“Second Phase of Cross-ministerial Strategic Innovation Promotion Program/ Research and Development on the Provision of Signal Phase and Timing (SPaT) Information using Cloud and other technologies toward Social Implementation”

Interim Report for Fiscal Year 2021
Overview

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

April 2022

[Reference] Research items in the publicly solicited documents

a) Examination of the social functional requirements (the need) of the SPaT Information Center
b) Examination of the technical requirements of the SPaT Information Center
c) Examination of the implementing entities of the SPaT Information Center
d) Examination of the integrated delivery of information other than SPaT information (traffic regulation information, etc.)
e) Examination of linking SPaT information and high-precision three-dimensional maps
f) Verification of the improvement in accuracy of SPaT information
g) Examination of reducing communication delays of SPaT information
h) Examination of reducing the functions of the National Police Agency's SPaT information aggregation system

* The contents indicated by the symbols a through h in the following documents are as above.

1. Assignment of Themes

Theme 1 **"R&D for the social implementation of the provision of SPaT information using cloud and other technologies [Examination of the social functional requirements (the need) of the SPaT Information Center] "**
[UTMS Society of Japan]

a, c

Theme 2 **"R&D for the social implementation of the provision of SPaT information using cloud and other technologies (Examination of the technical requirements of the SPaT Information Center)"**
[Panasonic System Solutions Japan Co., Ltd.]

b, h

Theme 3 **"R&D for the social implementation of the provision of SPaT information using cloud and other technologies (Examination of the integrated delivery of information other than SPaT information (traffic regulation information, etc.)"**
[NIPPON SIGNAL CO., LTD.]

d, g

Theme 4 **"R&D for the social implementation of the provision of SPaT information using cloud and other technologies (Examination of the verification of the improvement in accuracy of SPaT information and the examination of reducing communication delay of SPaT information)"**
[OMRON Social Solutions Co., Ltd.]

f, g

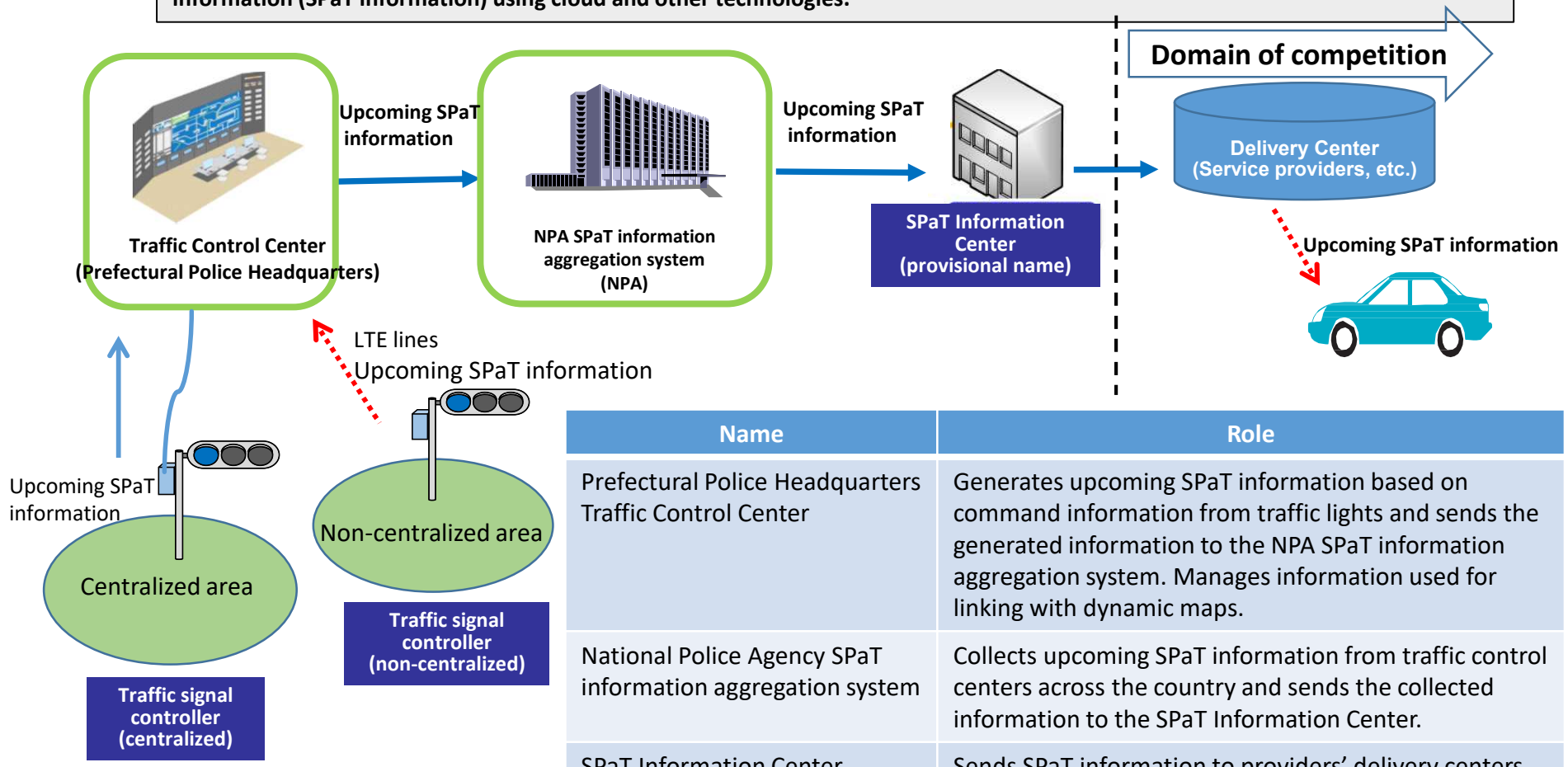
2. History of the project

Research name	Before FY 2018	FY 2018	FY 2019	FY 2020	FY 2021	FY2022
R&D on the provision of SPaT information using cloud and other technologies **[R&D on the provision of SPaT information using methods other than V2I communication via ITS roadside radio units and others]** **(V2N)**	Understanding the trends of technology development by private sector automakers and others	• **Basic research including overseas situation** • **Proposal of SPaT information provision methods** **Expectations for lower costs**	• **Refinement of functional requirements** • **Plant-level verification** • **Selection of SPaT information provision methods**	• **Refinement of functional requirements** • **Examination of measures to address issues** • **Building and verification of a model system** • **Development of specifications for the system to be built for verification for next year and beyond**	• **Examination of social requirements, technical requirements, etc. of the SPaT Information Center** • **Examination of the linking and integration with other information** • **Examination of the improvement of measures to address issues**	**Model project and verification**
[Reference] R&D on the enhancement of technologies to provide SPaT information toward the realization of automated driving (V2I)	• Practical application of TSPS using infrared beacons • Practical application of DSSS using ITS roadside radio units	• Basic research including research on overseas situations • Preparation for the next fiscal year	• Refinement of functional requirements • Development of measures to address issues • Plant-level verification • Comparison and examination including other methods • Specification based on the above		• Continued efforts toward widespread use by promoting cost reduction	

3. Overview of the research

[Overview]

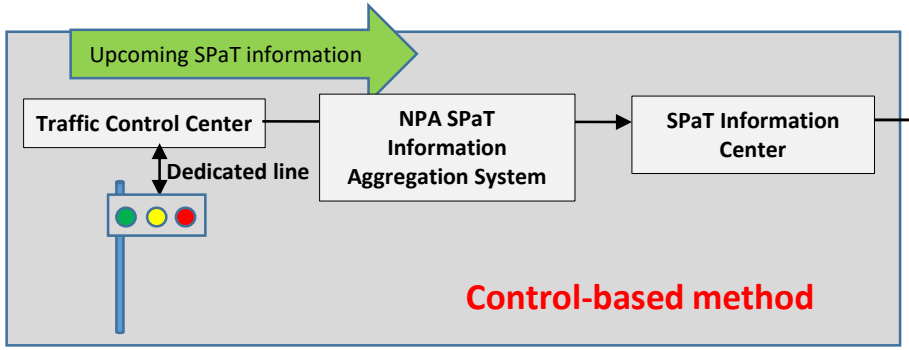
Automated driving (the expansion of systems and services) in the Phase 2 of the Strategic Innovation Program (SIP) stipulates, aiming to be competitive in the fierce international competition of automated driving, the establishment of the world's most advanced core technologies (such as technologies for collecting and distributing road traffic information, including traffic signal and probe information), which requires cooperation among automobile manufacturers, and the establishment and social implementation of a foundation for the realization of automated driving (equivalent of SAE Level 3) on ordinary roads. As part of these efforts, this project will conduct research and development for the social implementation of the provision of traffic signal information (SPaT information) using cloud and other technologies.



Name	Role
Prefectural Police Headquarters Traffic Control Center	Generates upcoming SPaT information based on command information from traffic lights and sends the generated information to the NPA SPaT information aggregation system. Manages information used for linking with dynamic maps.
National Police Agency SPaT information aggregation system	Collects upcoming SPaT information from traffic control centers across the country and sends the collected information to the SPaT Information Center.
SPaT Information Center	Sends SPaT information to providers' delivery centers.

4. SPaT information provision methods

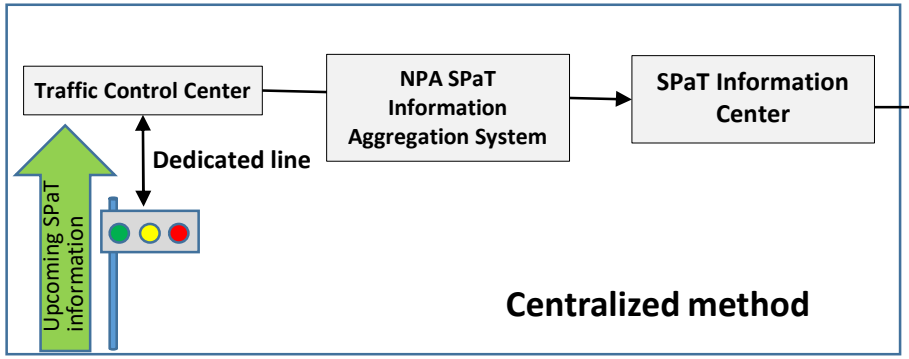
The R&D studies and develops methods for providing upcoming SPaT information, which is generated by traffic control centers or traffic signal controllers, aggregated temporarily to the NPA SPaT information aggregation system via LTE lines, etc. and then provided to delivery centers. Based on the results of the examinations carried out in fiscal 2020, the R&D will focus on the examination of the control-based method and explores the centralized and controller-based methods as complementary to the control-based method.



* SPaT Information Center and Delivery Center are provisional names.

Delivery Center (Servers of private sector providers, etc.)

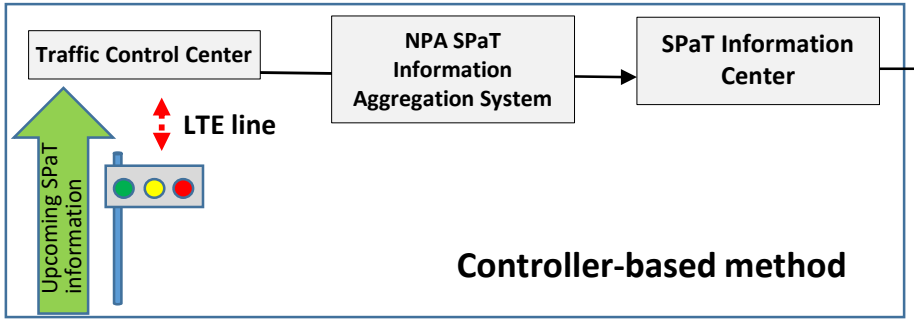
The method by which upcoming SPaT information is created at traffic control centers.



Delivery Center

The method by which upcoming SPaT information is created by traffic signal controllers.

★ Applicable to traffic signal controllers that are remotely controlled from traffic control centers



Delivery Center

The method by which the current traffic light information and upcoming SPaT information are created by traffic signal controllers at each intersection.

★ Applicable to independently operating traffic signal controllers

5. Implementation system

UTMS Society of Japan a, c

(Takes charge of the operation of both committees)

Panasonic System Solutions Japan Co., Ltd. b, h

Submit results of examination and verification

NIPPON SIGNAL CO., LTD. d - g

Verifies the control-based method and centralized method

OMRON Social Solutions Co., Ltd. f, g

Verifies the control-based method and controller-based method

SPaT Information Center Examination Committee

The National Police Agency, transportation infrastructure manufacturers, vehicle manufacturers, traffic information providers, communications carriers, etc.

[Deliberation issues]

a. Examination of social functional requirements (the need) of the SPaT Information Center

b. Examination of technical requirements of the SPaT Information Center

c. Examination of the implementation entity of the SPaT Information Center

h. Examination of reducing the functions of the National Police Agency's SPaT information aggregation system

To be confirmed through deliberations
Overlap areas are confirmed by both sides

Committee to examine technology for providing SPaT information utilizing cloud and other technologies

The National Police Agency, transportation infrastructure manufacturers, vehicle manufacturers, map-related companies, communications carriers, etc.

[Deliberation issues]

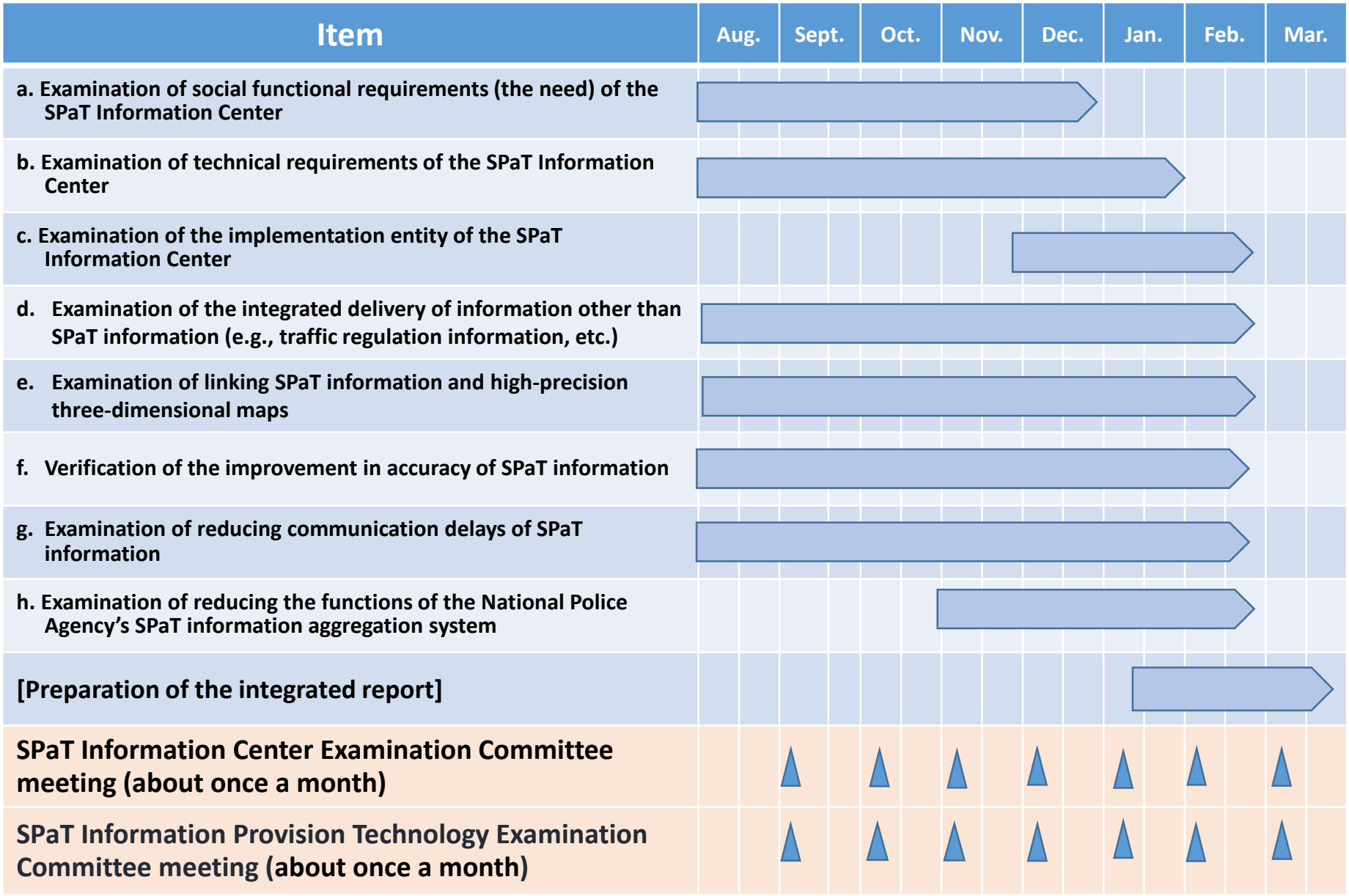
d. Examination of the integrated delivery of information other than SPaT information (e.g., traffic regulation information, etc.)

e. Examination linking SPaT information and high-precision three-dimensional maps

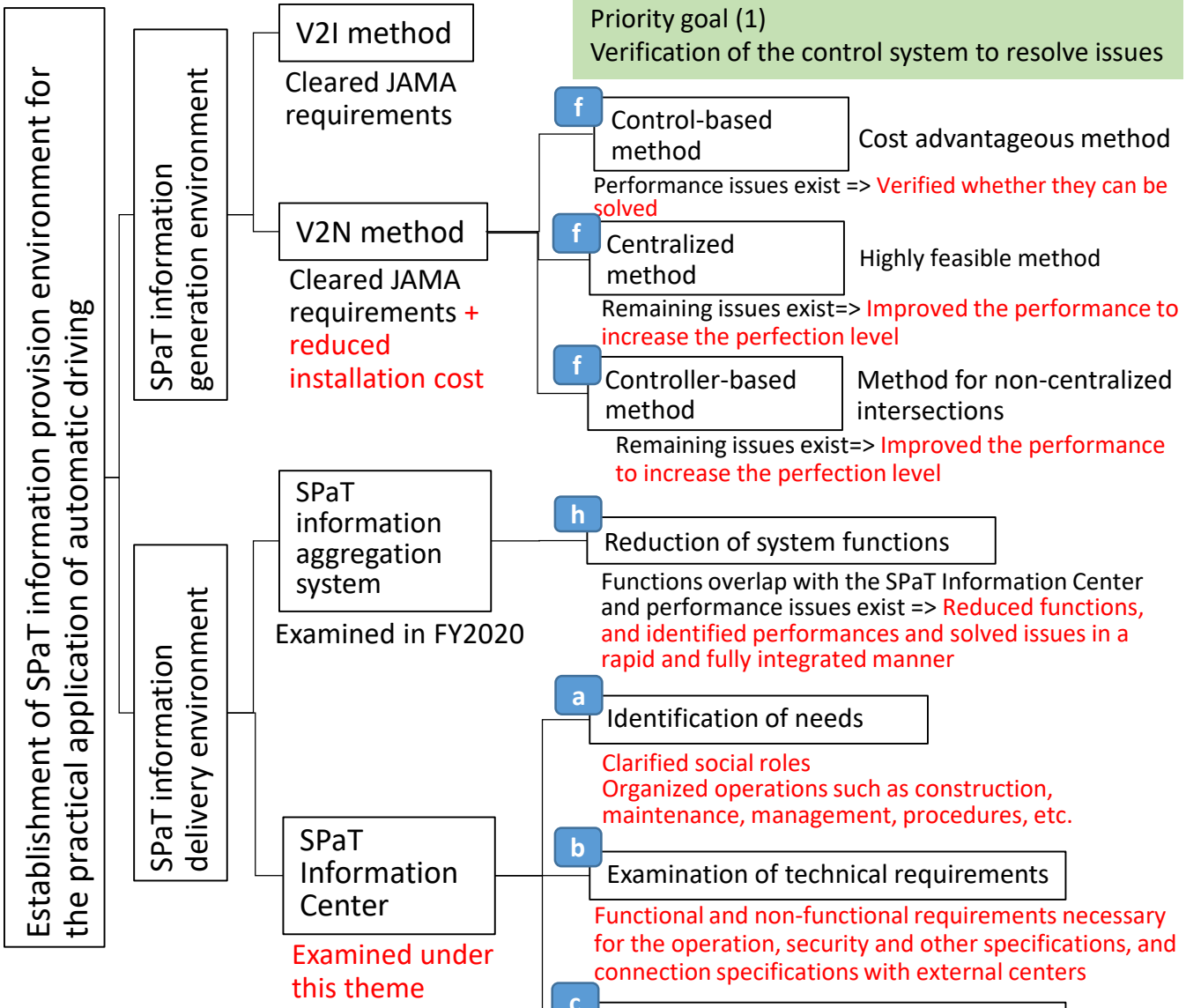
f. Verification of the improvement in accuracy of SPaT information

g. Examination of reducing communication delays of SPaT information

6. Schedule of the research and development

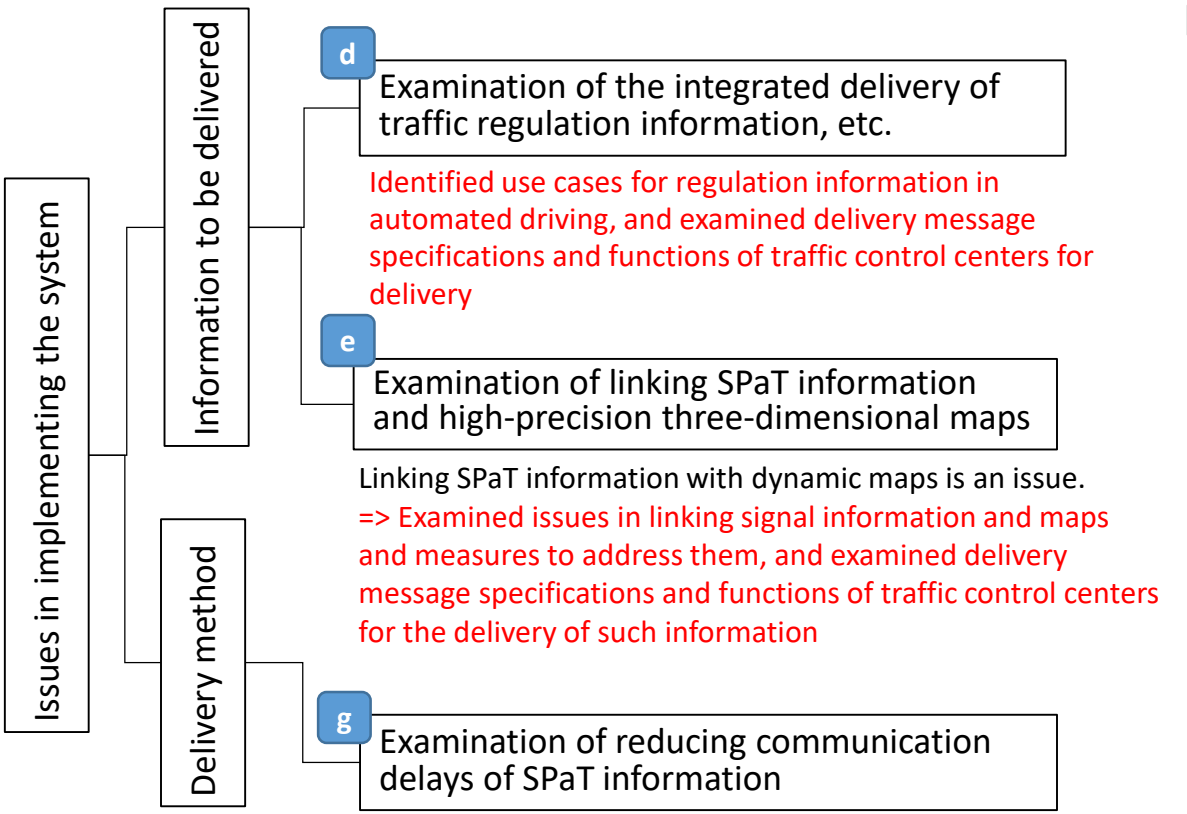


7. Results and issues against the R&D goals (1/2)



[Results]	[Future issues]
○	Completion of technical examination Examination of installation guidelines (ease JAMA requirements, expand applications to driver assistance)
○	Test in a final form
○	Test in a final form
○	Test in a final form
○	
○	
○	

7. Results and issues against the R&D goals (2/2)

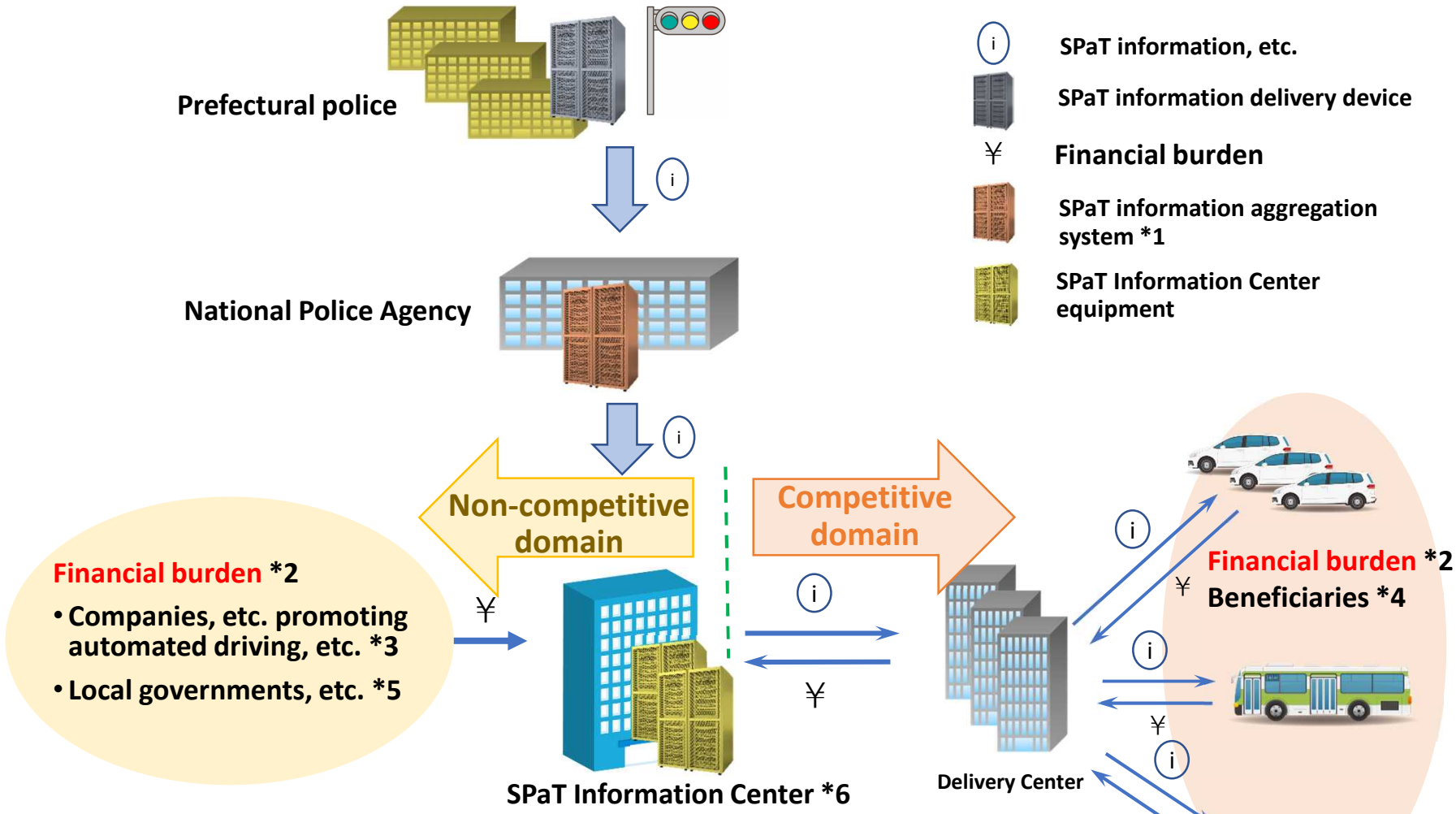


	[Results]	[Future issues]
d	Identified use cases for regulation information in automated driving, and examined delivery message specifications and functions of traffic control centers for delivery ○	
e	Linking SPaT information with dynamic maps is an issue. => Examined issues in linking signal information and maps and measures to address them, and examined delivery message specifications and functions of traffic control centers for the delivery of such information ○	Development of specifics of the linking method, and determination of function placement
g	Communication delay issues have emerged in the control-based method, centralized method, and center-to-center communications under the FY2020 theme. →Analyzed issues from SPaT information delivery origins to delivery destination and examined mitigation measures. ○	Test in a final form Identification of the relationship between the physical distance of each center and delay times

8. Overall picture of the SPaT Information Center project (assumption)

a

(UTMS Society of Japan)



*1 SPaT information aggregation system: Its functions including its technical perspectives need to be discussed in the process of starting operation
*2 Financial burdens: The allocation of the burden of initial and maintenance costs needs to be discussed, and the burden here is limited to those necessary for the operation of the SPaT Information Center.
*3 Companies, etc. promoting automated driving, etc.: OEMs and other companies promoting automated driving
*4 Beneficiaries: Including not only vehicle operators but also data users such as MaaS operators, etc.
*5 Local governments: Prefectural police are not included. They are, for example, prefectures, cities, towns, and villages that operate buses, etc.
*6 SPaT Information Center: Specified as a conceptual positioning, and the decentralization of functions to regions, etc. need to be discussed in the future.

8. Social requirements needed to be met by the SPaT Information Center

a

(UTMS Society of Japan)

Item	Necessary social requirements	Issues
Operation of an organizational entity	• Managerial planning function • Function to secure financing	• Securing of human resources (those with experiences in financing including the securing of payments from beneficiaries, and with the ability to think from a public perspective) • Smoothness of communication with related organizations
Relaying of SPaT information	• Relay-related operational functions • Recovery response function at the time of an event	• Securing of human resources (those with experiences in operations) • Experiences of similar tasks
Installation, preservation, management, repair and operation of the SPaT Information Center	• Planning and design of signal information center facilities and related ordering functions • Security management functions • Handling of routine failures • Support for delivery centers	• Securing of human resources (field engineering and dynamic database specialists) • Experiences of similar tasks • Ensuring of a nationwide system
Technical connection to the delivery center	• Functions to implement the installation, etc. of connection equipment, etc. (including the construction works of the SPaT Information Center facilities), etc.	• Securing of human resources (those with technology management skills) • Experiences of similar tasks
Procedural connection to the delivery center	• Acceptance (confirmation of terms and conditions) function • Fee (to be borne by beneficiaries) collection function	• Securing of human resources (those with customer service experiences) • Experiences of similar tasks
Technical support to the delivery center	• Technical support including the confirmation of specifications, standards, etc.	• Securing of human resources (those with knowledge of newly developed SPaT information provision technology)

※ **Human resources shown in red** should be secured by the SPaT Information Center. Operations and facility-related personnel can be outsourced.

8. Conditions for implementing entities of the SPaT Information Center

(UTMS Society of Japan)

C

Relationship with the Road Traffic Law

From the perspective of being responsible for SPaT information, etc., which requires higher reliability than conventional traffic information, it is necessary to satisfy at least Article 38-7, Paragraph 2 of the Enforcement Regulations of the Road Traffic Law.

"aims to contribute to the safety and smoothness of traffic on roads by providing information on road traffic….. and has the necessary and appropriate organizations, facilities and capacity to conduct affairs pertaining to the provision of traffic information prescribed in paragraph (1) of the same Article." (Article 38-7, Paragraph 2 of the Enforcement Regulations of the Road Traffic Law)

Fulfillment of social requirements

Need to fulfill the necessary social requirements (slide 12)

Items among the functional requirements for which it is appropriate to seek a technical solution, such as facility development, technical support, etc., can be entrusted to other organizations

Matters to consider

- Limiting the number
- Utilization of existing organizations
- Participation of experienced organizations

- Due to the nature of the operation of relaying between the police and the competitive domain, it is appropriate that the least possible number of organizations be responsible for the SPaT Information Center from the perspective of the burden on the police side, maintenance of security, nationwide uniformity, and operational feasibility (if possible, a single organization with a nationwide and 24-hour system that can guarantee neutrality and fairness and manage all functions in an integrated manner while taking into consideration regional decentralization of the functions).
- Due to the nature of supporting automated driving, management certainty to ensure sustainability is important, and one of the most promising ways to achieve this is to expand the operation of an existing organization that has a certain track record.
- The need to secure human resources for planning, management decisions, etc. requires the participation of organizations with experience in the field of traffic information.

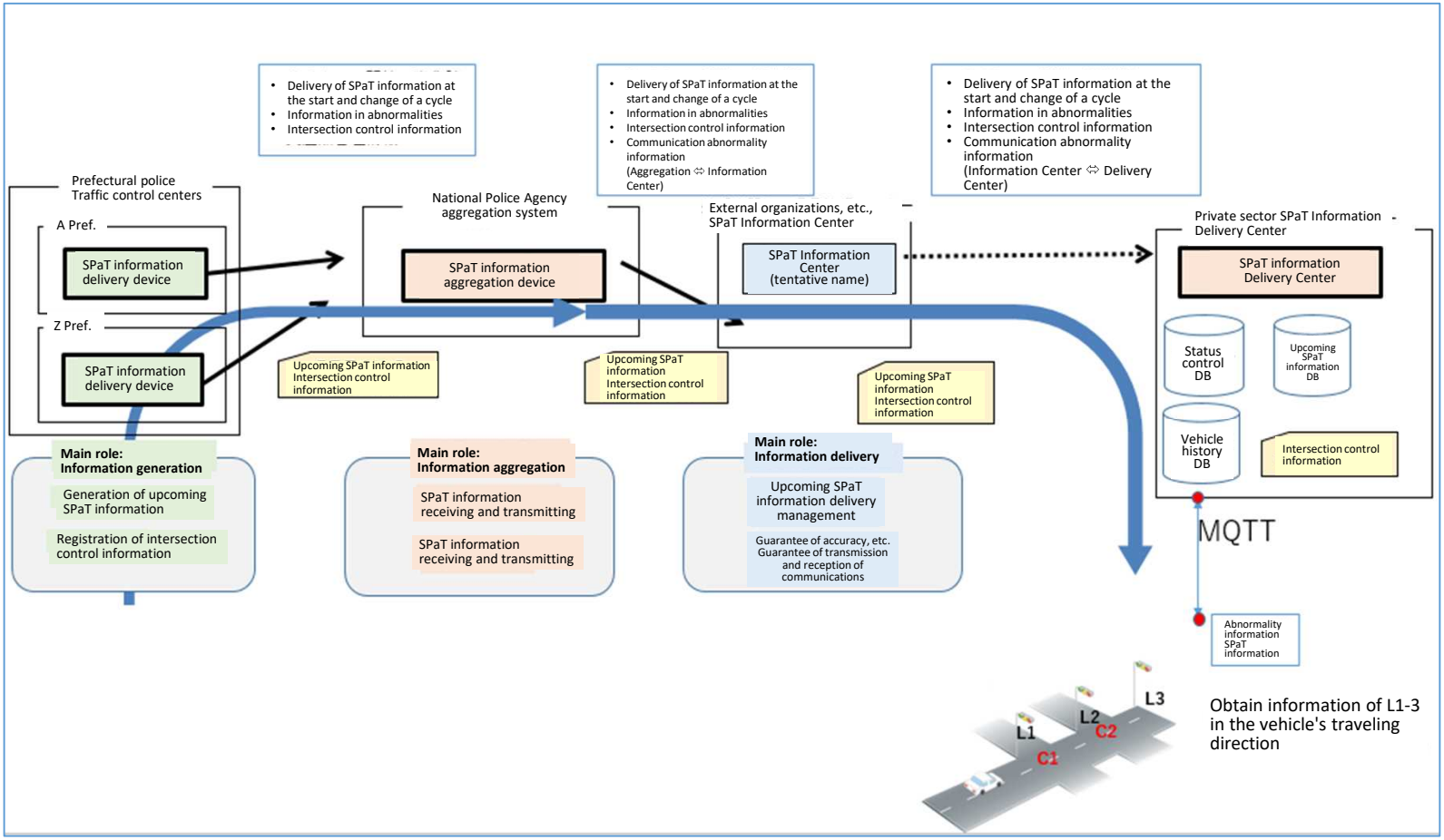
9. Overall configuration and necessary functions for the technical requirements of the SPaT Information Center

b

(Panasonic System Solutions Japan Co., Ltd.)

[Technical requirements of the SPaT Information Center, etc.]

- **Specification of a system for the SPaT Information Center that receives aggregated signal information from the Prefectural Police traffic control centers through the NPA SPaT information aggregation system and transmits the information to the SPaT Information Delivery Center.**
  (Draft specifications for the signal information aggregation system have already been prepared in FY2020)
- **Redesign of roles among each of the above devices**



9. Examination of configuration and functional placement for the technical requirements of the SPaT Information Center

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b

(1) Examination of hardware configuration

- **Organization of hardware configuration (roles of each device)**
- **Calculation of resource capacity (memory, hard disk) (per day, per month)**
- **Hardware and its functional requirements for SPaT information aggregation devices and the SPaT information Center's system devices**
- **Examination of technical (performance) requirements**

(2) System configuration (the consistency of device placement and function)

- **Verification of minimum required system configuration (monitoring, storing of communications logs, databases)**
- **Examination of the utilization of theory and devices (the following items should be considered)**
- **Data management consistent with the operation of intersection control information**
- **Method of transmitting error information between upcoming SPaT information and devices**
- **Examination with consideration to the system neutrality requirements of the software for building databases needed for other than OS and middleware.**

(3) Examination of reports (the reference system)

(4) Network environment and non-functional requirements

9. Identification of functions specified in the technical requirements of the SPaT Information Center

b, h

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Examination of the functions of the SPaT information aggregation system and the Signal Information Center and determination of functional items

Division of system functional roles

A proposed division of system functions that will serve as a premise for examining the requirements for the SPaT information aggregation system and SPaT Information Center system, in order to realize the service of providing SPaT information.

	Cooperative domain			Competitive domain (private sectors)
System	Prefectural police/Traffic control system	National Police Agency/ SPaT information aggregation system	SPaT Information Center/ SPaT Information Center System (tentative)	Delivery Center/Delivery Center System (tentative)
Main devices	SPaT information delivery device	SPaT information aggregation device	SPaT information provision device (tentative)	SPaT information delivery server (tentative)
Division of system functions	● Generation of SPaT information ● Registration of intersection control information	● Aggregation of nationwide information and integration of routes	● Ensuring of consistency of rules and regulations for SPaT information, etc.	● Management of delivery of upcoming SPaT information
	● Management of communications, etc. ● Historical records inquiry	● Communications monitoring (communication error response) ● Historical records inquiry	● Delivery management and inquiry	-
	● Management of provision of upcoming SPaT information (Ensuring of consistency of upcoming SPaT information)	● Various verifications of demonstration experiments (Including the time of launching the service)	● Management of information provided	-

[Legend] ● Red: Functions that were shifted from those in the last year's specifications.

10. Performance measurement (performance improvement and bottleneck factors)

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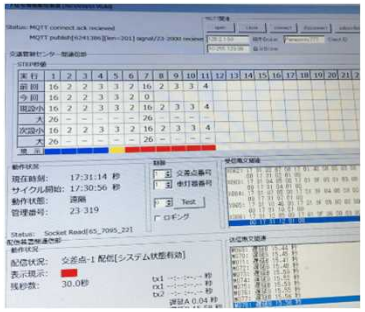
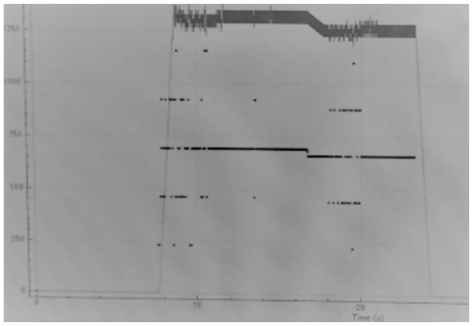
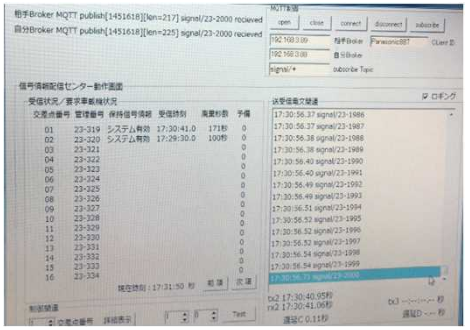
Traffic control center



SPaT information delivery device

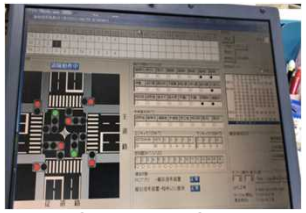


12.5 Mbps bandwidth with USB-LAN, etc.

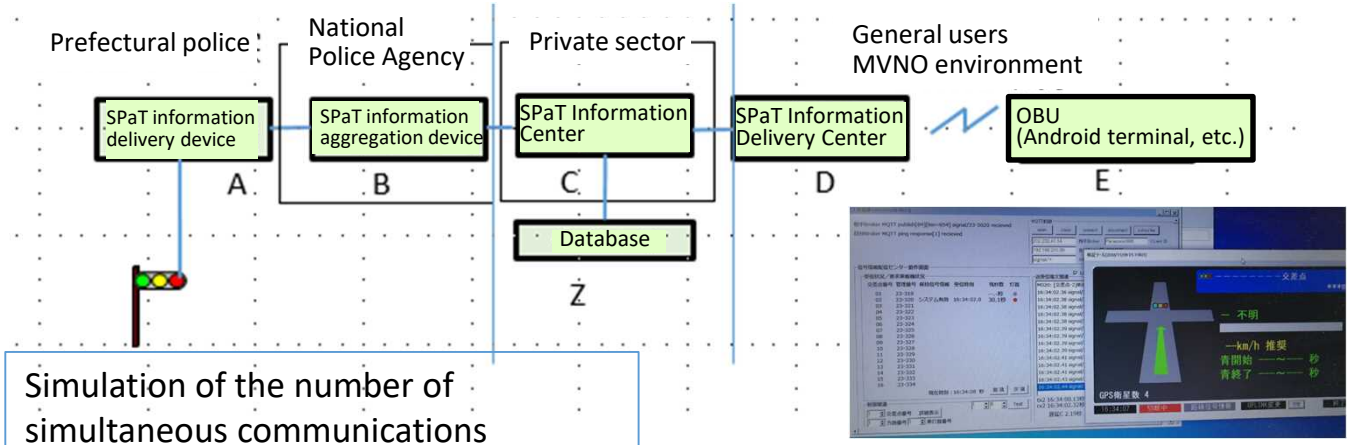


SPaT Information Delivery Center

Terminal control unit



Pseudo signal controller with 0.1 sec. processing



Simulation of the number of simultaneous communications
4000 intersections with the cycle length of 60 sec.
100 intersections (99.99%)

Aging data during the packet communication over a general public network will be obtained.
Obtained the number of retransmissions

10. Examination of internal processing to reduce delays, etc.

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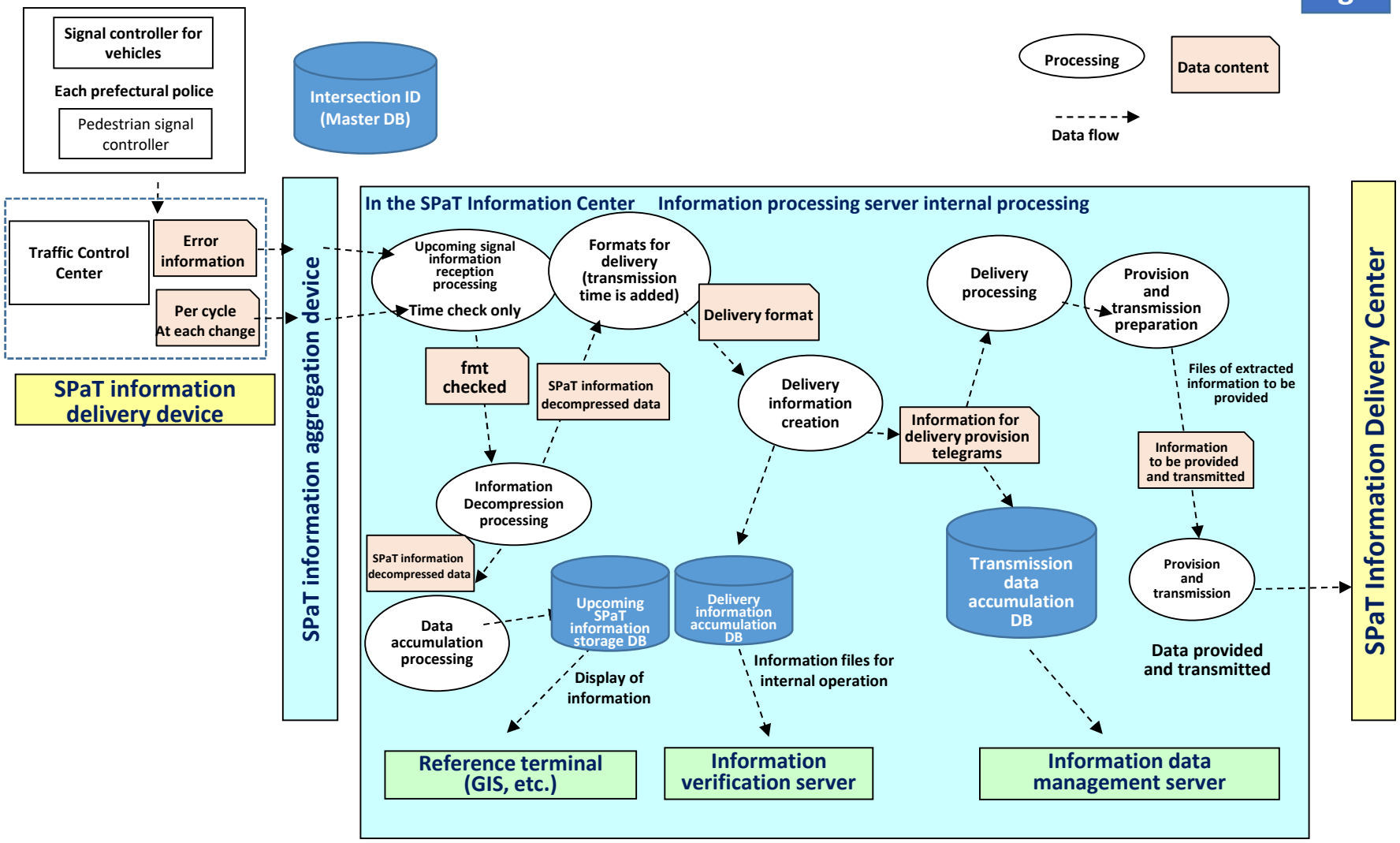

(1) Creation of an environment for measuring the performance of the header load processing section
(2) Revision of the number of simultaneous communication processing
(3) Time check processing
(4) No retransmission processing

10. Performance measurement results

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Measurement environment

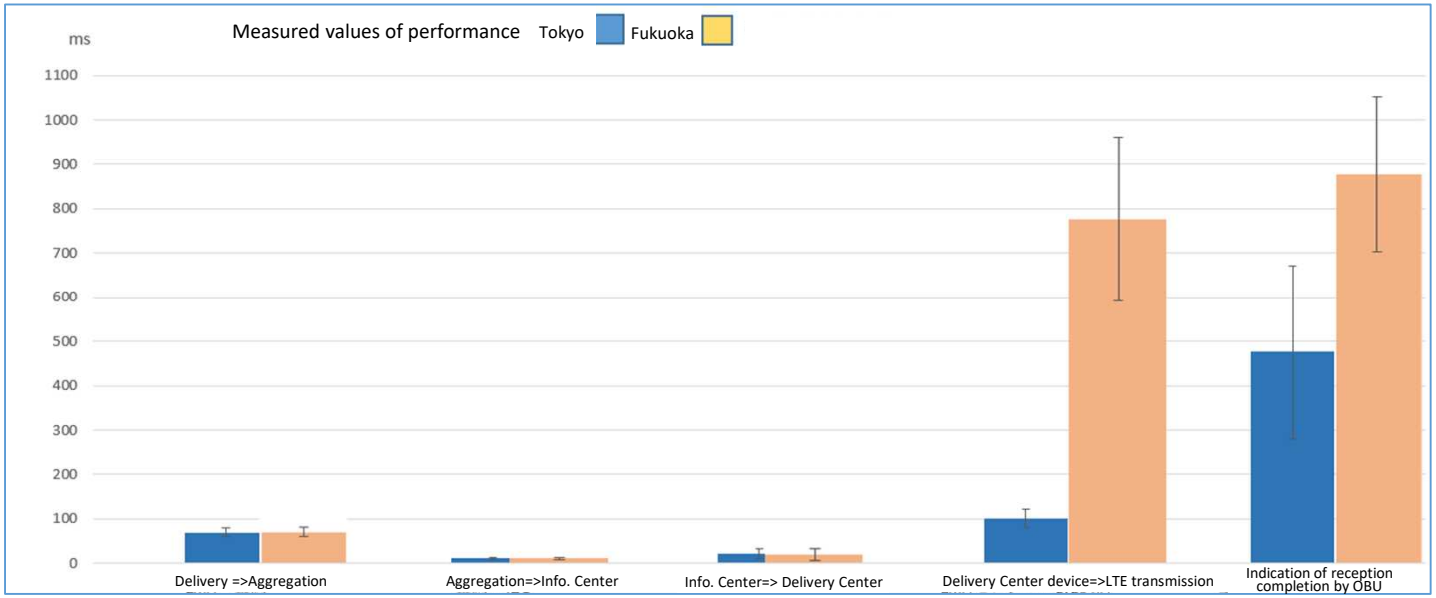
Between the simulated SPaT information delivery device (for each prefectural police) and the simulated SPaT information aggregation device Bandwidth: 12.5 Mbps
Cycle length: 100 sec Size of upcoming SPaT information: 585 bytes Number of simultaneous communications: 256 intersections
Location: In Fukuoka and Tokyo Measured at the same time period from 17:00 to 19:30

- In FY2020, verification was conducted between two devices. In FY2021, a simulated environment closer to the actual environment was created by such means as placing four devices (the generation device, aggregation device, and the devices for the SPaT Information Center and Delivery Center) in different segments.

Results

Fukuoka Maximum 2.63 sec. Average 0.87 sec.
Tokyo Maximum 1.57 sec. Average 0.47 sec.
(Connectivity environment with PULL communication)

- As the processing time of the SPaT Information Center, delivery took 30 to 60 ms including communication time.
- Communication delays increase as the distance between the prefecture where the center is installed and the OBU increases.



10. Performance measurement results

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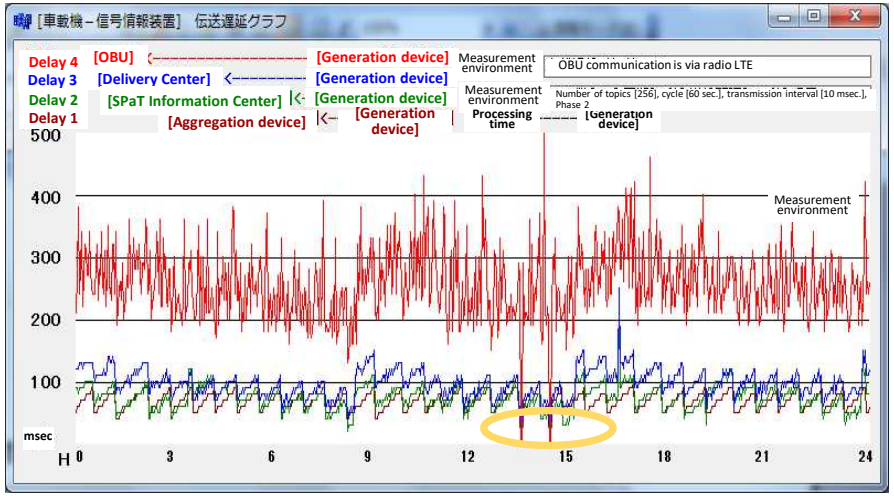
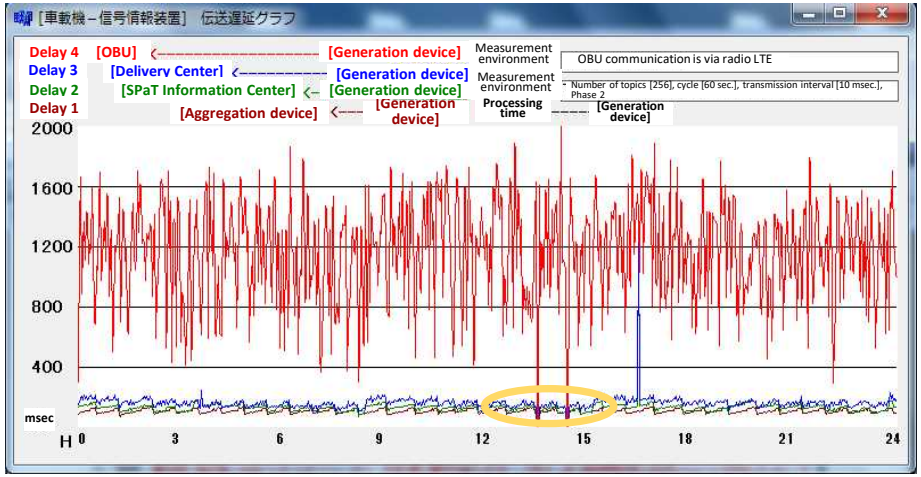
- In FY2020, the performance was evaluated by evaluating the delay time until writing data to the database and the delivery time from the Delivery Center to the simulated OBU, respectively, and then evaluating the results of the addition of both times. The result was a delay of around 2 to 3 seconds.
- In FY2021, the delay was reduced to 200 ms - 500 ms by setting up calls through the MQTT-PING data propagation result communication between the OBU and the Center at 1 second intervals in parallel with database writing.



Continuous operation with MQTT-PING at every 1 sec.



Continuous operation without MQTT-PING

Communication between the Center and the OBU was lost twice during 24-hour continuous operation, disabling measurement. Restored after retries.

10. Investigation of Δt and Δd (processing + communication delay)

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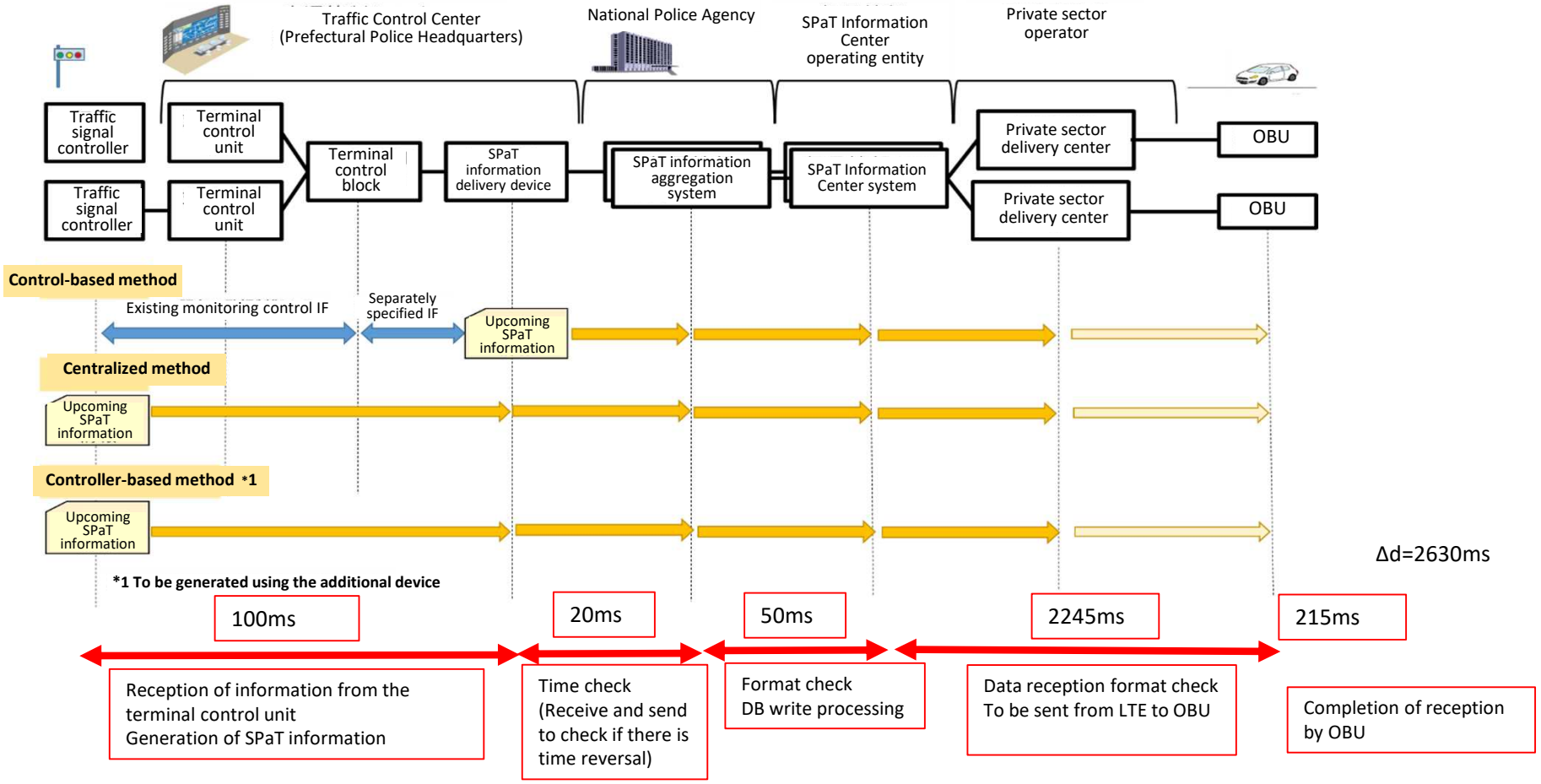
In the case of Fukuoka when the maximum value is 2630 ms (refer to Slide 19)



Time from the start of the cycle to the end of green > Time for the upcoming SPaT information to reach the OBU + ΔT was confirmed.

10. Verification of the improvement in accuracy of SPaT information (Control-based method)

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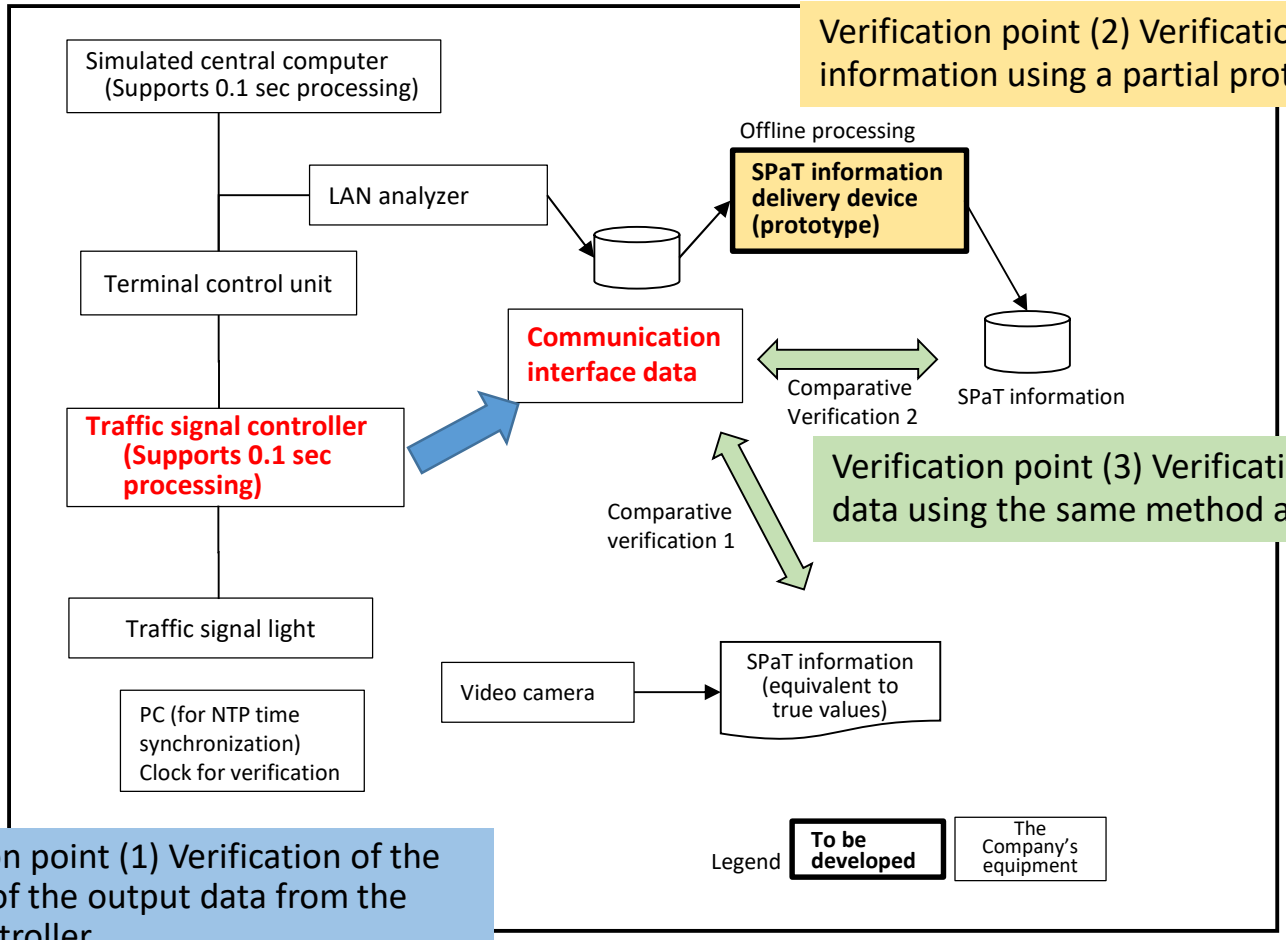
(OMRON Social Solutions Co., Ltd.)

The verification confirms that the accuracy of the output data is the required accuracy in order to edit signal information based on the output data from the signal controller (0.1 second processing). To perform effective verification in a short period of time, a prototype of off-line processing was developed. To verify more data (with a longer period of time), video cameras were used, and data-to-data comparisons were conducted.



11. Verification of the improvement in accuracy of SPaT information (Control-based method)

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(OMRON Social Solutions Co., Ltd.)

Verification point	Verification results	Issues and prospects
Verification of the accuracy of the output data from traffic signal controllers	Confirmed the improvement of time accuracy by GPS (error of less than 100 msec).	No problem under normal conditions. Need to check GPS satellite supplementation status at intersections.
	Confirmed the improvement of the accuracy of signal control history (error of less than 150 msec).	Sufficient accuracy as source information for upcoming SPaT information. No issues.
	Confirmed the accuracy of recall request receipt information.	SPaT information provision at pushbutton activated intersections, which had been an issue to date, is now possible.
Verification of the accuracy of SPaT information using a partial prototype	Verified that JAMA requirements are met for the Company's signal controllers. Examined operation specifications during abnormal conditions based on actual data.	Signal controllers manufactured by other companies may not meet JAMA's requirements due to expected performance degradation during offset transition. This is due to the fact that detailed specifications for offset transition of signal controllers are not made available to public. The committee discussed several proposed measures, but no conclusion has been reached. This issue will be discussed, including the relaxation of JAMA’s requirements. Confirmation is underway as to whether there are any issues or not, including the operation on the OBU side in the event of an abnormality.

Supplementary material: Error analysis model for the control-based method

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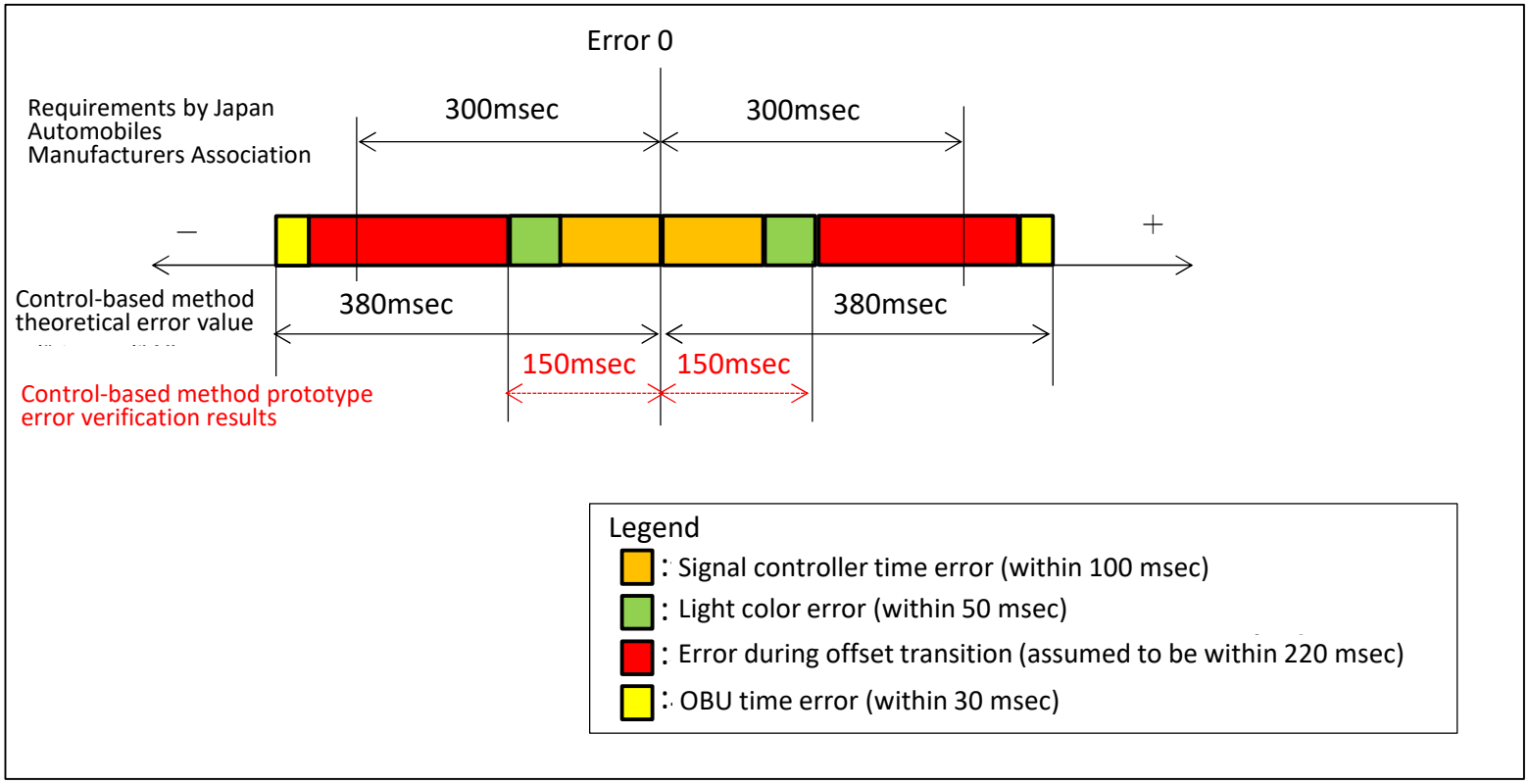
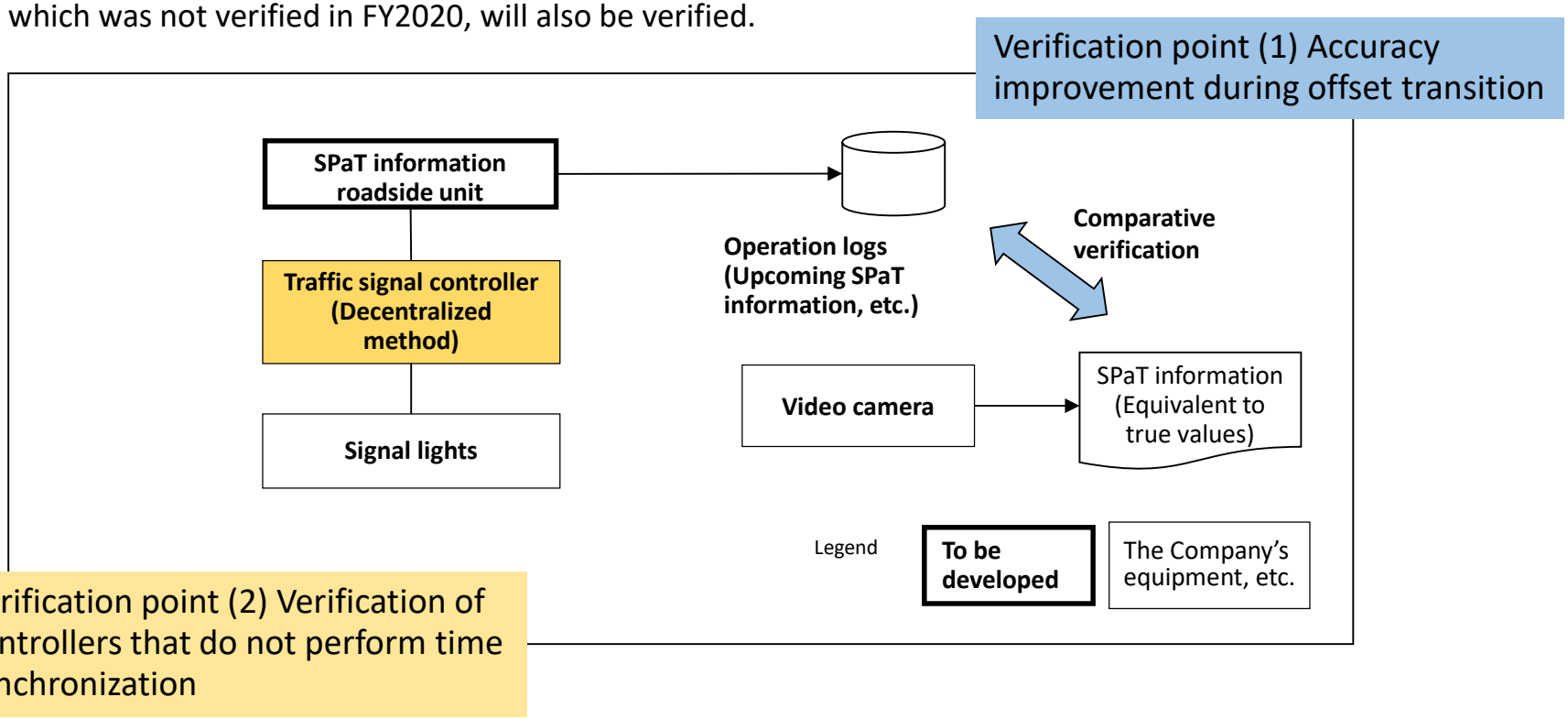
In the case of signal controllers manufactured by other companies, up to **200 msec is added** as an error during offset transition, which may result in **a total signal error of 380 msec. Measures to improve the error and relaxation of requirements will be examined.**



12. Verification of the improvement in accuracy of SPaT information (Controller-based method)

(OMRON Social Solutions Co., Ltd.)

Measures will be taken to address the accuracy decline during offset transition that was found in the FY2020 verification of the prefectural police model system, and the verification that the accuracy improves will be conducted. Also, the accuracy of controllers that do not perform time synchronization, which was not verified in FY2020, will also be verified.



Supplementary information: Other than "adding SPaT information roadside unit" to the signal controllers currently in operation, the controller-based method can also be implemented by upgrading current signal controllers to those that support the method.

12. Verification of the improvement in accuracy of SPaT information (Controller-based method)

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Verification point	Verification results	Issues and prospects
Accuracy improvement during offset transition	It was confirmed that during coordinated control, offset transition in 0.1 sec increments occurs depending on the manufacturer of the signal controller. It was confirmed that the JAMA requirements will be satisfied by learning offset transition in 0.1 sec increments.	It is necessary to verify the accuracy of SPaT information for signal controllers operated at intersections through long-term operation. It is desirable to verify the operation using signal controllers from manufacturers that performs offset transition in 0.1 sec increments.
Verification of SPaT information when traffic signal controllers are not time-synchronized	It was verified that, even when signal controllers are not time-synchronized, upcoming SPaT information is correctly generated by time estimation performed by the signal controllers.	It is necessary to verify the accuracy of SPaT information for signal controllers operated at intersections through long-term operation.

12. Reducing communication delays

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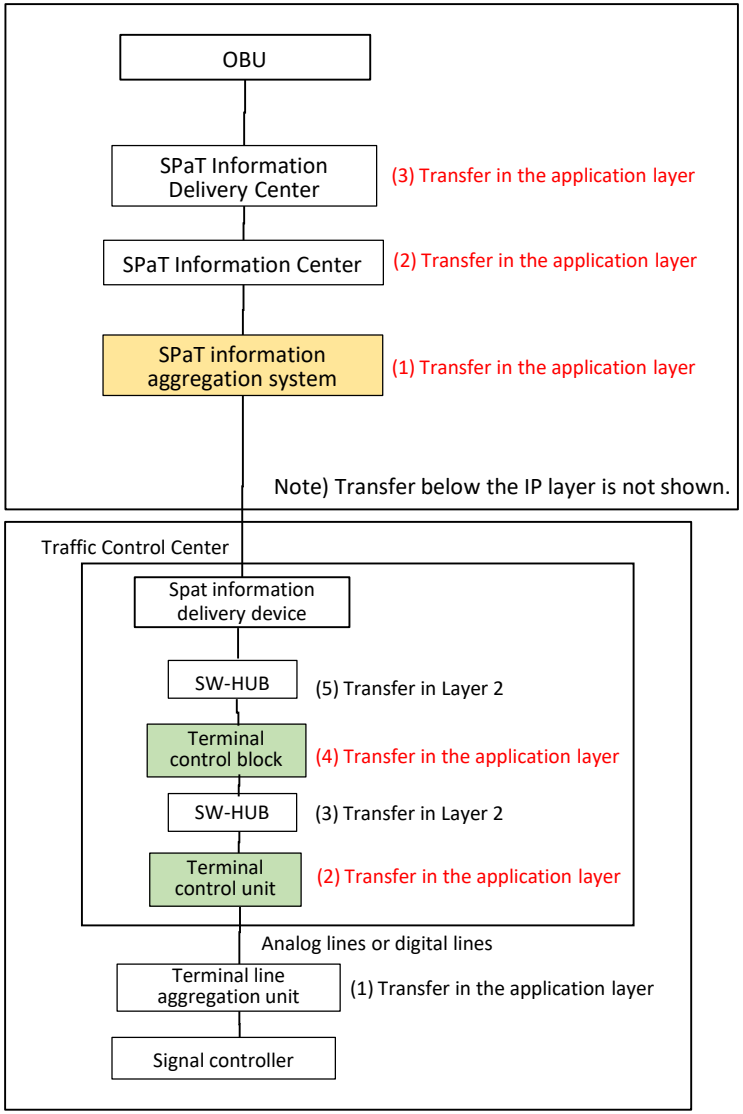
Assuming that the transfer time in the application layer is the cause of communication delay, the delay time for each device will be measured and measures to improve performance will be examined.



Verification point (1) The cause of the communication delay is assumed to be the transfer in the application layer.

With minimum required transfer functions, processing delays are small and there are no issues.

Verification point (2) For center-to-center communication, delays are measured by implementing transfer processing with MQTT using a prototype, and overall communication delay times are estimated.

Delay time increases by several percent when the number of traffic signals or the number of simultaneous generations of upcoming SPaT information increases.

Response to delays that are characteristic of communications are being examined

Verification point (3) Investigate transfer time of existing interfaces and examine measures to improve performance.

Confirmed the occurrence of a delay time of about 1.4 sec in the specifications. Timing will be designed as a precondition in the future.

13. Verification of the improvement in accuracy of SPaT information

(in the control-based method, centralized method)/communication delay reduction

f, g

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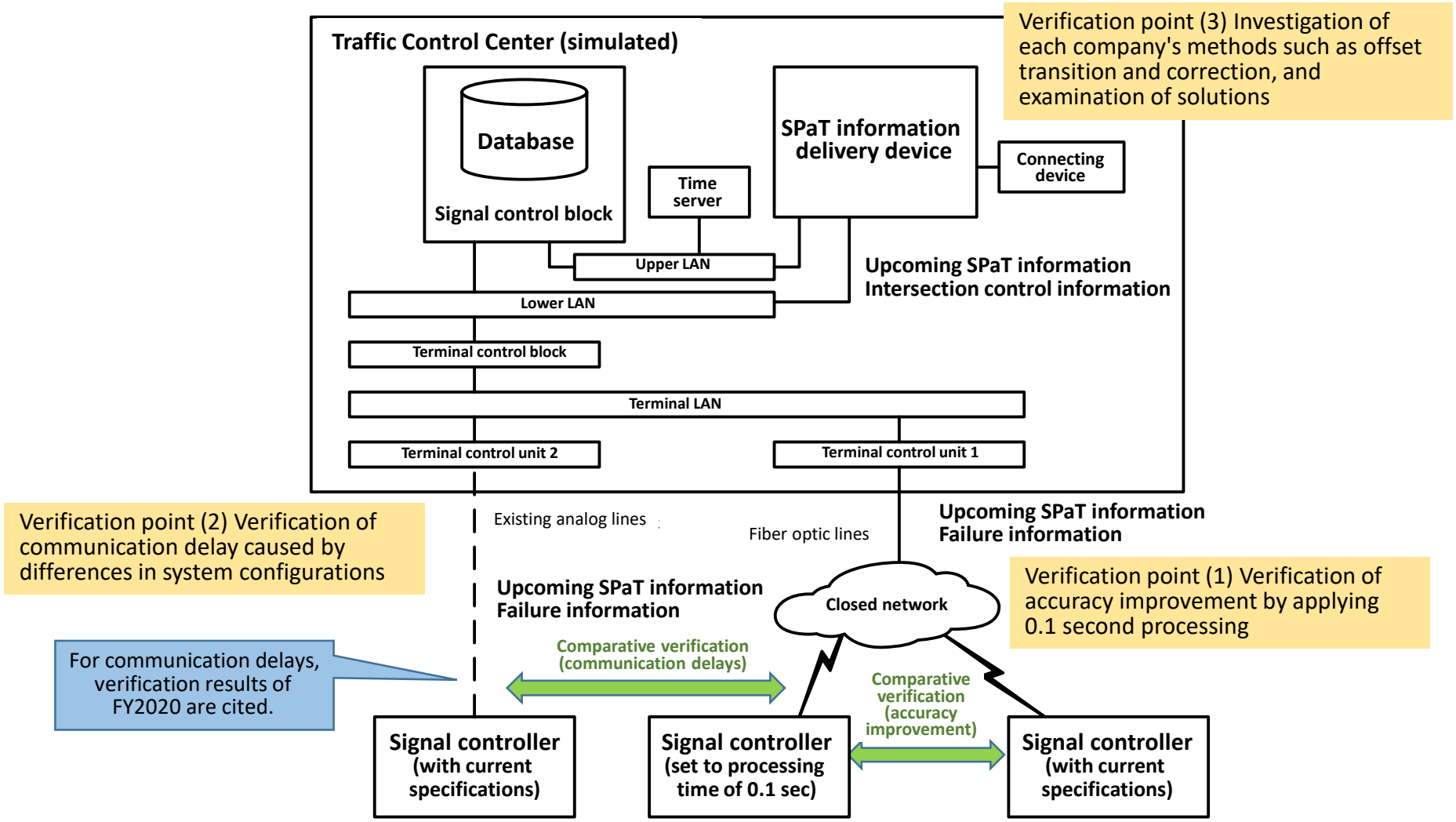
A simulated traffic control center environment was created, and comparative verification was conducted between signal control (0.1 second processing) and that of the current specification (1 second processing). The verification was conducted while effectively utilizing data from the actual field experiment in FY2020, and the effects of introducing the system to the actual field was estimated.



13. Verification of the improvement in accuracy of SPaT information (with control-based method, centralized method)/communication delay reduction

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Verification point (1) Verification of accuracy improvement by applying a 0.1 second processing cycle

The intersection tested in Saitama in FY2020 was simulated within the network, verified the accuracy of SPaT information with both the control-based and centralized systems, and compared the results with those of FY2020 (results of the experiment with the former specifications).

Comparison with the FY2020 experiment results (control-based method)

Fiscal year	Version of traffic signal controller	Number of measurements	Maximum value	Minimum value	Average value	Standard deviation
FY2020	Version 4	84	-3,073	-43	-2,066	645
	Version 4 (with GPS correction)	84	-2,191	-244	-1,366	631
FY2021	Version 5	114	267	-117	170	46

Compared to FY2020 (Version 4), deviations in FY2021 (Version 5) were significantly reduced, indicating an improvement in accuracy.

Comparison with the FY2020 experiment results (centralized method)

Fiscal year	Version of traffic signal controller	Number of measurements	Maximum value	Minimum value	Average value	Standard deviation
FY2020	Version 4	170	1,312	7	476	481
	Version 4 (with GPS correction)	181	274	0	-12	75
FY2021	Version 5	236	-167	0	-71	34

Compared to FY2020 (Version 4 with GPS correction), deviations in FY2021 (Version 5) were slightly reduced, indicating a modest improvement in accuracy.

13. Verification of the improvement in accuracy of SPaT information

(with control-based method, centralized method)/communication delay reduction

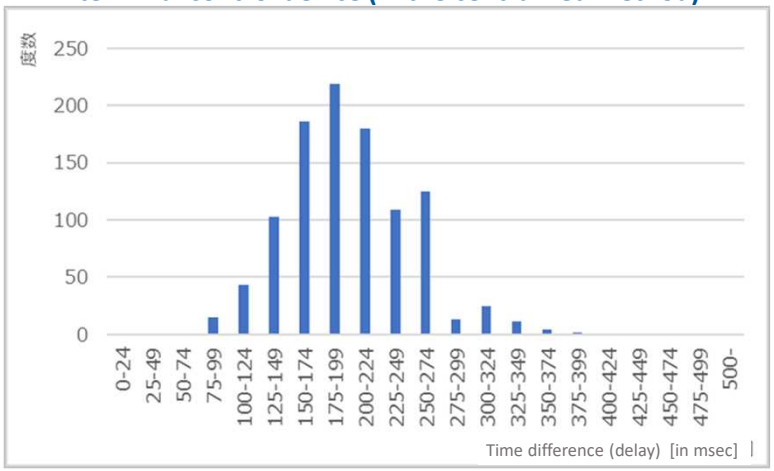
(NIPPON SIGNAL CO., LTD.)

f, g

Verification point (2) Verification of communication delay caused by differences in system configurations

The time difference between the data creation time in the traffic signal controller and the data reception time in the terminal control device and the simulated OBU was measured as communication delay and was compared with the FY2020 results (the results of a test using an analog line in the field).

Communication delays between traffic signal controller and terminal control device (in the centralized method)



- **The difference in time from data generation in the traffic signal controllers to data reception in the terminal control devices (≒ the delay that occurred in the MVNO line section) was from 90 to 390 milliseconds.**
- **In other Field Operational Tests(FOTs) that have been conducted to date, the actual results in the MVNO line section have averaged 100 to 200 milliseconds, which are equivalent to the results of the experiment this time.**

Comparison with the FY2020 experiment results (between the traffic signal controllers and simulated SPaT Information Center with the centralized method)

Fiscal year	Version of traffic signal controller	Communication line to terminal	Number of measurements	Maximum value	Minimum value	Average value	Standard deviation
FY2020	Version 4 (with GPS correction)	Analog	105	4720	1350	2307	855
FY2021	Version 5	MVNO	1035	1430	550	960	148

Although the delay in FY2021 (MVNO lines) is significantly lower than in FY2020 (analog lines), this is believed to be due partly to the impact of the decrease in the number of devices to be routed as a result of the change of the terminal control unit from II to I.

13. Verification of the improvement in accuracy of SPaT information (control-based method, centralized method)/communication delay reduction

f, g

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Verification point (3) Investigation of each company's methods such as offset transition and correction, and examination of solutions

[Background]

In the control-based method, change in the number of seconds of signal caused by offset transition needs to be added when SPaT information is generated in the traffic control center; however, detailed differences are assumed to be exist in each manufacturer's calculation methods, such as in methods of allocating the amount of offset transition to each split, and this may result in discrepancies between the calculation results of the traffic control center and the outputs of signal lights.

[Implementation of questionnaire survey]

Implementation period: From December 23, 2021 to January 7, 2022
Survey respondents: Five traffic signal controller manufacturers
Content: Method of determining and calculating the amount of offset transition and solution to this issue

[Results]

The results of the questionnaire survey found that there are differences between the companies in methods of determining and calculating the amount of offset transition. Generating upcoming SPaT information following each company's calculation logic may be one solution; however, when assuming signal control using traffic signal controller with new specifications, improvement in accuracy is expected for recognition errors, and although there is the possibility of not being able to satisfy the accuracy of ± 300 msec required by JAMA, the errors caused by this problem is believed to be limited to around 500 msec at the maximum. Therefore, it was decided that measures will be determined together with other solutions, giving priority to cost advantage.

<Reference> **Offset: A phase difference between traffic signals (difference in switchover timing)**
Offset transition: When the cycle length and offset change due to traffic conditions, time of day, etc., values are changed gradually to meet the target values, taking into account the impact on traffic and safety.

13. Summary on the verification of the improvement in accuracy of SPaT information

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It was confirmed that the increase of recognition errors in the control-based method, which was the issue for FY2020, is improved by the new specification for traffic signal controllers and the central computer of the traffic control center. Improvement was also confirmed, although modest in degree, in the centralized method.

Item	Content	Control-based method	Centralized method	Controller-based method (information generated by roadside unit)	Controller-based method (information generated by controller)	Police A
SPaT information generation accuracy	Normal operation Note 1	○	○	○	○	○
	During offset transition	× Note 2	○	○	○	○
	Traffic-actuated control by terminals	—	○	○	○	○
Fail-safe	Detection of abnormal conditions (consistency with signal light colors)	×	○	○	○	○
Operation	Centralized control	○	○	—	—	○
	Non-centralized control	—	—	○	○	—

－： Not appliable

Note 1) A state in which the traffic signal controller operates at timings in seconds determined by the control center.

Note 2) Recognition errors of up to around 500 msec may occur. (JAMA target ±300 msec)

The recognition error of ±300 is believed to be satisfied by combining the control-based method and centralized method for intersections with centralized control and by applying the controller-based method for intersections with non-centralized control. However, issues of communication delays exist in the fail-safe system of the control-based method and in both methods in the V2N environment, and continued examination is necessary to address notification delays in the event of abnormalities and when the number of seconds of signal steps changes due to traffic-actuated control by terminals.

14. Examination of the integrated delivery of information other than SPaT information (traffic regulation information, etc.)/Examination of linking SPaT information and high-precision three-dimensional maps

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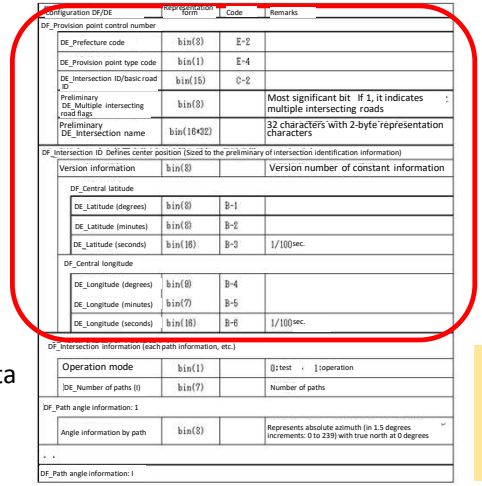
In addition to examination of the feasibility with experts toward realization, simulations (desk-top verification) were conducted based on several examples.

Intersection control data (example)

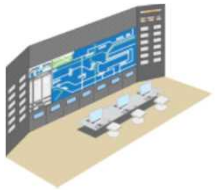


Configuration DF/DE	Representation form	Code	Remarks
DF_Provision point control number			
DE_Prefecture code	bin(8)	E-2	
DE_Provision point type code	bin(1)	E-4	
DE_Intersection ID/basic road ID	bin(15)	C-2	
Preliminary DE_Multiple intersecting road flags	bin(8)		Most significant bit If 1, it indicates multiple intersecting roads
Preliminary DE_Intersection name	bin(16*32)		32 characters with 2-byte representation characters
DF_Intersection ID Defines center position (Sized to the preliminary of intersection identification information)			
Version information	bin(8)		Version number of constant information
DF_Central latitude			
DE_Latitude (degrees)	bin(8)	B-1	
DE_Latitude (minutes)	bin(8)	B-2	
DE_Latitude (seconds)	bin(16)	B-3	1/100sec.
DF_Central longitude			
DE_Longitude (degrees)	bin(9)	B-4	
DE_Longitude (minutes)	bin(7)	B-5	
DE_Longitude (seconds)	bin(16)	B-6	1/100sec.
DF_Intersection information (each path information, etc.)			
Operation mode	bin(1)		0:test 1:operation
DE_Number of paths (I)	bin(7)		Number of paths
DF_Path angle information: 1			
Angle information by path	bin(8)		Represents absolute azimuth (in 1.5 degrees increments: 0 to 239) with true north at 0 degrees
DF_Path angle information: I			

Verification point (1) Whether information can be integrated with traffic regulation information

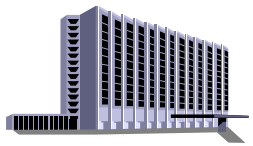
Linking

Verification point (2) Information required for linking to maps and rules for assigning IDs, etc.



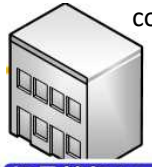
Traffic Control Center (Prefectural Police Headquarters

Intersection control data



National Police Agency SPaT information aggregation system (National Police Agency)

Intersection control information



SPaT Information Center (tentative)

Intersection control data

SPaT Information Delivery Center (providers, etc.)

Competitive domain

Verification point (3) Function placement and maintenance and management methods

System configuration (example)

14 Examination of the integrated delivery of information other than SPaT information (traffic regulation information, etc.)/Examination of linking SPaT information and high-precision three-dimensional maps

d, e

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Integration with traffic regulation information (Examination point (1))

It was decided that, among the items of intersection control information to be defined by each prefectural police for linking them with high-precision three dimensional maps, intersection IDs and central longitude and latitude information will be aligned with traffic regulation information that had already been made available as open data.

Large category	Format item	Attribute	Byte count	Notes
Prefecture information				
	Prefecture code	Code	2	[Common code] Refer to prefecture codes
	Police station code	Code	4	[Defined by prefectural police
	Related police station code 1	Code	4	[Defined by prefectural police
	Related police station code 2	Code	4	[Defined by prefectural police
	Related police station code 3	Code	4	[Defined by prefectural police
	Related police station code 4	Code	4	[Defined by prefectural police
	Related police station code 5	Code	4	[Defined by prefectural police
	Related police station code 6	Code	4	[Defined by prefectural police
	Related police station code 7	Code	4	[Defined by prefectural police
	Related police station code 8	Code	4	[Defined by prefectural police
Information by regulation type				
	Code by common regulation type	Code	6	[Common code] Refer to codes by common regulation type
	Point, line and area code	Code	2	[Common code] Refer to point, line and area codes
	Name by regulation type by prefecture	Characters	100	
Date management				
	Regulation decision date	Date	10	YYYY/MM/DD
Regulation number management				
	Unique key by prefecture	Numerical value	12	Unique key by prefecture
	Regulation number	Numerical value	8	
	Number	Numerical value	8	
Regulation information Location				
	Longitude and latitude of regulation location	Coordinate	No limit	World Geodetic System (WGS84) Fractional degree values with variable length Up to 16 bytes (16 characters) including decimal points of each longitude and latitude "Longitude (X1) Latitude (Y1)" "Longitude (X2) Latitude (Y2)" ..... "Longitude (Xn) Latitude (Yn)" Example: "135.22490 35.31567" "135.22411 35.31572" ..."135.24131 35.72572"
	Regulation location start point	Characters	200	
Regulation information Route name				
	1 – Route 1	Characters	60	
	1 – Route 2	Characters	60	
	1 – Route 3	Characters	60	
	1 – Route 4	Characters	60	
Regulation information Direction				
Regulation information Targets and exemptions Time				
Regulation information Items by regulation type				
	Reason for update	Characters	200	
	Remarks	Characters	600	

From instructions of Traffic Regulation Information (103 kinds) on JARTIC Website

Traffic control information prepared by each prefectural police

Configuration DF/DE	Representation form	Remarks
DF_Provision point management No.		
DE_Prefecture code	bin(8)	
DE_Provision point type code	bin(1)	
DE_Intersection ID/Basic road ID	bin(47)	
Preliminary DE_Multiple intersecting road flag	bin(8)	If most significant bit is 1, it indicates multiple intersecting roads.
Preliminary DE_Intersection name	bin(16*32)	32 characters with 2-byte representation characters.
DF_Intersection information		
Version information	bin(8)	Represents the generation of traffic control information (1 -). This information prevents inconsistencies between the static information recognized by the vehicle side and SPaT information caused by changes of intersection locations and the number of paths due to road improvement works, etc.
DF Central longitude and latitude		
DE Longitude	bin(32)	Location longitude information. The geodesic is WGS84 (or its equivalent.) Positive values indicate east longitude, negative values indicate west longitude Unit is 0.0000001 degrees, range is -180 to 180.
DE Latitude	bin(32)	Location latitude information. The geodesic is WGS84 or its equivalent. Positive values indicate north latitude, negative values indicate south longitude. Unit is 0.0000001 degrees, range is -90 to 90.
Operation mode	bin(1)	0: Test 1: Operation
DE Number of paths (I)	bin(7)	Number of paths (up to 8)
DF_Path angle information: I		
DF_Angle information by path	bin(8)	Represents absolute azimuth (in 1.5 degrees increments: 0 to 239) with true north at 0 degrees.
DF_Path angle information: I		

14. Examination of the integrated delivery of information other than SPaT information (traffic regulation information, etc.)/Examination of linking SPaT information and high-precision three-dimensional maps

d, e

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1. Summary of investigation results of the linking of high-precision three-dimensional maps (Examination point (2))

In the Tokyo Waterfront area FOTs, the linking of signal lights on the high-precision three-dimensional maps with SPaT information was realized by creating the association table (hereafter SPaT information association table) to link the maps with SPaT information. Therefore, the realization of the provision of SPaT information using high-precision three-dimensional maps is believed to be feasible by providing **intersection ID (including location identification) and paths**, which are defined by the SPaT information association table.

2. Proposed function placement (Examination point (3))

In the Tokyo Waterfront FOTs, the SPaT information association table was managed by the simulated OBU; however, when looking at social implementation, it is believed that, rather than the information managed by each service provider, this is the information that needs to be managed by the cooperative domain as is the case with dynamic maps.

<Proposed function placement>

Prefectural police (including National Police Agency)	Cooperative domain for SPaT information provision (SPaT Information Center, map vendors, etc.)	**Competitive domain (Vehicle manufacturers, automated driving operators, etc.)**
Provision of the following information • Intersection IDs to identify information and location information to identify locations on maps • Information to identify path IDs and locations on maps	• Management of the SPaT information association table to link SPaT information (intersection IDs, paths) with high-precision three dimensional maps (stop lines (paths), signal lights) • Linking of high-precision three dimensional maps and SPaT information	Provision of SPaT information to vehicles

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