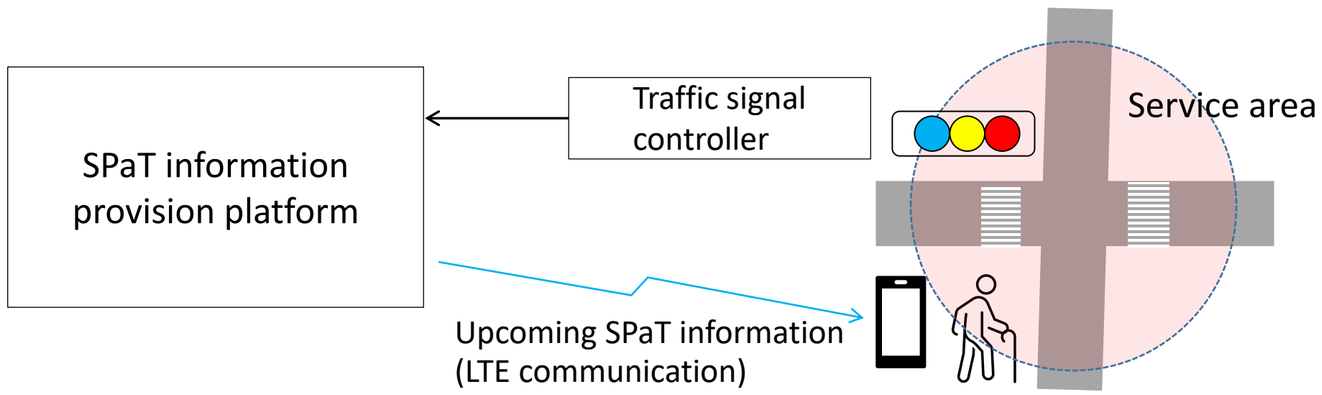


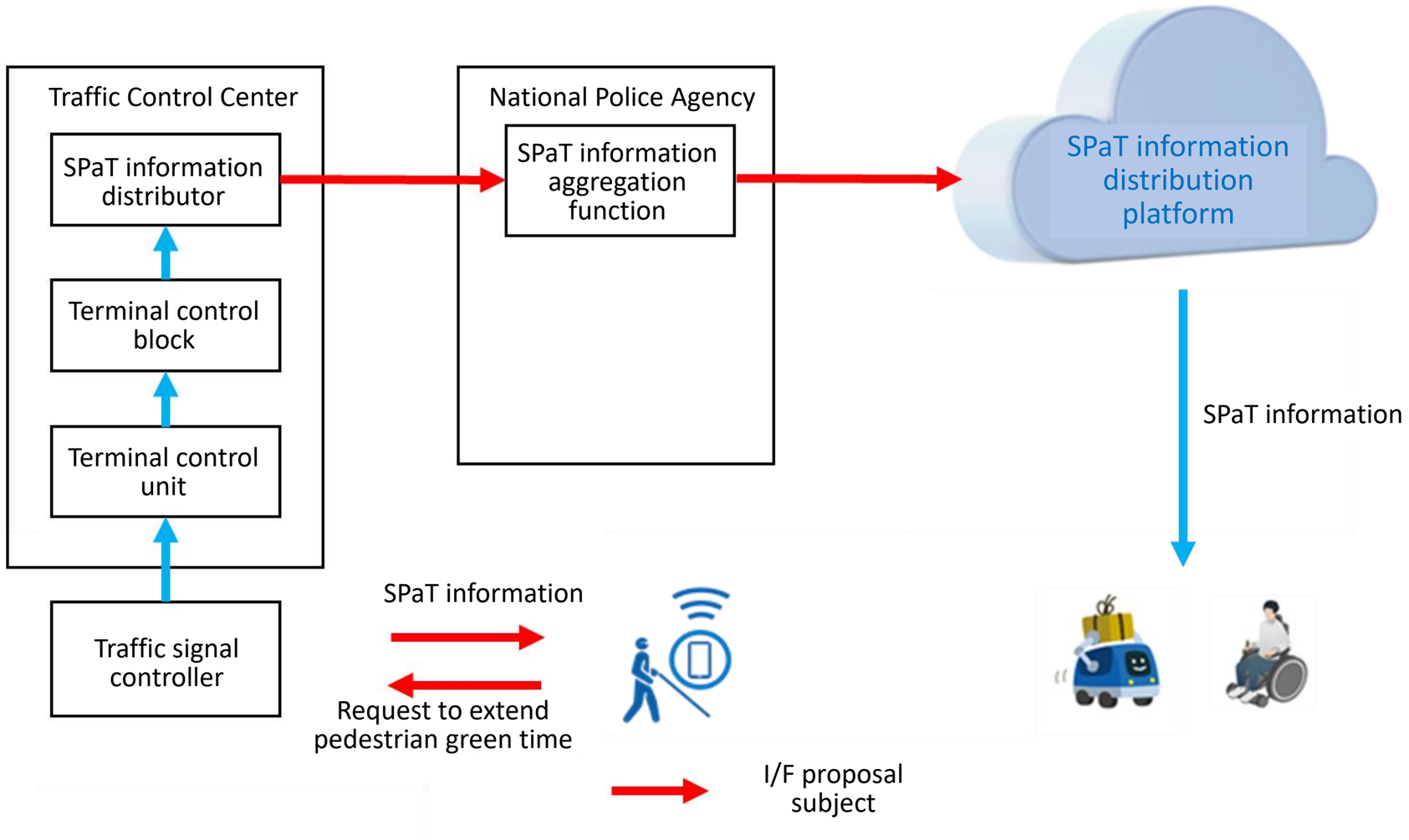
Image of technical verification for V2N-PICS

5.3 Sub-theme 3 “Research and development of I/F standardization that enables smooth distribution of SPaT information from the platform to various types of mobilities”

5.3.1. Outline

In the 1st and 2nd phases of the SIP, research and development of SPaT information provision for automated vehicles were conducted in cooperation with automobile manufacturers that use SPaT information, and requirements and message sets for SPaT information provision based on V2I and V2N methods were examined.

The requirements and message sets determined by the SIP 2nd phase were all intended for automated vehicles, and did not take into account mobilities that use pedestrian spaces, such as delivery robots and compact mobilities, for which the need for SPaT information distribution is increasing.



5.3 Sub-theme 3 “Research and development of I/F standardization that enables smooth distribution of SPaT information from the platform to various types of mobilities”

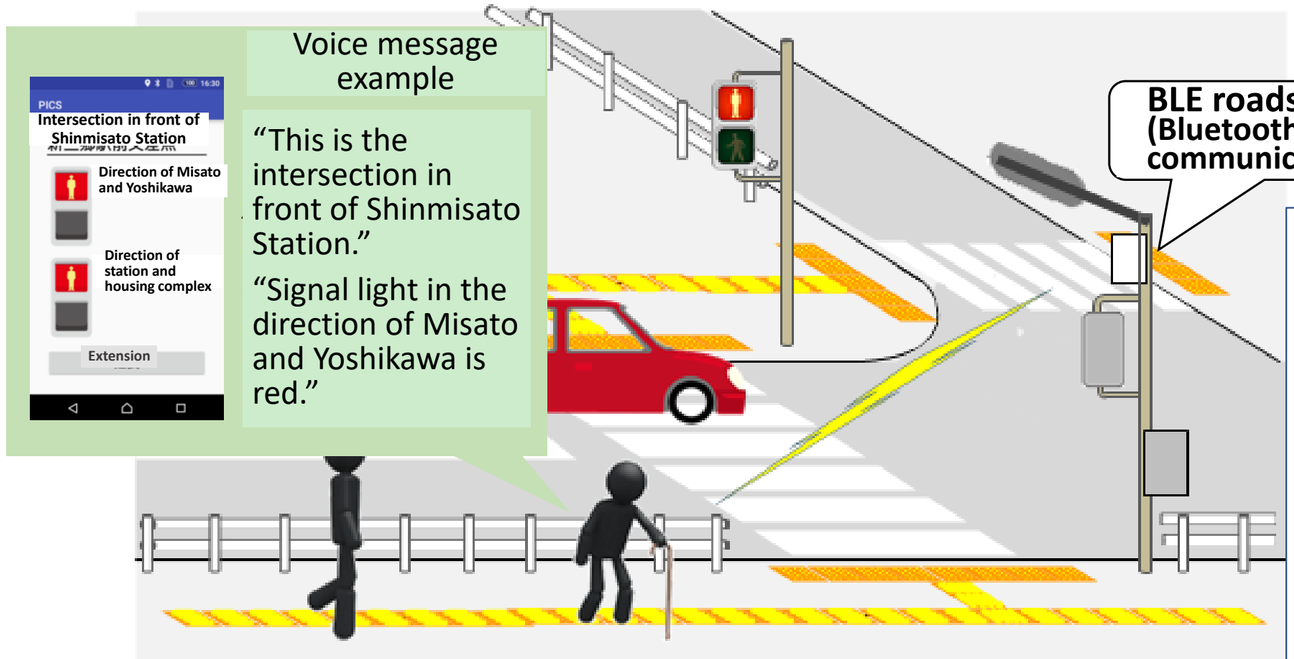
5.3.1. Outline

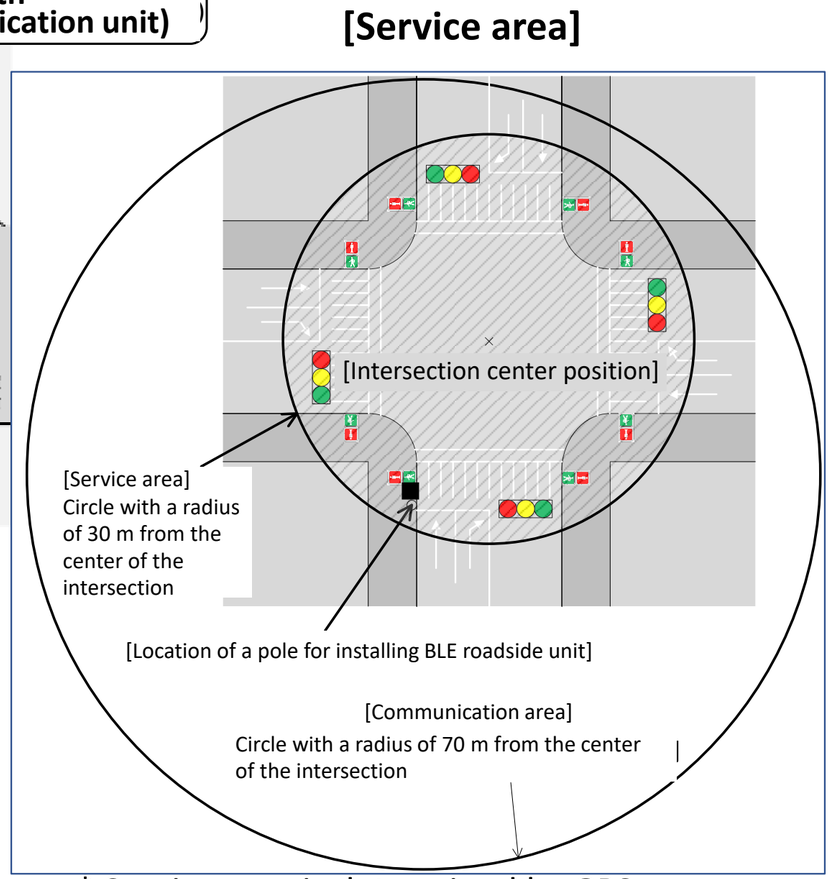
◆[Reference] Outline of advanced PICS

Advanced PICS is a service implemented based on the results of the SIP 1st phase. By using a smartphone with an application that supports Advanced PICS, the name of the intersection and signal status can be provided by voice and vibration, and push-button operation (pedestrian green time extension and pedestrian green request) is available using the application.

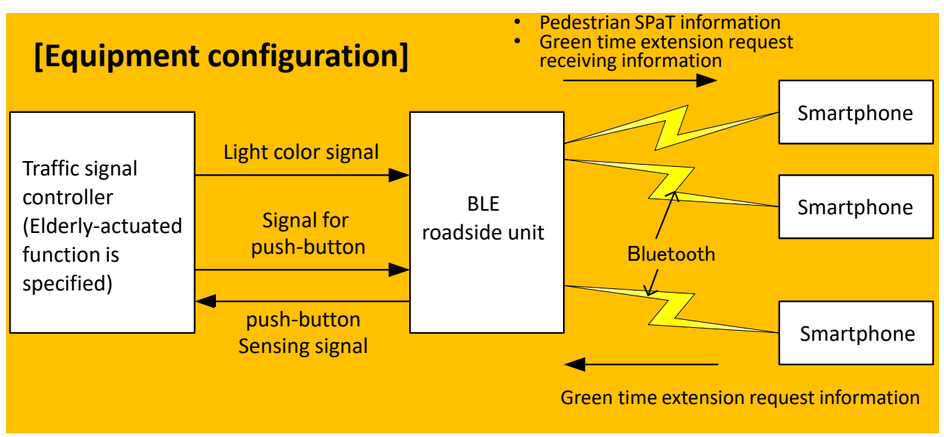
Overview of services using smartphones

- **Service to provide intersection names and signal status by voice, etc.**
- **Service to extend pedestrian green time by operating a smartphone**





* Service area is determined by GPS.



5.3 Sub-theme 3 “Research and development of I/F standardization that enables smooth distribution of SPaT information from the platform to various types of mobilities”

5.3.2. Results

1) Definition of targets of assistance and survey of related organizations

The survey to define the requirements for providing SPaT information for various mobility systems will be conducted in conjunction with the needs survey under sub-theme 6.

During the needs survey for sub-theme 6, necessary items will be added in the requirement definition for this sub-theme, and questionnaires and hearings will be conducted during FY2024.

Based on the results of the questionnaire and hearings, the requirement definition for each target of assistance and examination of I/F will be carried out in the future.

2) Improvement of advanced PICS

Measures are being examined for the following issues in the advanced PICS that were raised during the process of starting operation. Detailed examination of measures will be conducted in the future, along with the preparation of experimental specifications.

Issue	Details of the examination
Guidance assistance in crossing intersections cannot be realized with only information from the current infrastructure.	Whether it is possible to guide pedestrians by providing information from the infrastructure side without using sound-added equipment is being examined. (such as BLE 5.x features, etc., or in combination with other pedestrian assistance)
In push-button traffic signals, the push-button must be pressed to start the green (start crossing).	System side functions and operation rules to improve convenience for users such as the visually impaired, such as automatically issuing push-button requests at push-button traffic signals, are being examined.

5.4 Sub-theme 4 “Research and development on the seamless SPaT information distribution in zones with various types of traffic signals, including those of centralized and non-centralized control systems”

5.4.1. Outline

Although there is a request to realize the SPaT information provision distribution service at all signalized intersections, the functions of signal control systems for which it is difficult to generate SPaT information were excluded from the SPaT information provision in the SIP 1st and 2nd phases, .

Functions	Recall 1 function	Recall 2 function	Recall 3 function	Pedestrian-actuating function	Elderly-actuating	Gap-actuating function	Interlocking master unit function	Interlocking slave unit function	Speed-actuation function	Dilemma zone avoidance function	Bus-actuation function	Auto-generation function	Profile control function	Multiple intersection control interlocking function
Information to be provided	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	△

✓: To be provided, ×: Not to be provided, △: To be provided only at intersections placed Interlocking master units

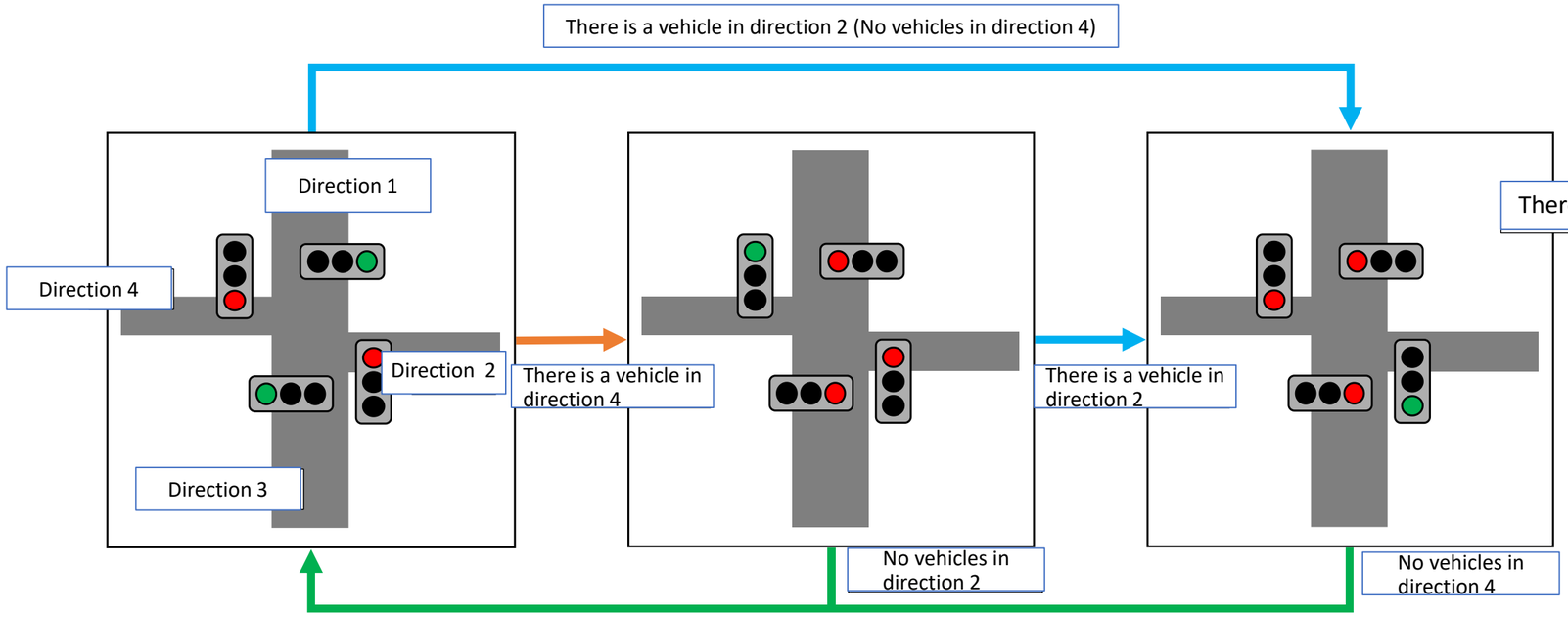
Functions of signal control systems that were determined to be excluded from the scope of SPaT information provision in the SIP 1st and 2nd Phases.

5.4 Sub-theme 4 “Research and development on the seamless SPaT information distribution in zones with various types of traffic signals, including those of centralized and non-centralized control systems”

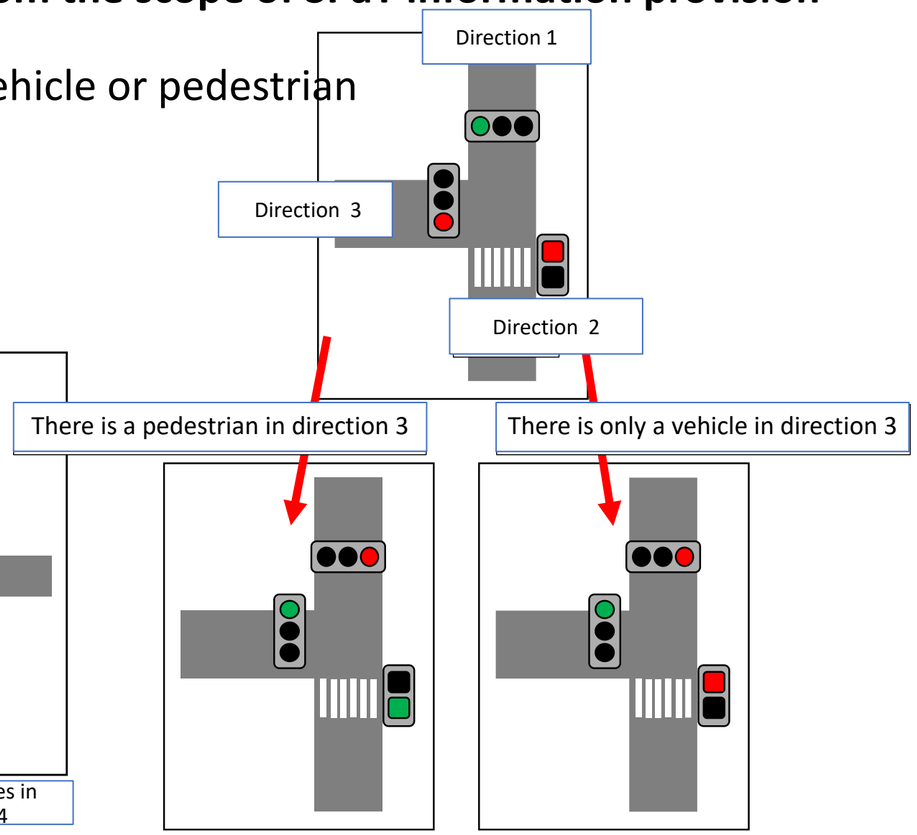
5.4.1 Outline

◆ **Functions of control systems that were determined to be excluded from the scope of SPaT information provision**

◇ Functions of recall 2 and 3: Indicate green only when requested by a vehicle or pedestrian

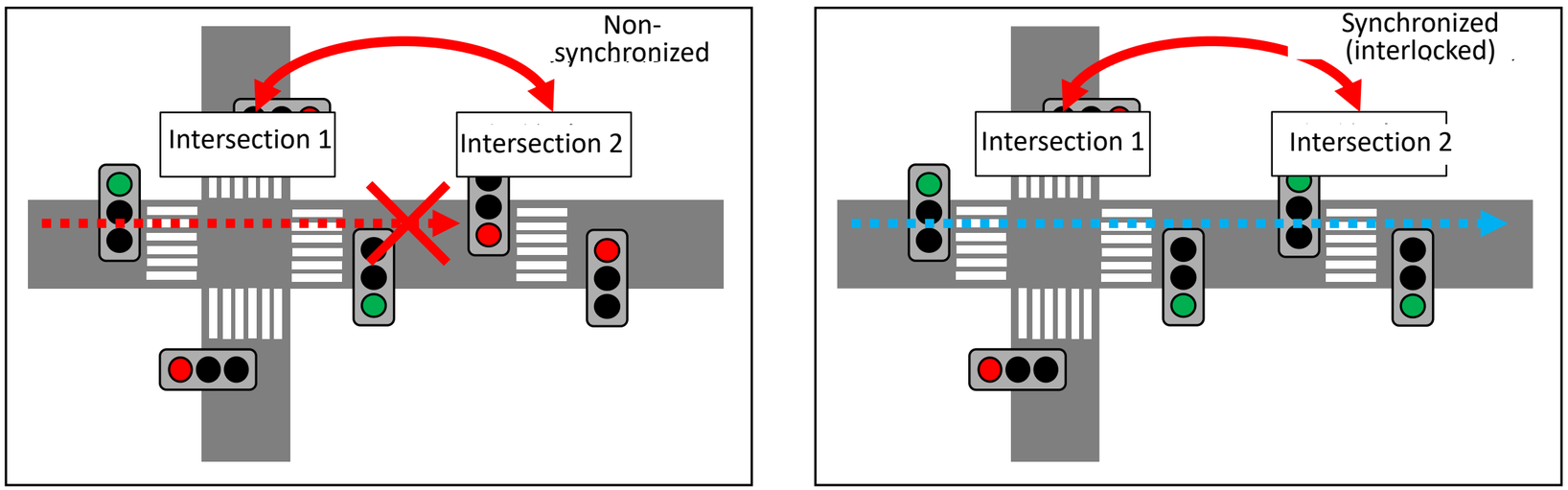


Recall 2 function operation example



Recall 3 function operation example

◇ Interlocking slave unit function: Synchronizes green signal indication timing by passing yellow signal and other signals between adjacent intersections.



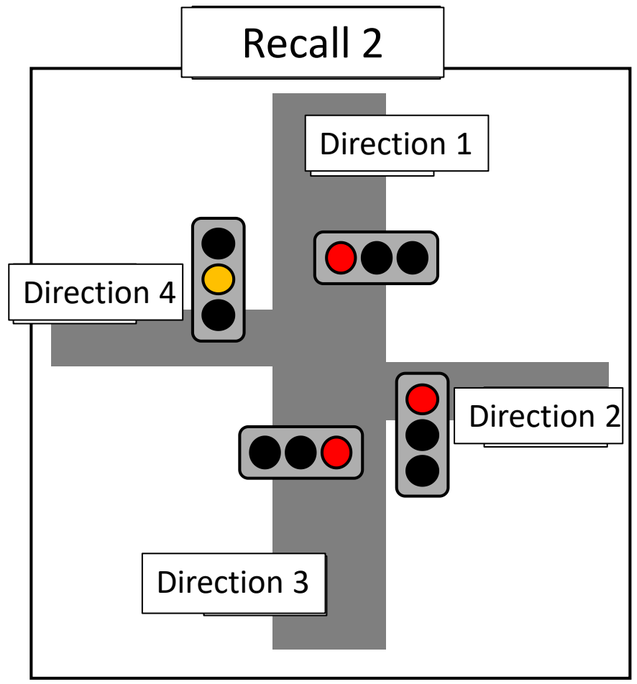
Interlocking slave unit operation example

5.4 Sub-theme 4 “Research and development on the seamless SPaT information distribution in zones with various types of traffic signals, including those of centralized and non-centralized control systems”

5.4.1 Outline

◆ Issues in Recall 2 and 3

There are cases where it is not possible to know the green start time from the SPaT information until the signal light actually turns green.



[Control]

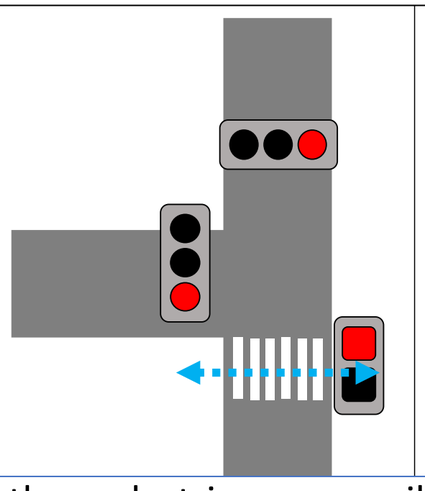
If there is no vehicle in Direction 2, Directions 1 and 3 are green; if a vehicle enters Direction 2 (before the green starts in Direction 1), the signal light in direction 2 turns green.

State of SPaT information (Example)

Direction 1, 3	Current light color	Red	Direction 2	Current light color	Red
	Remaining seconds	Min. 3 sec. to max. 20 sec.		Remaining seconds	Min. 3 sec. to (Max. unknown)

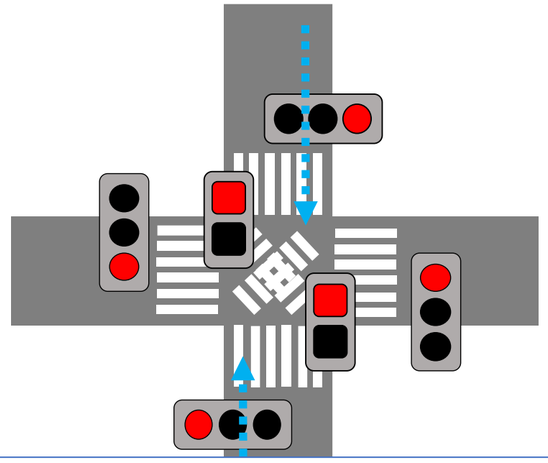
→ If it is known that no vehicle will enter Direction 2, the start time of green for Directions 1 and 3 will be after 3 seconds, which is the minimum remaining seconds of red. However, since there is a possibility that a vehicle may enter Direction 2 during these 3 seconds, the start time of green for Directions 1 and 3 will not be known until 3 seconds have elapsed and the lights for Directions 1 and 3 turn green, or until a vehicle enters Direction 2.

Recall 3 (for pedestrians only)



The fact that the pedestrian green will not be indicated is unknown until immediately before that.

pedestrian-vehicle separation signal control (push-button type phases indicated only for pedestrians)



The fact that the pedestrian green will not be indicated is unknown until immediately before that. (The start of vehicle green is not determined until the green is displayed.)

*Phases that are only indicated for pedestrians in the pedestrian-vehicle separation signal control (push-button type phases indicated only for pedestrians) are implemented by the recall 1 and recall 2 functions.

5.4 Sub-theme 4 “Research and development on the seamless SPaT information distribution in zones with various types of traffic signals, including those of centralized and non-centralized control systems”

5.4.2. Results

1) Identification of issues to assist seamless mobility

Examination of proposed measures, as well as identification and examination of issues were conducted for functions that are currently determined not to be included in the scope of SPaT information provision (Recall 2, Recall 3, and interlocking slave units).

The proposed measures are roughly classified into the following four directions, each of which would cause an increase in cost and have a negative impact on traffic.

- Change equipment specifications in order to be able to provide signal information (increase in cost).
- Substitute Recall 2 and Recall 3 functions with Recall 1 function (reduction in functionality).
- Substitute the functions of the interlocking salve units with the implementation of centralized control system (coordinated control system) (increase in cost).
- Provide SPaT information after deactivating the functions of the interlocking slave units (impact on traffic).

The impact of each proposed measure will be examined and final measures will be determined.

2) Proposal of experiment specifications

The operational specifications for the experiment were examined for the functions that are currently excluded from SPaT information to be provided.

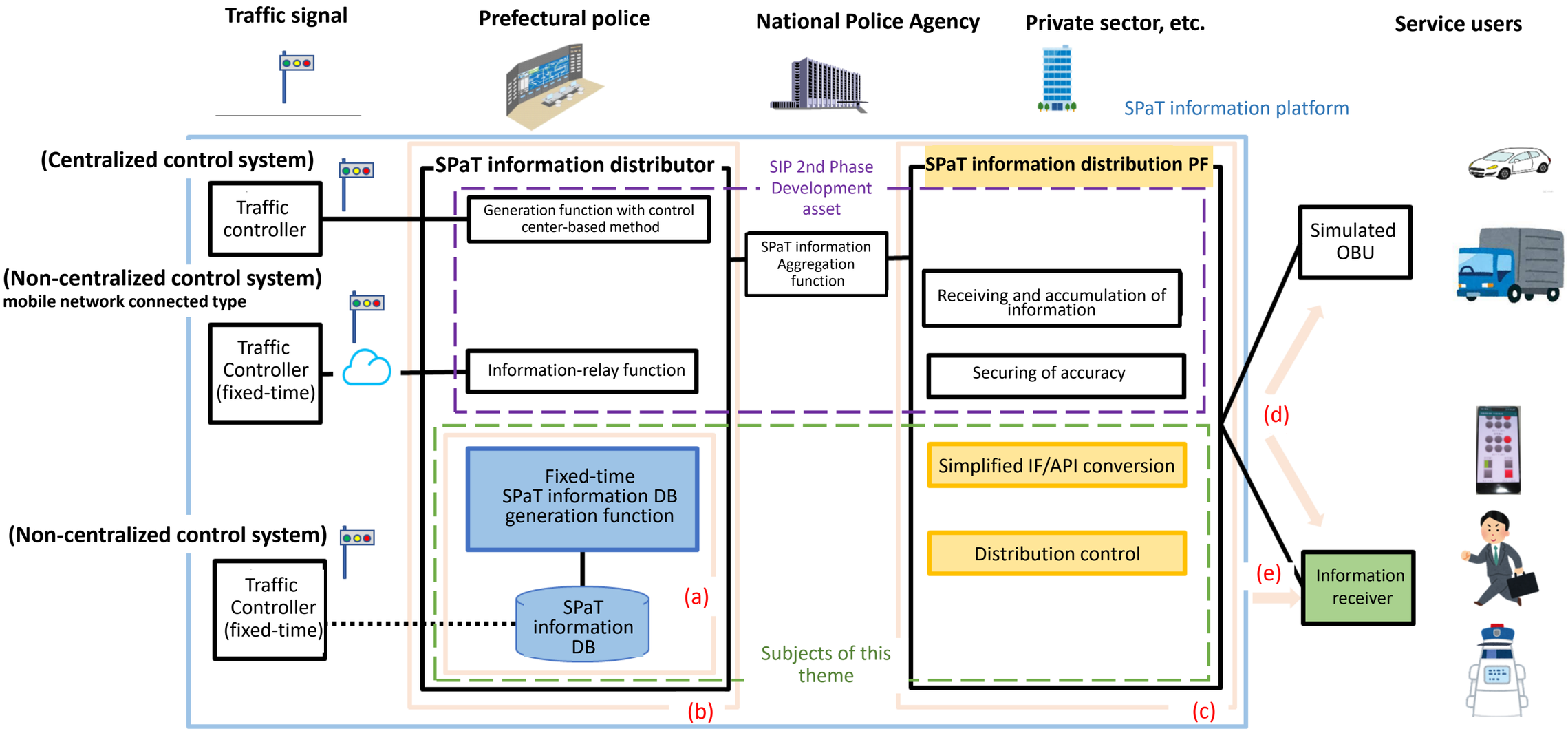
The operation of SPaT information generation in each function will be discussed at UTMS Society of Japan with traffic signal manufacturers and vehicle manufacturers to finalize operating specifications.

Subsequently, the final experiment specifications will be determined based on the results of the requirement definition in Sub-theme 3.

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.1. Outline

- Develop technology to provide accurate SPaT information of non-centralized fixed-time traffic signal controllers.
- Examine interfaces for various mobilities, build a SPaT information distribution platform (PF) that implements such interfaces, and verify the distribution of SPaT information.



(1) Development of SPaT information generation technology for fixed-time traffic signals (a) (b) Activities in FY2023

(2) Interface design, etc. for various types of mobilities (c) (d) Activities in FY2023

(3) Building of SPaT information provision platform for various types of mobilities (e) (f)

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

Desk verification of fixed-time SPaT information DB

Comparison and verification of a simulated TSDB generated from time limit table information and the execution log of SPaT information of fixed-time traffic signal controllers

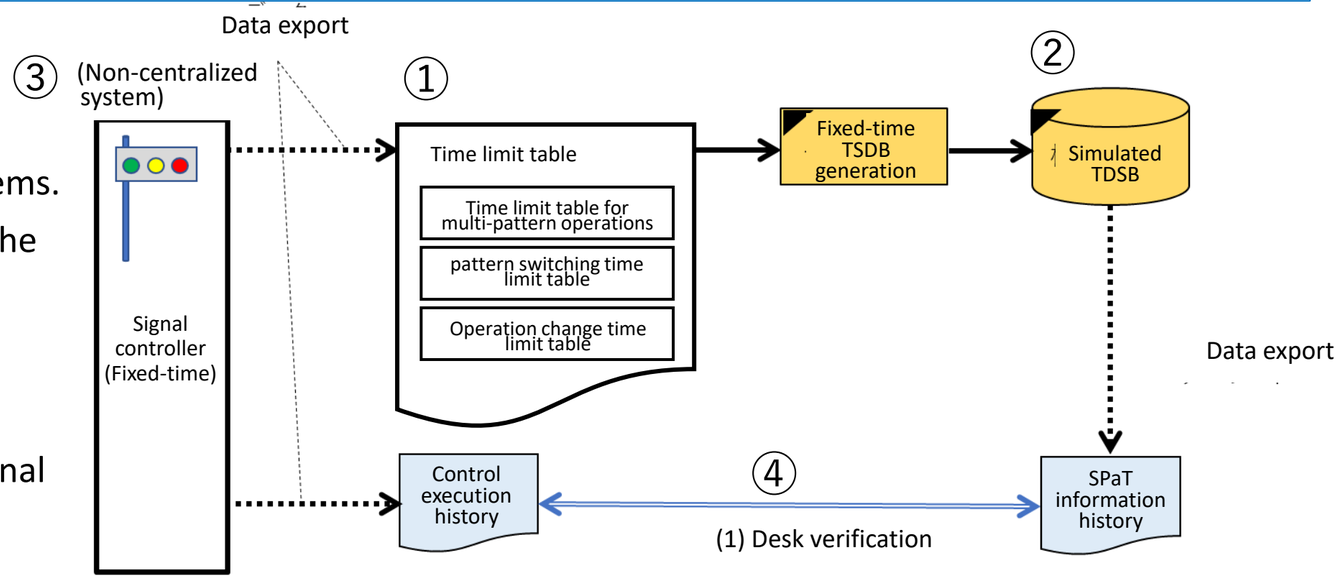
[Method of theoretical verification]

(1) Create a time limit table according to the verification items.

(2) From the time table, calculate the cycle start time and the the number of seconds per step on the desk.

(3) Set the same time limit table to a fixed-time signal controller and run it on the actual machine.

(4) Obtain the control execution history of the fixed-time signal Controller and compare it with the results of the desk calculation.



Legend: ◤ Targets of development in desk verification

Figure: Desk verification environment for fixed-time SPaT information

[Items and subjects of desk calculation]

Verification items

- Verification after changing patterns (in and after 6 cycles)
- Offset tracking operation verification (within 5 cycles)

Verification subjects

- Ver. 5 fixed-time traffic signal controllers
- Ver. 4 fixed-time traffic signal controllers (Preliminary verification)

Hour	Min.	Sec.	100ms	1	2	3	4	5	6	7	8	9	10
0	0	11	0	34.6	4	2	3	3	17.4	4	2	3	3
0	1	27	0	34.6	4	2	3	3	17.4	4	2	3	3
0	2	43	0	35.2	4	2	3	3	17.8	4	2	3	3
0	4	0	0	37	4	2	3	3	19	4	2	3	3
0	5	20	0	37	4	2	3	3	19	4	2	3	3
0	6	40	0	37	4	2	3	3	19	4	2	3	3
0	8	0	0	37	4	2	3	3	19	4	2	3	3
0	9	20	0	37	4	2	3	3	19	4	2	3	3
0	10	40	0	37	4	2	3	3	19	4	2	3	3
0	12	0	0	37	4	2	3	3	19	4	2	3	3

Figure: Example of desk calculation results

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

(1) Development of SPaT information generation technology in fixed-time traffic signals of the non-centralized control system

Desk verification results of the fixed-time traffic signal SPaT information DB (Desk verification results of fixed-time traffic signal controllers made by A company)

(1) Desk verification after pattern switching

Ver. 5

	Day of verification	Day before verification	Number of pattern switchings	Desk verification results	Remarks
1	Saturday	Weekday	pattern switching: 6 times	1176/1176 matches	
2	Holiday	Saturday	pattern switching: 2 times	1223/1223 matches	
3	Holiday	Holiday	pattern switching: 2 times	1223/1223 matches	
4	Weekday	Holiday	pattern switching: 10 times	1097/1101 matches	4 discrepancies are due to the time lag of the first phase by 100 ms caused by time synchronization.
5	Weekday	Weekday	pattern switching: 10 times	1102/1102 matches	
6	Weekday	Weekday	pattern switching: 10 times	1105/1105 matches	

Ver. 4

	Day of verification	Day before verification	Number of pattern switchings	Desk verification results	Remarks
1	Weekday	Weekday	pattern switching: 10 times	1102/1102 matches	
2	Weekday	Weekday	pattern switching: 5 times	1181/1181 matches	
3	Weekday	Weekday	pattern switching: 10 times	1105/1105 matches	

(2) Desk verification during offset tracking operation

Ver. 5

	Day of verification	Day before verification	Number of pattern switchings	Desk verification results	Remarks
1	Saturday	Weekday	pattern switching: 6 times	30/30 matches	
2	Holiday	Saturday	pattern switching: 2 times	10/10 matches	
3	Holiday	Holiday	pattern switching: 2 times	10/10 matches	
4	Weekday	Holiday	pattern switching: 10 times	50/50 matches	
5	Weekday	Weekday	pattern switching: 10 times	50/50 matches	
6	Weekday	Weekday	pattern switching: 10 times	50/50 matches	

Ver. 4

	Day of verification	Day before verification	Number of pattern switchings	Desk verification results	Remarks
1	Weekday	Weekday	pattern switching: 10 times	44/50 matches	All discrepancies are due to round-off errors.
2	Weekday	Weekday	pattern switching: 5 times	23/25 matches	
3	Weekday	Weekday	pattern switching: 10 times	43/50 matches	

Ver. 5: Confirmed the effectiveness of the designed calculation method.

- After pattern switching: Mostly matched (match with an error of ±300 ms or less) *Will continue to confirm the amount of error and probability of occurrence through desk verification.
- During offset tracking operation: 100% matched

Ver. 4: Completed the preliminary verification. The errors will be reconfirmed by video verification on the premises in the future.

- After pattern switching: 100% match
- During offset tracking operation: Rounding of the tracking amount in 100 ms increments caused a time lag of ±1 second in the first phase green time.

*In the future, verification of fixed-time traffic signal controllers made by other companies will also be promoted with coordination within the consortium in consideration of issues and workload.

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

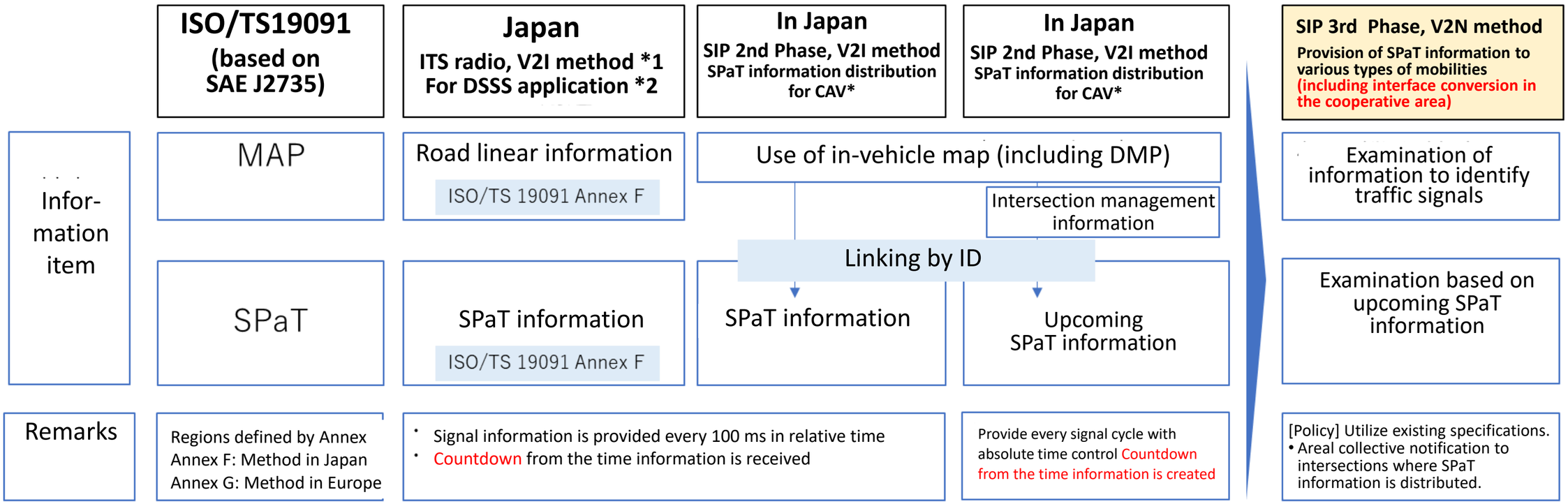
(2) Examination and design new SPaT information provision interfaces based on standardization trends of International Organization for Standardization, etc.

[Implementation plan]

- Examination of the need for a new form of provision for the SPaT information provision, which had been examined until the SIP 2nd phase, in light of the needs survey of new users, etc.
- Design of appropriate provision interfaces according to the need for new SPaT information provision methods, based on the standardization trends of the International Organization for Standardization and other organizations.

[Image of examination and basic research for the provision of signal information for various mobilities]

- Past efforts focused on providing SPaT information for vehicles, for which standards such as international standards have been established.
- In order to distribute SPaT information to various types of mobility (including pedestrians), a more desirable method of providing information will be studied, by using the information that has been provided to vehicles as a reference.



*1 V2I system: Abbreviation for Vehicle to roadside Infrastructure. Here, it mainly refers to those used for infrastructure-to-vehicle communications from ITS radio unit (700 MHz band radio).
*2: DSSS: Abbreviation for Driving Safety Support Systems, a system that assists drivers to drive safely.
*3：CAV: Abbreviation for Connected Autonomous Vehicle.

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

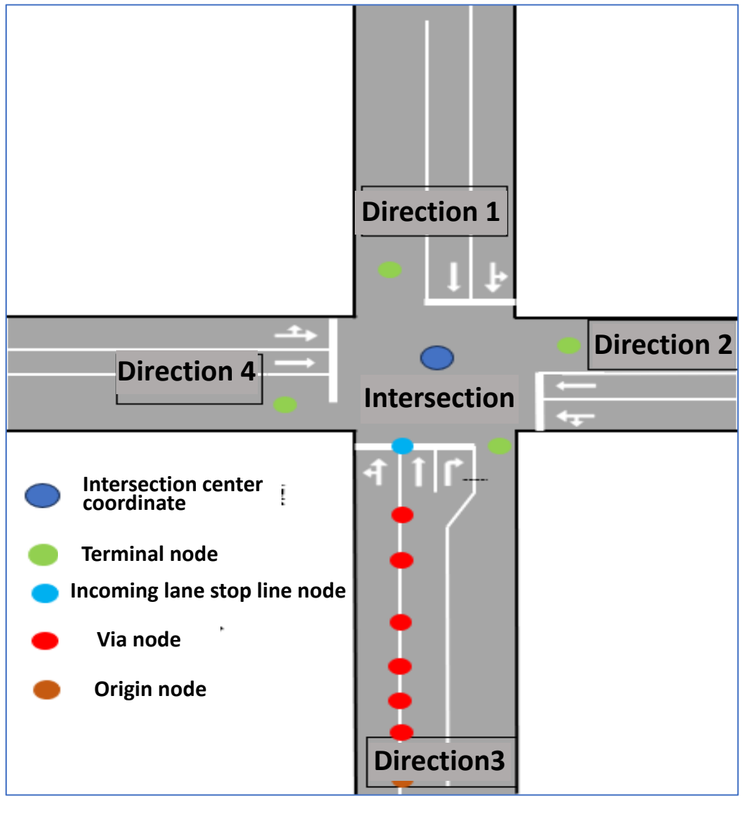
(2) Examination and design of new SPaT information provision interfaces based on standardization trends of International Organization for Standardization, etc.

[Road linear information and MAP]

Key points about road linear information

- Vehicles are determined by direction and angle information in the direction of travel.
- In addition to the latitude and longitude of the center of the intersection, stop line information is also available.

ISO Road linear information　　The U.S. J2735 MAP



- Intersections (Geographical information list)
  - region (Region ID)
  - id (Intersection ID)
  - laneSet (Lane list)
    - lane ID (Lane ID)
    - laneType (Lane type attributes)
      - manuevers (Traveling direction information)
    - connectsTo (List of destination lanes)
      SignalGroup (Group ID of traffic signals)
  - ○**speedLimits (Regulatory speed information)**
- ○**roadSegments (Data on work areas and accidents)**

Legend

○: Indicates there is no supporting entity.

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

(2) Examination and design of new SPaT information provision interfaces based on standardization trends of International Organization for Standardization, etc.

[Data structure of SPaT information]

Differences between domestic and U.S. signaling information were surveyed in examining a new interface.

⇒There were differences in the confidence in SPaT information and in the signal information of pedestrian traffic signals.

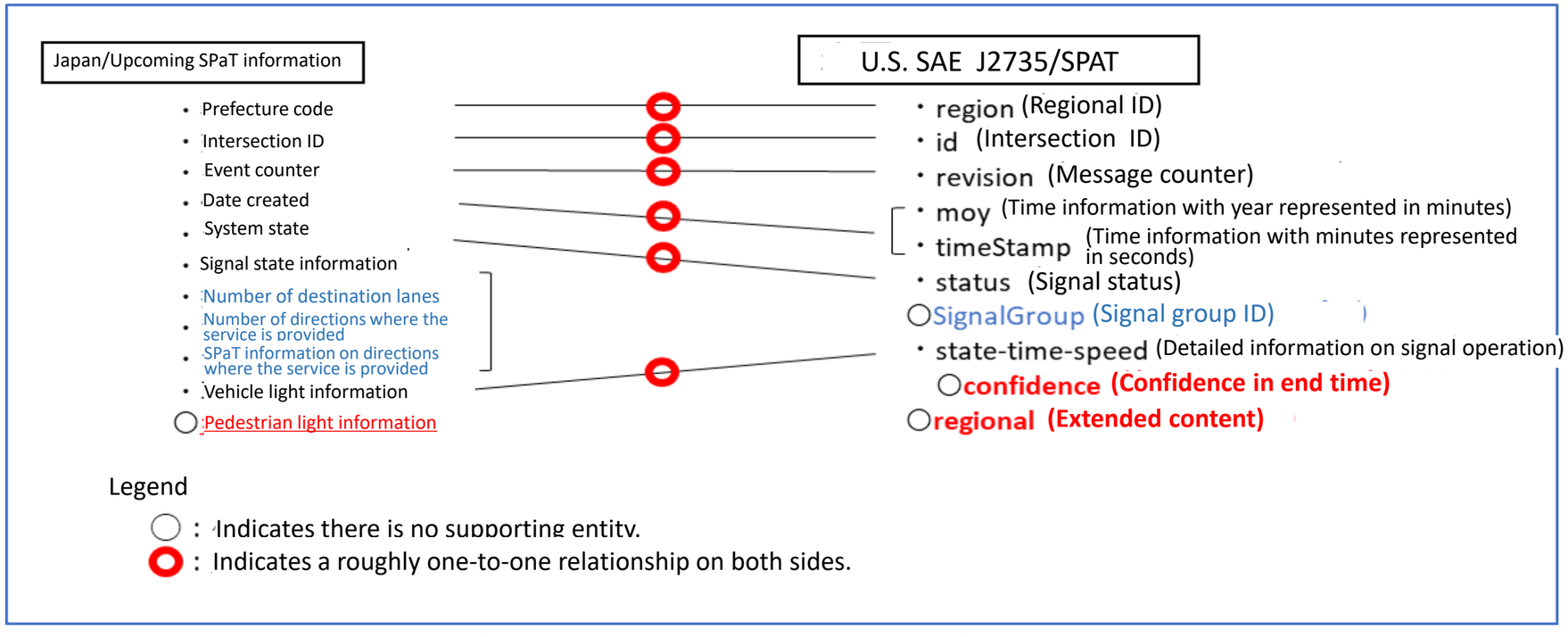
Differences in provision destination and information provided between signal information in Japan and SPaT (SAE J2735) in the U.S.

[Japan]
- Provides information on both vehicle and pedestrian lights.

(in each direction where the service is provided)

[The U.S.]
- Provides information on vehicle lights only.

(on a signal group ID basis.)
- Provides information about confidence.
- Handles extended content for each region (country).



Would like to utilize the differences in the design of new interfaces.

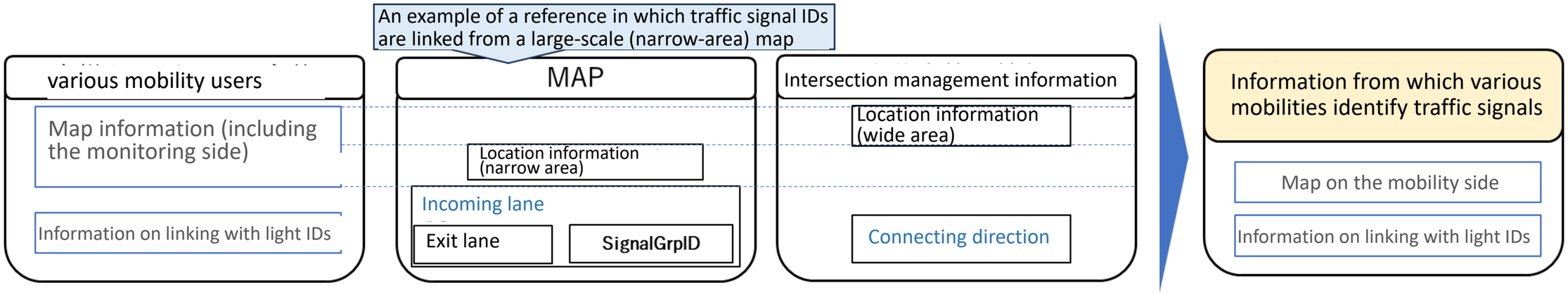
5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

5.5.2. Results

(2) Examination and design of new SPaT information provision interfaces based on standardization trends of International Organization for Standardization, etc.

[Data structure of information that identifies intersections, etc.]

- The V2N method defines and utilizes intersection management information, which is based on road linear information with a simple data structure that is easy to maintain.
- MAP information was examined in depth to use it as a reference for providing SPaT information to various types mobilities. MAP information has a list of exit lanes connected to incoming lanes, and "Signal Group IDs" are assigned to the lanes to utilize the information. Using this as an example, we would like to examine a data structure that is simpler and easier to understand for information users.



Japan (V2N information)	Geographical information (Intersection management information)
The U.S. (SAEJ2735)	Geographical information (MAP)

For information users who are not familiar with data structures, the data representation in Europe and the U.S. (ISO/TS 19091) is considered to be helpful.

5.5. Sub-theme 5 “Research and development to expand applications of the SPaT information database of fixed-time traffic signals and to expand the use of SPaT information by recipients of the information”

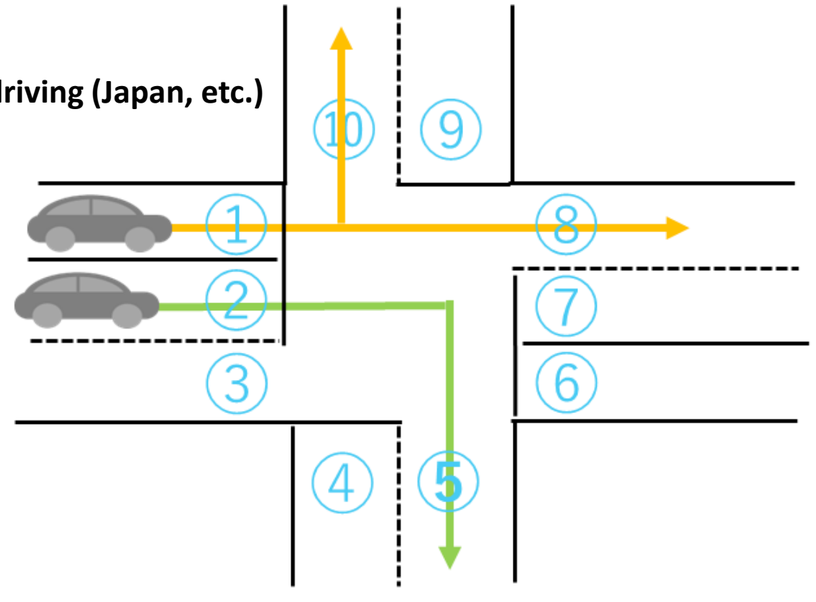
5.5.2. Results

(2) Examination and design of new SPaT information provision interfaces based on standardization trends of International Organization for Standardization, etc.

(Example) Relationship between lanes and signal group IDs by MAP

DF_connectsToList (connectsTo)
- DF_Connection
  - DF_ConnectingLane (ConnectingLane)…Connecting lane
  - DF_IntersectionReferenceID (remoteIntersection)
    …Provides means of creating a mesh of lanes
  - DE_signalGroupID (signalGroup)…Signal groups
  - DE_RestrictionClassID (userClass)…Restrictions of users
  - DE_LaneConnectionID (connectionID)…Indeces for connection between lanes

Left-hand side driving (Japan, etc.)



Orange line (LaneID : 1)
- connectsTo
  - connection : 1
    - connectingLane
      - lane : 10
      - manuever : 1 (Turning left)
    - signalGroup : 1
  - connection : 2
    - connectingLane
      - lane : 8
      - manuever : 0 (Traveling straight)
    - signalGroup : 1

Yellow green line (LaneID : 2)
- connectsTo
  - connection : 1
    - connectingLane
      - lane : 5
      - manuever : 2 (Turning right)
    - signalGroup : 2

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.1. Outline

☐ Committee operations

Committee to examine the SPaT information provision platform for various mobilities based on the V2N method

- **Compilation of specifications and other documents necessary for establishing facilities for the comprehensive demonstration experiments**
- **Confirmation of the process, results, etc. of the feasibility and comprehensive demonstration experiments**
- **Confirmation of documents to be drafted by the joint proposers (including reconciliation of differences among the joint proposers)**
- **Compilation of an integrated report**

Classification	Company/organization name
Traffic infrastructure manufacturers	OMRON SOCIAL SOLUTIONS CO., LTD. Kyosan Electric Manufacturing Co.,Ltd. KOITO ELECTRIC INDUSTRIES, LTD. Sumitomo Electric Industries, Ltd. NIPPON SIGNAL CO.,LTD. Panasonic Connect Co., Ltd
Automobile manufacturers, etc.	SUBARU CORPORATION Toyota Motor Corporation Nissan Motor Co., Ltd. Honda Motor Co., Ltd. DENSO CORPORATION
Operators of mobility providers	BOLDLY Inc. Advanced Smart Mobility Co., Ltd. KYOSERA Communication Systems Co., Ltd. Rakuten Group, Inc. ROBOT DELIVERY ASSOCIATION Micromobility Promotion Council
Map-related companies, etc.	Google Japan G.K. Tomtom Sales B.V. ZENRIN CO., LTD. LY Corporation NAVITIME JAPAN Co., Ltd.
Telecommunications carriers, etc.	NTT DOCOMO, INC. SoftBank Corp. KDDI CORPORATION KYOCERA Corporation NEC Corporation
Related organizations	Japan Automobile Manufacturers Association, Inc. Japan Road Traffic Information Center VEHICLE INFORMATION AND COMMUNICATION SYSYTEM CENTER
Trustee cooperation	Consortium for Research and Development of Traffic Accident Prevention Support

☐ Needs survey (FY2023 - FY2024)

[1] Survey of domestic companies and organizations that may use SPaT information, including automated driving, driver-operated driving, pedestrians, micromobility, delivery robots, and others.
[2] Survey of companies and organizations outside Japan that may use SPaT information, including automated driving, driver-operated driving, pedestrians, micromobility, delivery robots, and others.
[3] Needs survey through questionnaires to the companies and organizations surveyed in [1].
[4] Needs survey through interviews with companies and organizations with high potential to use SPaT information among those surveyed in [3].
[5] Analyze the results of the above and plan the targets of publicly solicited applications for the comprehensive demonstration experiment.

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.2. Results

Committee meetings held

Date held	Main agenda
1st February 1, 2024	• Explanation of the project • Explanation of needs survey for sub-theme 6 • Report on the schedule and status of examinations on sub-themes 1 and 2
2nd February 22, 2024	• Results of SIP 2nd phase projects • Outline of “SPaT information" to be provided • Status report on each sub-theme • Draft questionnaire to be conducted in the needs survey
3rd March 22, 2024	• SPaT information errors, delays, etc. • Draft questionnaire to be conducted in the needs survey • Status report on each sub-theme

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.2. Results

Domestic survey results

Field	Number of companies surveyed and main companies	Trends in SPaT information utilization, etc.
(1) Related to automobile manufactur-ing	Companies surveyed: 7 companies Main companies surveyed • SUBARU CORPORATION • Toyota Motor Corporation • Nissan Motor Co., Ltd. • Honda Motor Co., Ltd., and others	• **A number of automobile manufacturers are developing systems for automated driving or driving safety support by linking the systems with traffic signal.** • **In the SIP 2nd Phase Automated driving (Expansion of systems and services), a demonstration experiment was conducted in which SPaT information was distributed to vehicles using the V2I and V2N methods, with multiple automobile manufacturers participating as experiment participants.** • **On the other hand, implementation of functions is also underway, such as detecting the color of signal lights ahead using an in-vehicle camera and warning the driver in the event of a delay in starting the car.** ⇒There is a high need for SPaT information distributed by the V2N method in terms of both automatic driving and driving safety support.

Field	Number of companies surveyed and main companies	Trends in SPaT information utilization, etc.
(2) Related to mobility	Companies surveyed: 21 companies Main companies surveyed • BOLDLY Inc. • KYOSERA Communication Systems Co., Ltd. • Rakuten Group, Inc. • Advanced Smart Mobility Co., Ltd. • ROBOT DELIVERY ASSOCIATION • Micromobility Promotion Council • Luup, Inc., and others	• **There are several operators of micromobility sharing services, and it has become common for users to use dedicated smartphone applications to search for ports, make reservations, and pay for the service.** • **In addition, some service providers use GPS terminals to warn drivers when they enter no-entry zones and provide other driving safety support**. ⇒in the near future, it is expected that SPaT information will be provided via smartphones and other devices as part of safe driving support services for users. • **In the area of delivery robots, several companies in Japan have started demonstration experiments for home delivery and mail delivery.** • **In 2023, the Road Traffic Law was revised to define delivery robots and other vehicles as "small vehicles operated remotely," which are allowed to pass on public roads as those equivalent to pedestrians under a registration system.** ⇒in the near future, it is envisioned that signal information distributed by the V2N system will be used to reduce the burden on remote operators and to reduce recognition errors. In addition, the importance of signal information distributed by the V2N system is expected to increase in the phase of automated driving in the near future.

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.2. Results

Domestic survey results

Field	Number of companies surveyed and main companies	Trends in signal information utilization, etc.
(3) Related to map information provision	Companies surveyed: 5 companies Main companies surveyed • Google Japan G.K. • Tomtom Sales B.V. • ZENRIN CO., LTD. • LY Corporation • NAVITIME JAPAN Co., Ltd.	• **There are some car navigation service providers that provide location information of traffic signals in their services**. ⇒Location information of traffic signals is already provided as car navigation information. **There are companies that have started services to provide information to support pedestrian mobility for movement-restricted people, including the elderly and people with visual impairments.** ⇒At present, static information such as the presence or absence of acoustic signals is provided, but it is expected that dynamic information such as signal indication information will be provided in the future. • **There are companies that are working on the building of a SPaT information provision platform to reflect dynamic information such as traffic signals, pedestrians, and oncoming traffic on high-precision map data for the purpose of safe driving support and automated driving.** ⇒In the future, when the above SPaT information provision platform is implemented in society, it is expected that SPaT information distributed by the V2N method will be used as an information source. • **In addition, there are companies that have started providing applications that use smartphone cameras to recognize changes in the light color of traffic signals ahead and warn drivers when there is a delay in starting the car.** ⇒Services that detect traffic light colors from smartphone camera images and provide safe driving assistance to drivers have been launched, and it is assumed that the information source will be replaced with or supplemented by signal information distributed by the V2N system.

Field	Number of companies surveyed and main companies	Trends in signal information utilization, etc.
(4) Related to telecommu-nications	Companies surveyed: 7 companies Main companies surveyed • NTT DOCOMO, INC. • SoftBank Corp. • KDDI CORPORATION • KYOCERA Corporation • NEC Corporation, and others	• **There are several operators that have started demonstration experiments of infrastructure-to-vehicle cooperation for automated driving services.** • **There are operators that are working on providing SPaT information using 5G to support driving at intersections.** • **On the other hand, there are operators that have conducted demonstration experiments of delivery robots that cross intersections in conjunction with traffic signals along the route using the V2N method.** ⇒In the future, it is expected that SPaT information distributed by the V2N system will be utilized in the social implementation of automated driving mobility services and delivery robots.

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.2. Results

Survey flow [Items implemented] [Entities surveyed] (Estimate)

(1) Survey on domestic companies and organizations — About 40 companies

(2) Survey on companies and organizations outside Japan — About 10 companies

Targets of the questionnaire survey were extracted based on the survey (1)

(3) Needs survey by questionnaire — About 40 companies

Targets of interview survey were extracted based on the survey (3)

(4) Needs survey by interview — About 10 companies

(5) Compilation of survey results

[Implementation policy]

- Survey of companies with businesses and technologies related to the movement of people and goods by road in the fields of automobiles, mobility, logistics (delivery), telecommunications, mapping, etc.
- In Japan, the survey is expected to cover about five major companies in each field, plus two to three companies that are making advanced efforts in the field.
- Information was collected through literature and the Internet.

- Conducted a written questionnaire survey of the companies and organizations surveyed in (1) above.
- Identified needs for specific use cases, data accuracy and conditions, and acquisition methods, etc., if signal information could be acquired using the V2N method.

- Conducted interviews with about 10 companies and organizations from among those targeted in (3) above.
- Companies and organizations that can assume specific use cases of signal information were preferentially selected as survey targets.
- （Based on the results of the survey in (3), detailed interviews were conducted.

5.6. Sub-theme 6 “Research on diversified needs of the SPaT information provision platform, etc.”

5.6.2. Results

Summary of draft questionnaire

- To conduct the survey, survey targets were selected, a survey form was prepared, and the survey forms were sent out.
- Approximately 40 companies were selected for the survey, which consisted of three main items: (1) businesses being conducted by the companies surveyed, (2) demand for SPaT information, and (3) requests regarding the provision of SPaT information.
- The survey results are scheduled to be compiled in FY2024.

Table Details of needs survey by questionnaire

Main item		Main questions (excerpts)	Purpose
1	Businesses, etc. conducted by the companies surveyed	• Are any of your company's businesses or technologies related to travel and logistics by road?	Understand the business activities of the companies and organizations surveyed and their relevance to the mobility and logistics sector
2	Demand for SPaT information	• Is there any possibility of utilizing signal information in your business? Do you have any specific scenarios for its use? • Where and how often would you like to receive signal information? • If signal information is provided, would you like to use the data?	Identify use cases and needs for signal information
3	Requests for SPaT provision information	• What are the expected objects that will receive and use the signal information? (e.g., vehicles, micromobility, pedestrians, etc.) • What range of signal information should be available? • How far in advance of the traffic signal do you need the information? • How many cycles ahead do you need information? • What is the acceptable delay or error margin? • How many seconds before the end of the green light do you need to know the end time of the green light?	Understand the accuracy required for signal information and the range of data needed
		• Is there any information you would like to see provided in conjunction with signal information? • Do you have any safety measures, support, or issues that need to be addressed when providing signal information? • Would you be willing to bear the cost of providing signal information? • Other comments or requests	Identify other requests for signal information

6. Objective Achievement Levels

- The following goals (X-RLs and KPIs) have been set; for FY2023, this is the first year and we have not yet reached the stage of measuring the degree of achievement.

■ X-RL Objectives to be achieved by 2027

- **TRL**
  - **Seamless provision of SPaT information in zones containing a variety of traffic signals, including centralized and non-centralized traffic signals: 7 or more**
  - **Establishment of a SPaT information provision platform for various types of mobility: 7 or more**
  - **Standardization of interfaces between platforms and mobility devices: 7 or more**
  - **Diversification of SPaT information provision destinations: 7 or more**
- **BRL: 7 or more**
- **GRL: 6 or more**
- **SRL: 6 or more**

■ Goals to be achieved at each stage (SIP midpoint/end/post end)

[At SIP midpoint]

- **Completion of mobility-assistive technology development and technology evaluation**
- **Concretization of mobility-assistive technology specifications**
- **Confirmation of accident risk reduction against accident statistics due to missed signals, etc. in the demonstration area**

[At SIP end]

- **Formulate plans for commercialization of mobility-assistive technologies**
- **Release reference roadmaps for implementation of mobility-assistive technologies in several cities**
- **Confirmation of accident risk reduction based on accident statistics in several cities due to missed signals, etc.**

[At SIP post end(for reference)]

- **Commercialization of mobility-assistive technologies**
- **Implementation of mobility-assistive technologies in several cities**
- **Reduction in the number of traffic accidents**

■ Goals to be achieved for data linkage

- **Standardization of interfaces for data linkage of traffic signal information provision platforms**
- **Promotion of the use of traffic signal information provision platforms by other contractors and mobility service providers**

This report includes the results of Cross-ministerial Strategic Innovation Promotion Program (SIP) 3rd Phase, “Development of Smart Mobility Platform” promoted by Council for Science, Technology and Innovation, Cabinet Office.(Project Management Agency:New Energy and Industrial Technology Development Organization (NEDO) (Project Code JPNP23023))