

**SIP-adus
Workshop
2020**



Provision of Traffic Signal Information for Automated Vehicles

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Requirements for Automated Vehicles



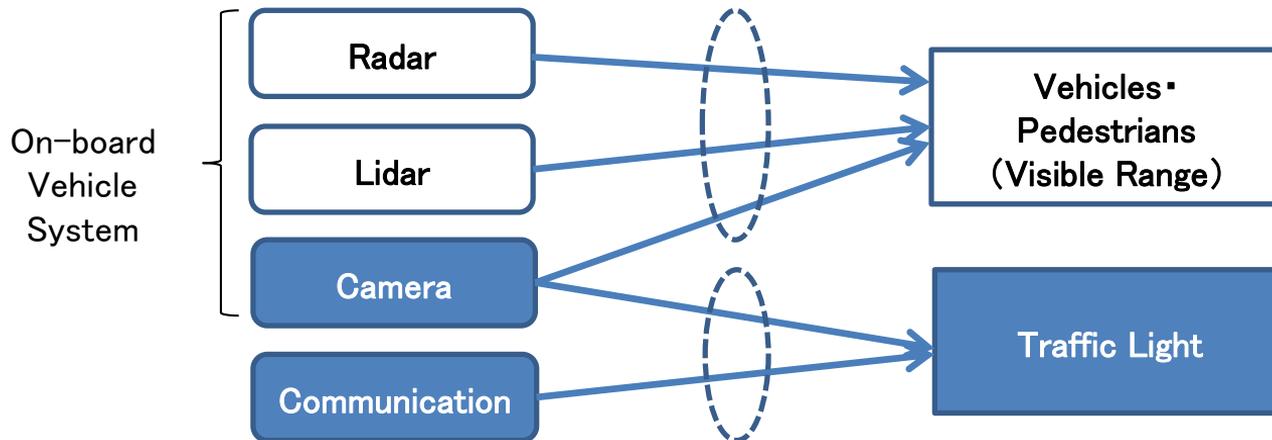
1.1 Needs of Traffic Signal Information

- Reliable awareness of the surrounding environment is essential for safety automated driving
 - Ensure certainty by "multiplexing" the recognition method
- Only the camera can recognize the signal light autonomously.
 - Reliable recognition by duplicating camera and communication information

■ Driving Process

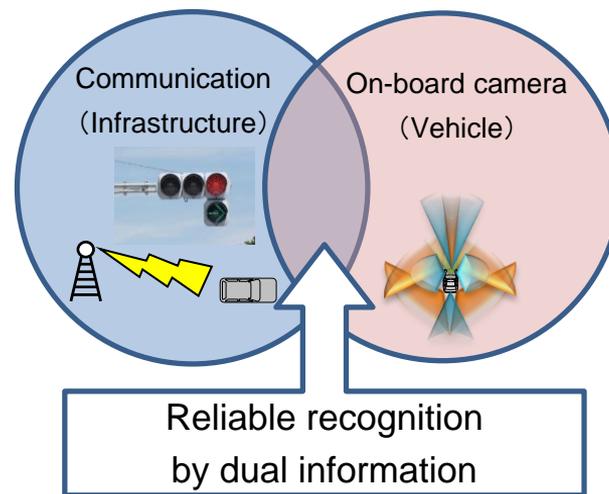
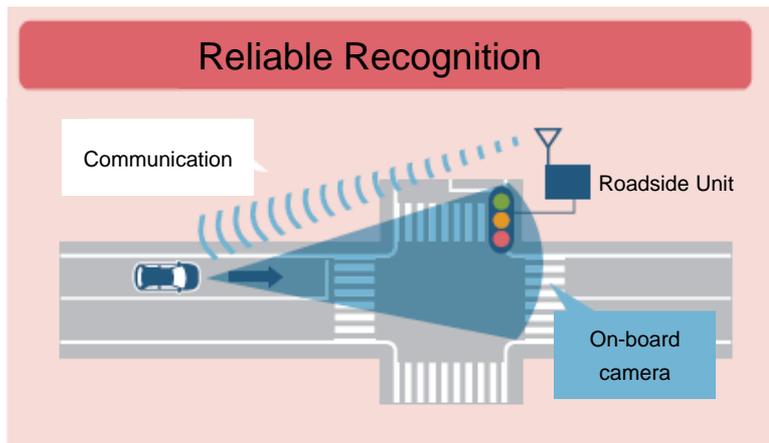


■ Recognition with Multiple Methods



1.2 Usage of Traffic Lights Information

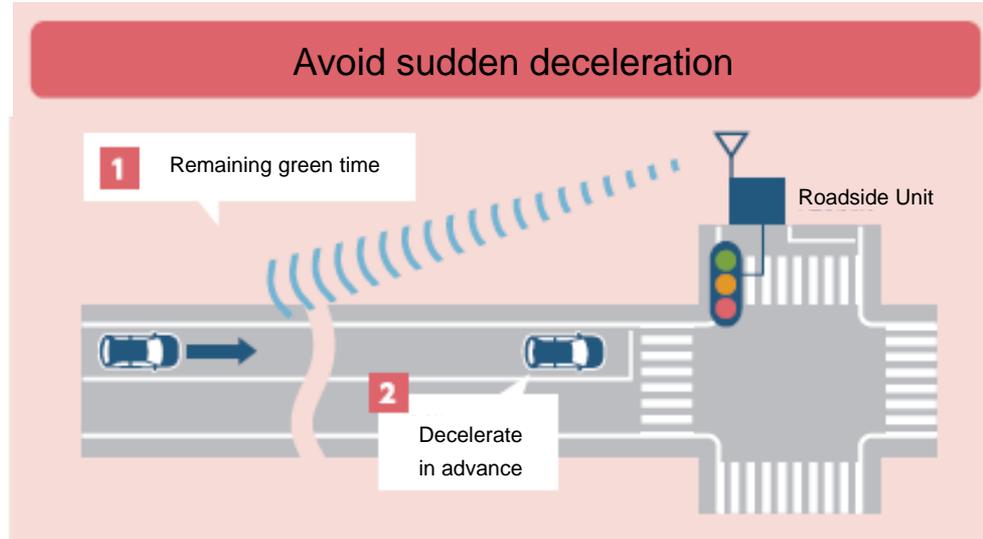
Dual system of information delivered from infrastructure and on-board camera information
→ Reliable recognition realizes safe intersection passage



1.3 Usage of Remaining Green Time

Decelerate in advance before the red light by getting the remaining green time (avoid entering the dilemma zone)

⇒ Avoid sudden deceleration and reduce the risk of rear-end collision



The remaining green time must be fixed before a certain amount of time before the light turns yellow.

1.4 Requirements for Automated Vehicles

◆ Accuracy

Information error when changing traffic light should be $\pm 300\text{ms}$ or less

◆ Ensuring the reliability

Implement a fail-safe function that confirms the match between the signal light color and the information and immediately notifies the occurrence of an abnormality

◆ Ensuring the availability

Realizing the provision of traffic signal information in various signal control methods

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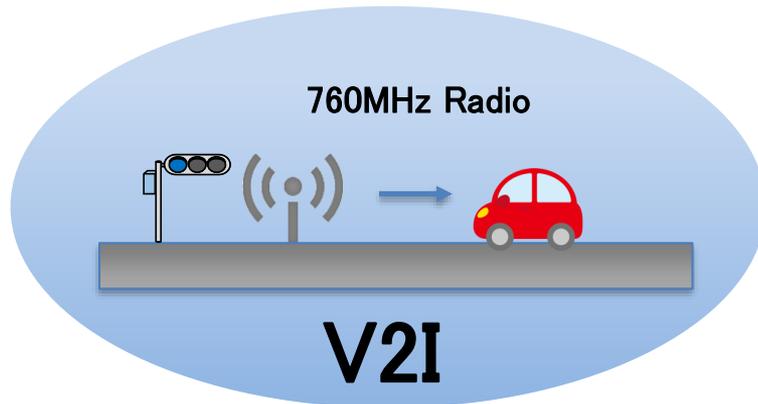
Research Outlines in SIP-adus



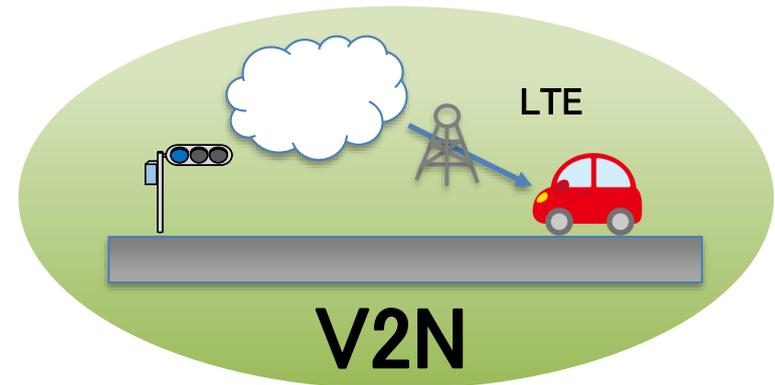
2.1 Outline of researches

Research of Traffic Signal Information Provision for Automated Vehicles

Provision of Traffic Signal Information using ITS radio

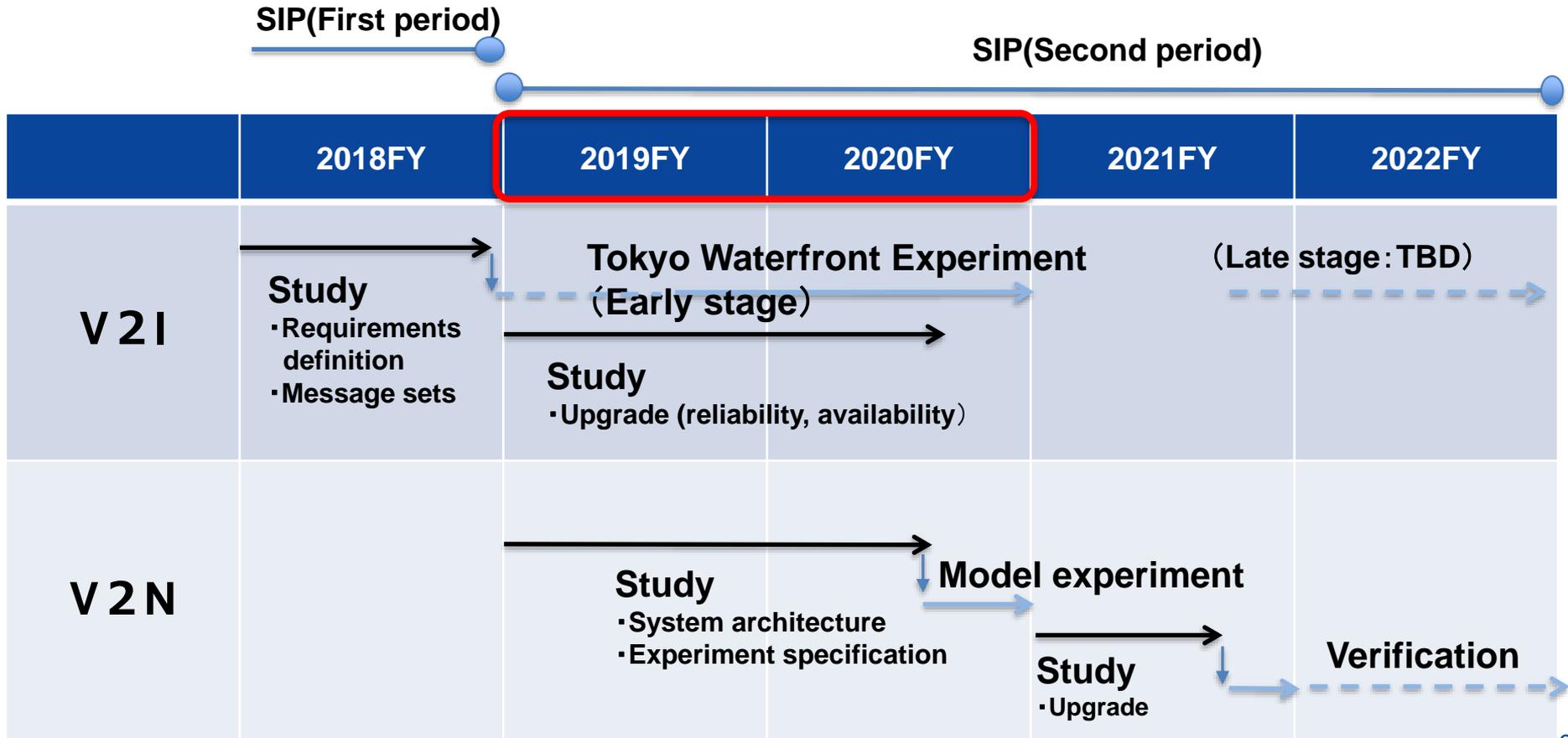


Provision of Traffic Signal Information via Cloud



- Optimal placement of both is required according to the features of intersections (signal control method, use case, etc.)

2.2 Schedule



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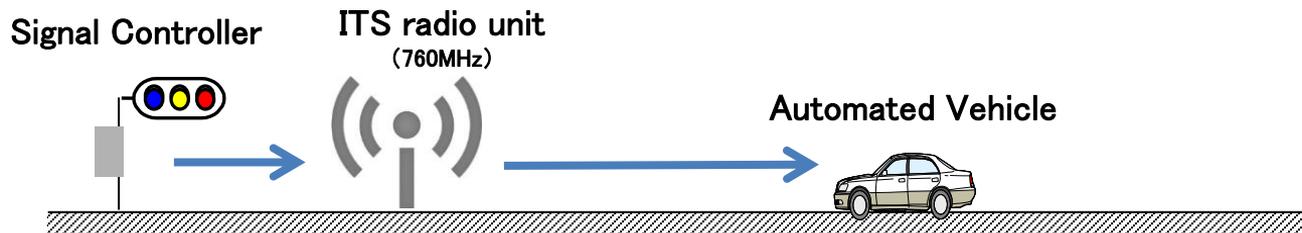
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Advanced Provision of Traffic Signal Information using ITS Radio



3.1 Outlines of ITS Radio

Item	General
Communication	Communication Band : 760MHz (755.5-764.5MHz) Protocol : ARIB STD-T109 Communication Type : Broadcast (once every 100ms) Security : Not published
Provision information	SPaT (Signal Phase & Timing complied with ISO/TS19091 Annex-F Profile-B)
Operation examples	The system, DSSS(Driving Safety Support Systems), has been introduced in more than 100 intersections in 10 prefectures and is providing services for commercial vehicles.
Location reference method	Utilize high-definition 3D map (Layer 1 of Dynamic Map)
Signal information reference method	Remaining time from the provided time (relative method) (In order to support DSSS vehicles that do not have an absolute time)

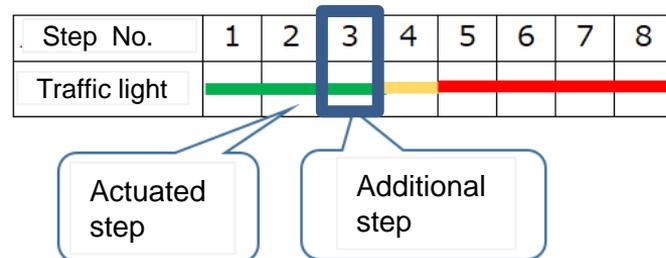


3.2 Data Accuracy

Classification	Example	Error	Supplementary description
Remaining time determined in advance	Cycle-by-cycle control	$\pm 100\text{ms}$	Satisfy requirements with a correction that subtracts a fixed delay time from the remaining time
Remaining time not determined in advance	Actuated Control	500ms (provision delay)	Not satisfy requirements

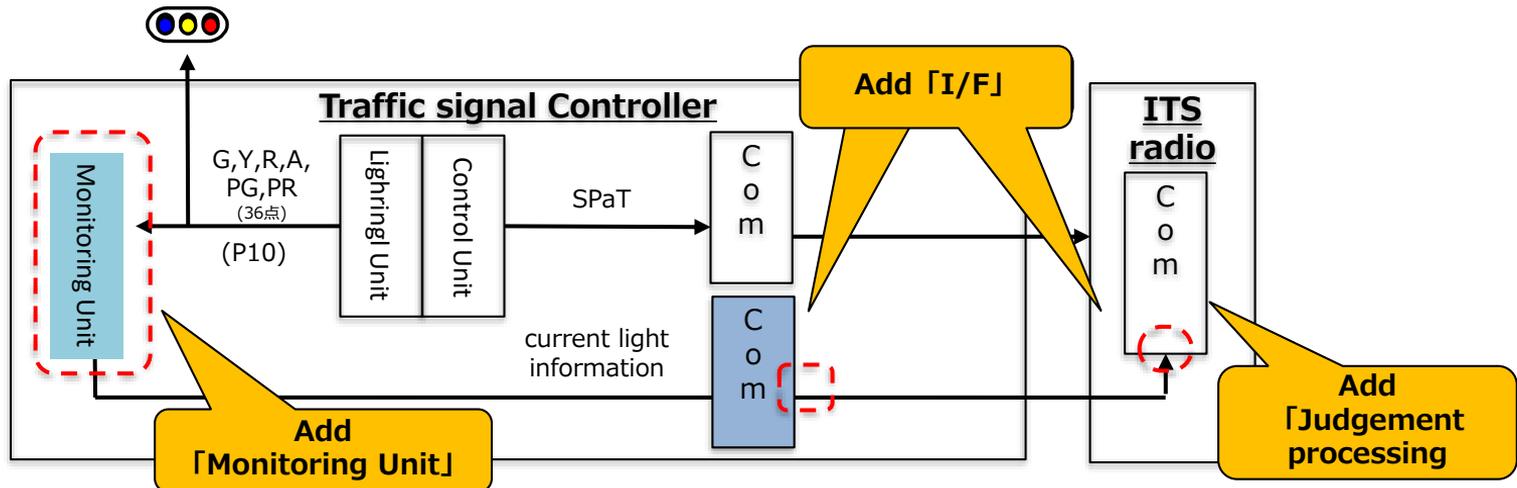
【Countermeasures for actuated control】

- Add a fixed green step equivalent to the delay (about 0.5 seconds) or more between the actuated control step and yellow light step. Thereby green time is predetermined.
- In case the above measures cannot be taken due to restrictions on signal control operation, the event will be notified to vehicles in advance.



3.3 Reliability

Items	Supplementary description
Fail-safe Specification	<ul style="list-style-type: none"> ➤ Traffic signal controller: Monitors the light status (voltage) of traffic lights. The monitoring result is transmitted to the ITS radio as current light information. ➤ ITS radio: Judges the matching of signal information and current light information
Verification Results	Delay time from fail occurrence to output judgment results is 600ms → Input as design information for error handling on the vehicle side



3.4 Availability

- **Consideration for improving availability**

Extract events that affect the provision of SPaT. Consider countermeasure policies from both functional and operational aspects

- **Research results**

Organize requirements for signal control operation

Expand SPaT provision function (1) Emergency vehicle priority control, (2) Push button control

No	Items	Issues	Measures
1	Yellow light	<ul style="list-style-type: none">• Dilemma zone occurrence in case of short yellow• Different operations at each intersection	At intersections above the specified speed limit, the yellow time shall be 4 seconds or more or uniformly 4 seconds (request for operation).
2	Actuated control	A dilemma zone occurs because the start of yellow cannot be notified in advance.	At intersections above the specified speed limit, a fixed green time is set between the actuated green and yellow (request for operation).
3	Push button control	Non-target of signal information provision	Verification of signal information provision function by secondary trial (specification revision)
4	Emergency vehicle priority control	Non-target of signal information provision	Verification of signal information provision function by secondary trial (specification revision)
5	Information disclosure	At an intersection where special signal control is executed such that the signal information changes suddenly, the abnormality / normality of the signal information cannot be determined by the car.	<ul style="list-style-type: none">Disclosure of operational information on signal control (request for operation)Notify events with I2V message (specification revision)

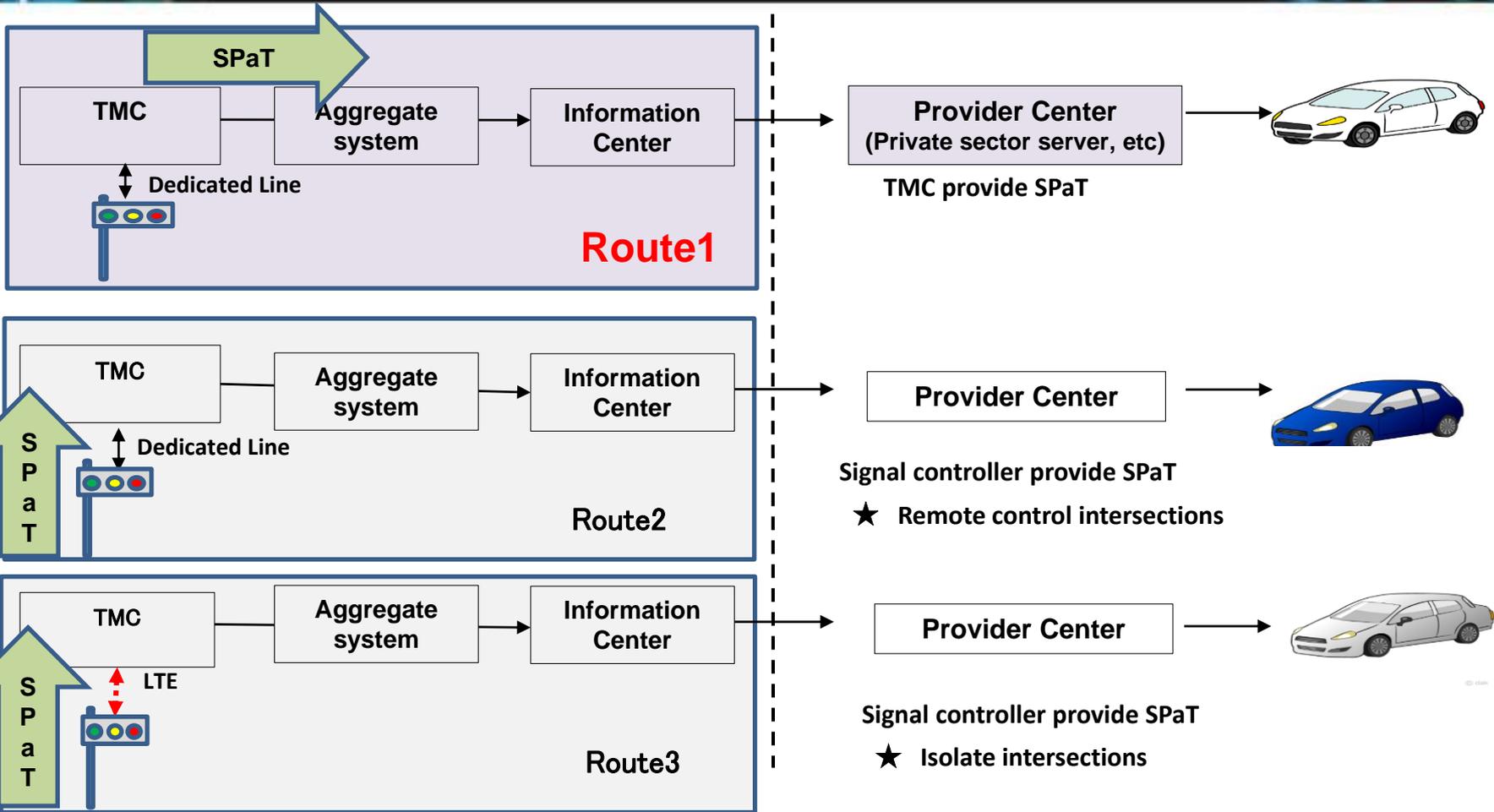
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Provision of Traffic Signal Information via Cloud

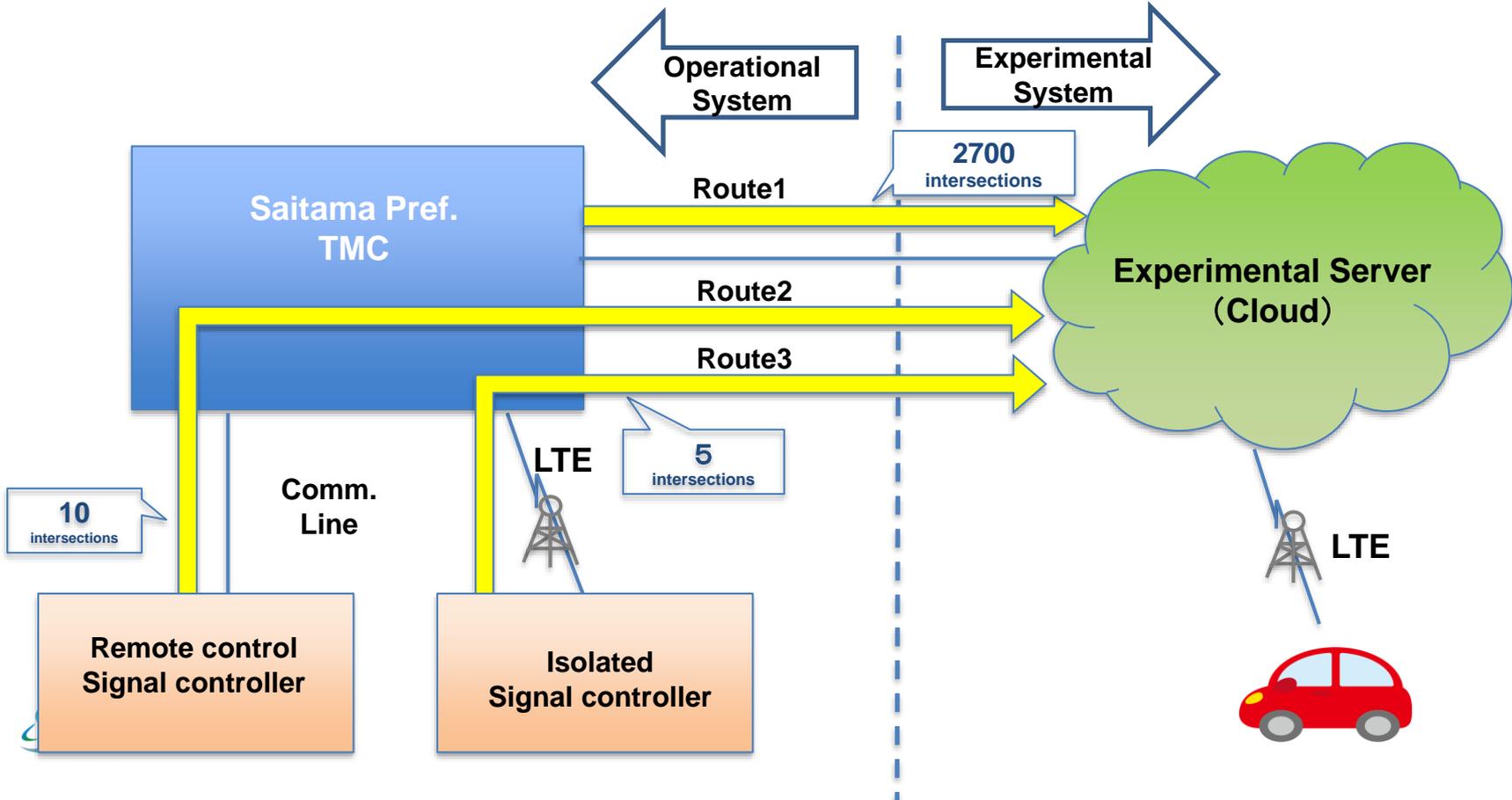


4. 1 V2N System Architecture Plans



4.2 Model System in 20202

Build a model system to verify three methods



4.3 Verification Items

Item	Issues	Targets
Error	Improvements of time accuracy of each device	Minimize the difference between the actual traffic light status and signal information (Requirement: $\pm 300\text{ms}$ or less)
Provision Delay	Reduce provision delay time from source device of signal information to a vehicle	
Actuated control	Determine green remaining time in advance with operational improvements	Evaluate the impact of operational restrictions on traffic flow
Others	Security	Examination of implementation method that complies with unified standards for information security measures of government agencies, etc.
	Failure notifications	Ensure to notify the occurrence of system failure to operators, users and so on

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Summary

5.1 Comparison of V2I and V2N (technical issues)

Requirements	V2I	V2N		
		Route1	Route2	Route3
Accuracy Less than $\pm 300\text{ms}$	○ Less than $\pm 100\text{ms}$ in Cycle-by-cycle control	○ Update a TMC with time synchronization function by GPS etc. Update a signal controller with time synchronization function by GPS etc.		
	In case of actuated control, countermeasure is required	—	Need to take additional measures against delay time that is larger than V2I	
Availability (location)	Remote: ○ Remote (actuate): ○ Isolate: —	Remote: ○ Remote (actuate): × Isolate: ×	Remote: ○ Remote (actuate): ○ Isolate: ×	Remote: — Remote (actuate): — Isolate: ○
Availability (time)	○	Verification required when switching parameters, etc.	○	Verification required when switching parameters, etc.
Reliability (failsafe function)	○	×	×	○ Equipped with Fail-safe function
Summary	Achieve traffic signal information requirements	Required to Loosen requirements or need to rethink use cases	Required verifications on provision delay time	Required verifications on provision delay time

5.2 Comparison of V2I and V2N (maintenance cost / operational restrictions)

Items	V2I	V2N		
		Route1	Route2	Route3
Initial cost items	<ul style="list-style-type: none"> • Update signal controller • ITS radio installation 	<ul style="list-style-type: none"> • Update TMC • Build information center (Service provider burden is not considered) 	<ul style="list-style-type: none"> • Update signal controller • Update TMC • Build information center (Service provider burden is not considered) 	<ul style="list-style-type: none"> • Signal monitoring unit installation • Update TMC • Build information center (Service provider burden is not considered)
Running cost items	<ul style="list-style-type: none"> • Communication costs • Operation and maintenance costs • Security key management fee 	<ul style="list-style-type: none"> • Communication costs • Operation and maintenance costs (Service provider, user burden is not considered) 		
Issues	<p>Measures to promote the spread of RSU</p> <ul style="list-style-type: none"> • Drafting target route plans and process plans • Reducing the financial burden of prefectures • Operation and maintenance 	<p>• Measures to promote the spread of system</p> <ul style="list-style-type: none"> • Determining the operator of the signal information center / service operator • Responsibility decomposition point 	<ul style="list-style-type: none"> • Measures to promote the spread of RSU • Determining the operator of the signal information center / service operator • Responsibility decomposition point 	

5.3 Summary

【Summary of research results】

V2I:

- Achieve a high level of accuracy, reliability and availability of traffic signal information requirements
- It is required to reduce the financial burden of roadside units installation on the prefectures in order to spread the automated vehicle systems.

V2N:

- It is expected to provide traffic signal information in a wide area at low cost.
- It is required to verify technical issues such as delay time by model projects to achieve traffic signal information requirements and to clarify arrangement of constraint conditions such as target intersections

【Future Issues】

Based on the examination results, clarify an appropriate division of V2I and V2N according to the signal control method and signal information use case.

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Thank you

