Cross-ministerial Strategic Innovation Promotion Program

「Cross-ministerial Strategic Innovation Promotion Program (SIP)/ Automated Driving for Universal Services/ Research on the Enhancement of Technologies to Provide Traffic Light Information toward the Realization of Automated Vehicles」

FY 2020 Report

UTMS Society of Japan
Sumitomo Electric Industries, ltd.

November, 2020

1. Overview of Research

1.1 Aims and outlines of Research

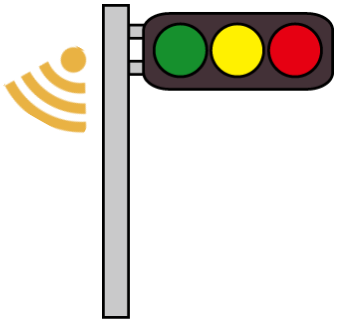
【Aims】

In SIP-ads Phase 2, with practical and spread of automated driving,

- Reduction of traffic accidents and traffic congestion
- Securing mobility for people who are restricted in travel
- Solving social issues such as improving driver shortages and reducing costs for logistics services

We aim to realize a society in which everyone can lead a high quality life

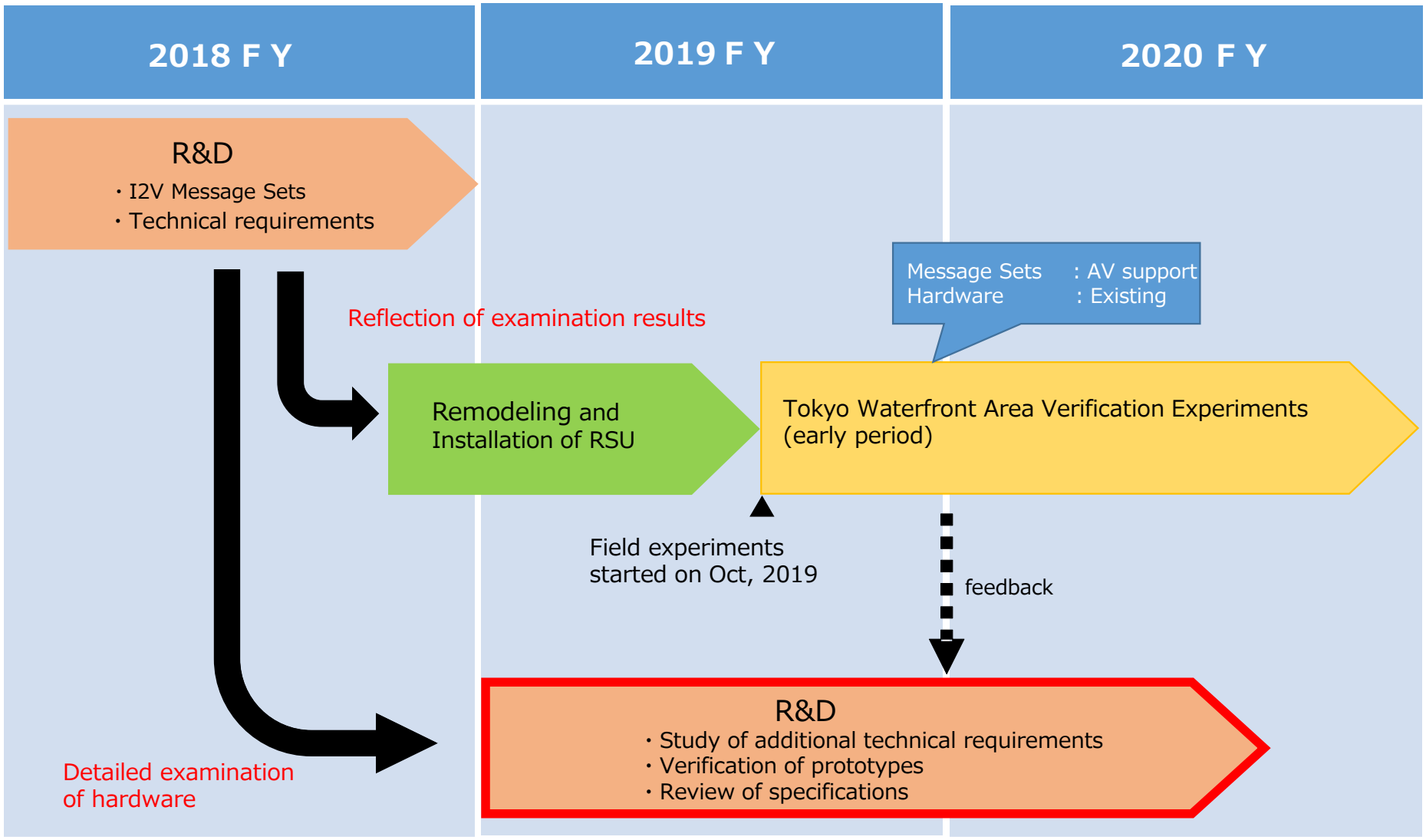
Toward automated driving,
We examine functions of ITS Roadside Unit (ITS RSU) providing traffic light information



【outlines】

Based on the research in FY2019, examining technical requirements that contribute to the provision of signal light information, as well as creation and verification of prototypes. Then, determining the final specifications of the signal information provision infrastructure.

1.2 Positioning of this research in the SIP-ads overall plan



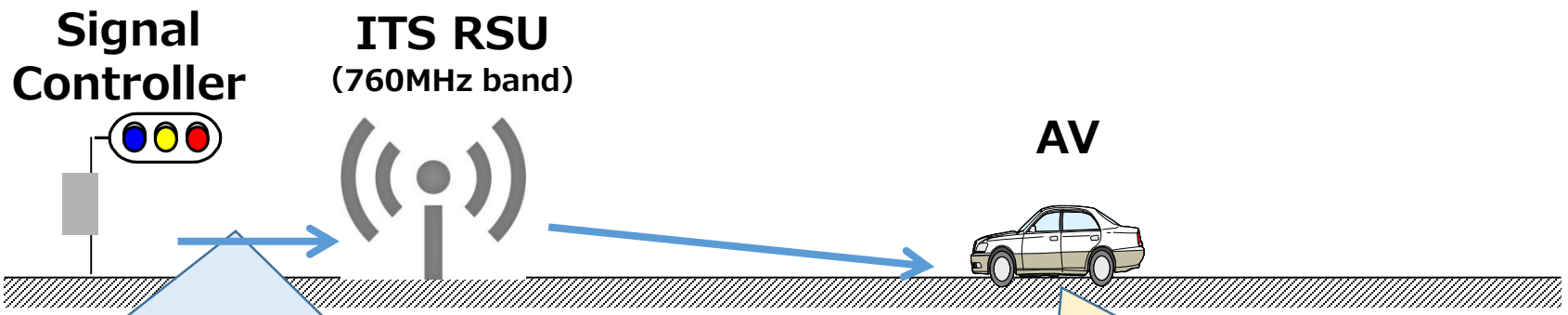
1.3 Summary of research

【Expected results】 Determining the final specifications of signal information provision infrastructure

Experiment participants

Exchange of opinions

【Reflection of experimental results】
Feedback of results related to I2V message sets.



【Continuation of previous research】

- **Verification of fail-safe function**

⇒Prototype creation, function evaluation, detection delay time measurement, etc.

- **Signal information for actuated control**

⇒ Review of operational rule, specifications, etc.

. **Special signal control modes**

⇒Evaluation of necessity of signal information during special control mode, etc.

. **Comparison with other communication method**

【Validation of infrastructure requirements】
Allowance for delay time in providing signal information, Verification of signal information contents (test courses experiment)

2. Requirements for Automated Vehicles

2.1 Needs of Traffic Signal Information

・Reliable awareness of the surrounding environment is essential for safety automated driving

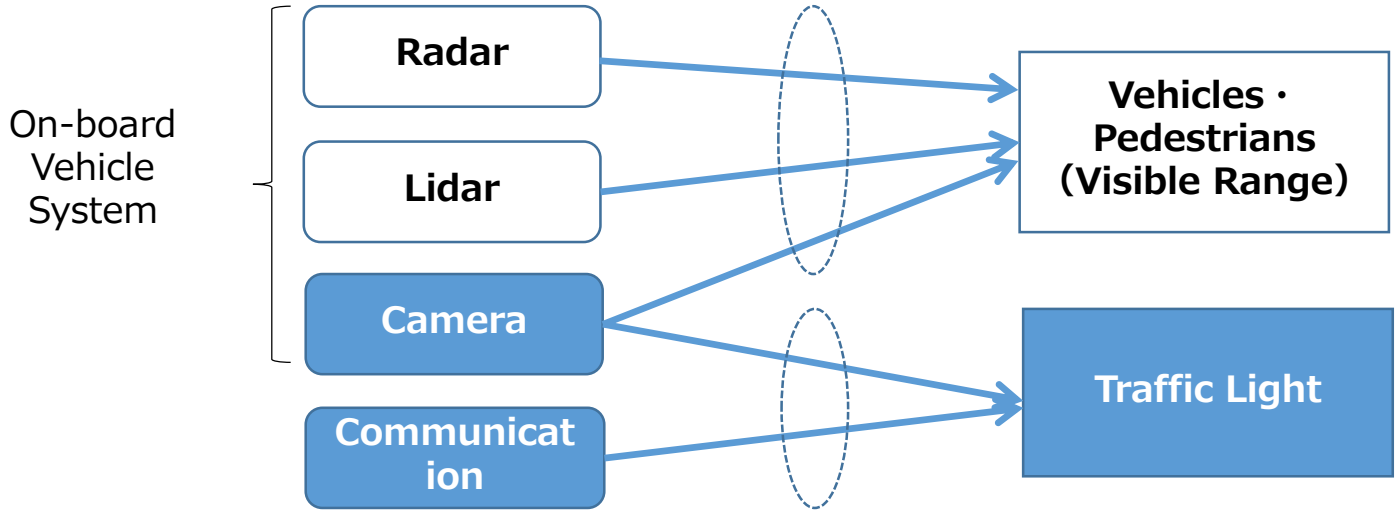
→ Ensure certainty by "multiplexing" the recognition method

・ Only the camera can recognize the signal light autonomously.

→ Reliable recognition by duplicating camera and communication information

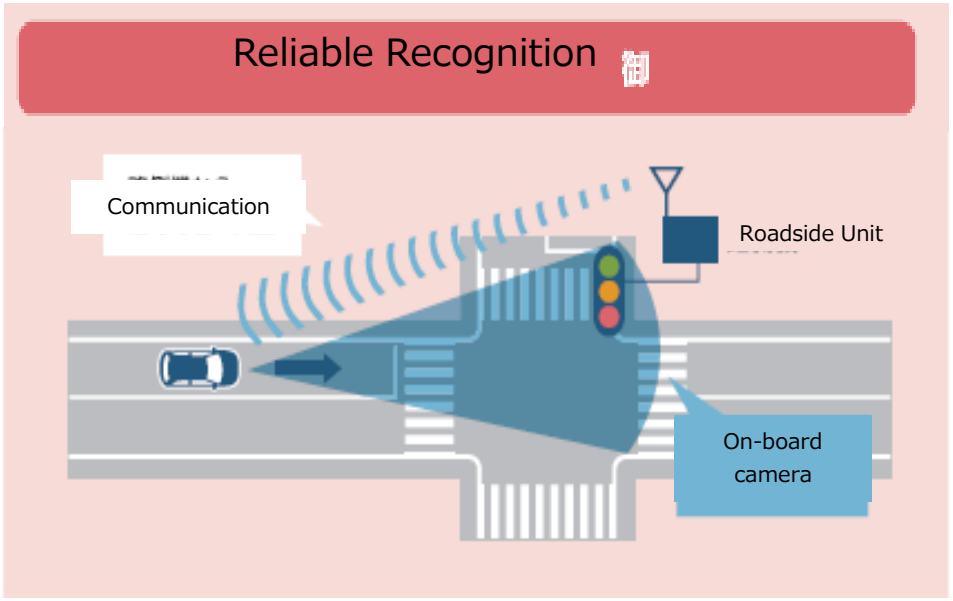
■ **Driving Process**

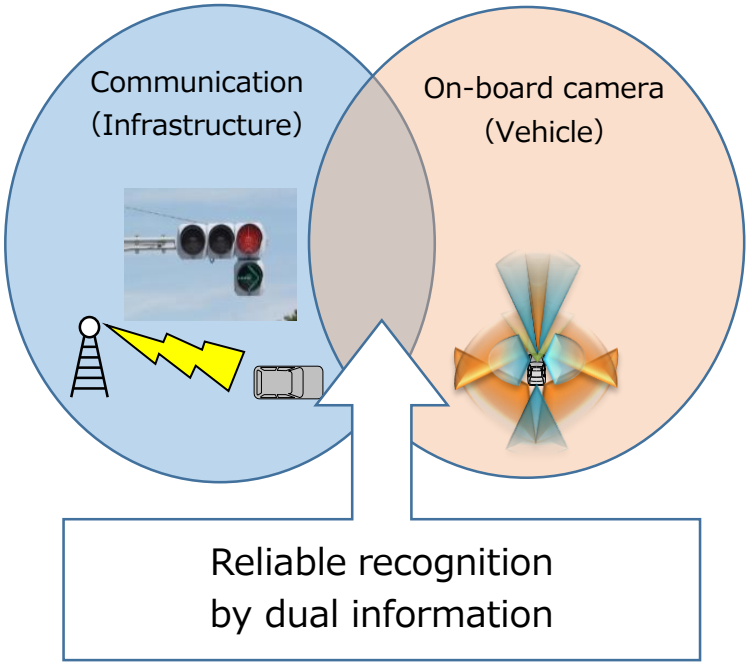
■ **Recognition with Multiple Methods**



2.2 Usage of Traffic Lights Information

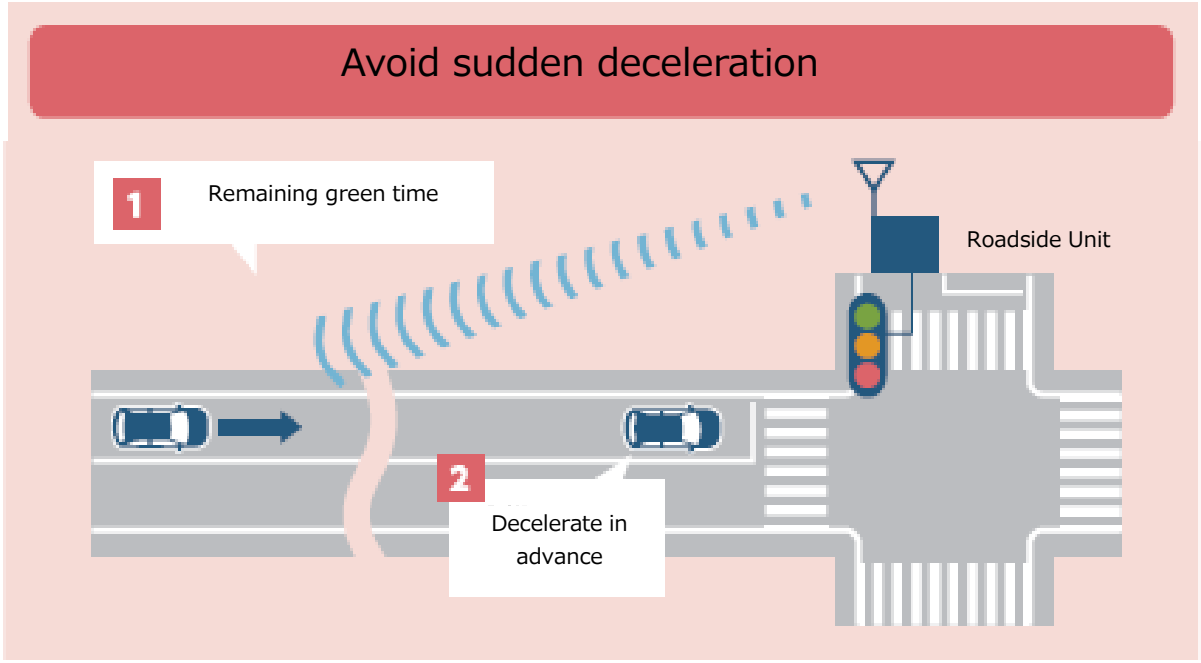
Dual system of information delivered from infrastructure and on-board camera information
→ Reliable recognition realizes safe intersection passage





2.3 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.

2.4 Requirements for Automated Vehicles

- Accuracy

  Information error when changing traffic light should be ± 300ms 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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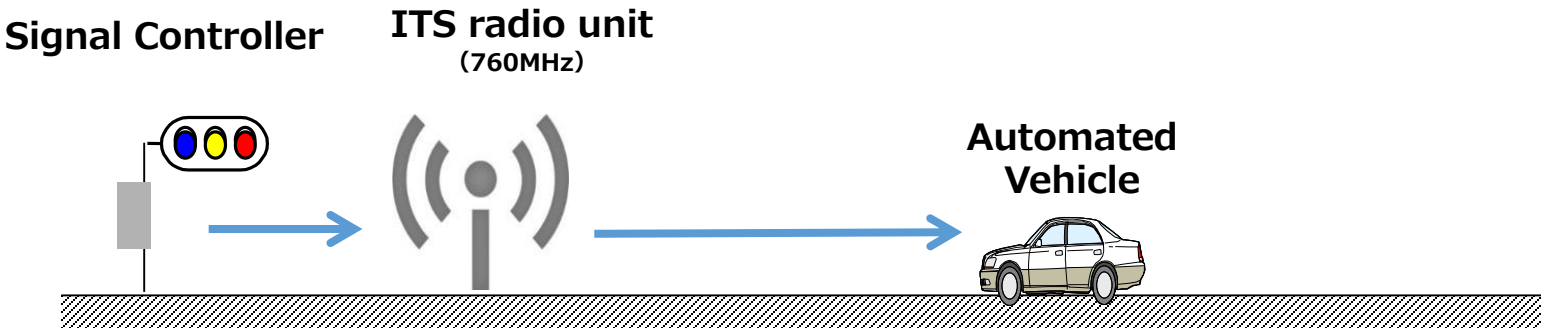
3. Advanced Provision of Traffic Signal Information using ITS Radio

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)



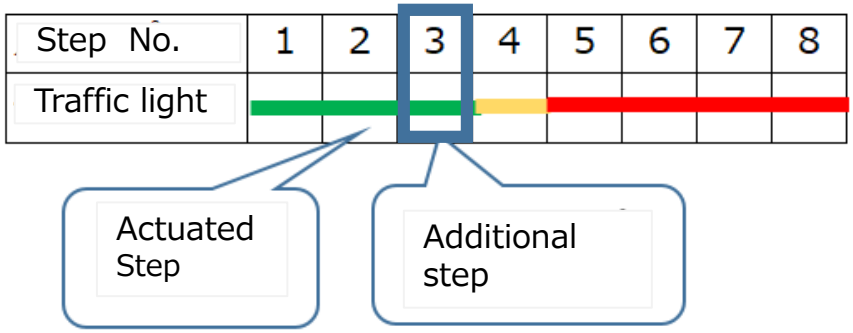
3.2 Data Accuracy

Classification	Example	Error	Supplementary description
Remaining time determined in advance	Cycle-by-cycle control	±100ms	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.



(Ref) Experiment in field simulation environment

【Methods】

- Construct infrastructure system outdoors that simulates a real road
- Performs signal control under various signal modes and collects the history of how the signal information changes with experimental equipment
  - ✓ Ex. When the green light timing changes due to actuated control
- Requesting review from committee members based on the analysis results before and after the signal modes change

【Date】

Feb, 13, 2020

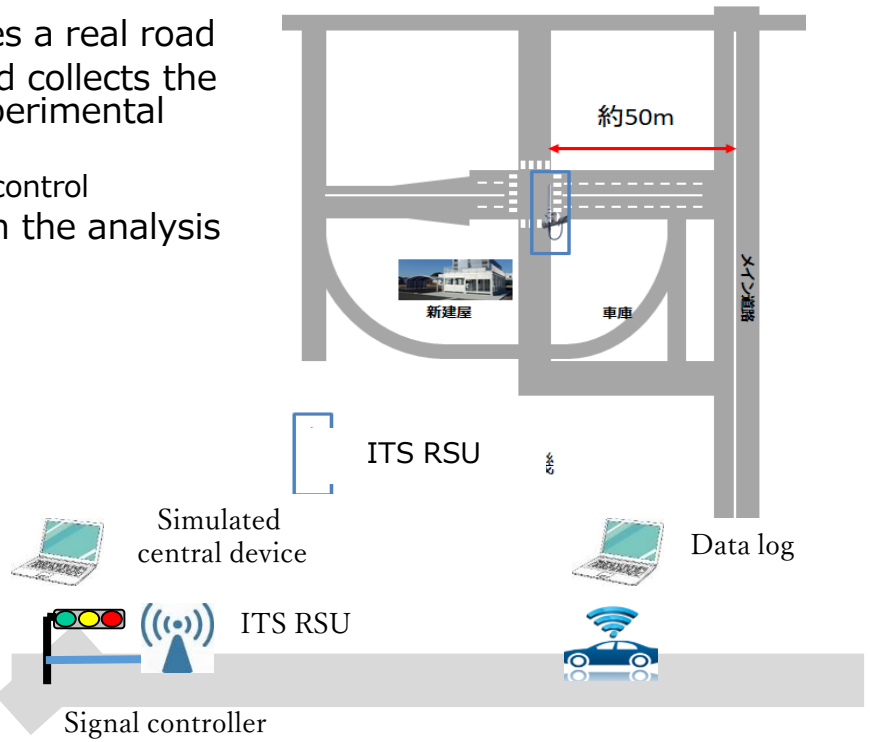
【Location】

Testbed in Yokohama factory, Sumitomo Electirc

【Participants】

JAMA:4, NPA:4, NEDO:2, UTMS:1

Testbed in Yokohama factory



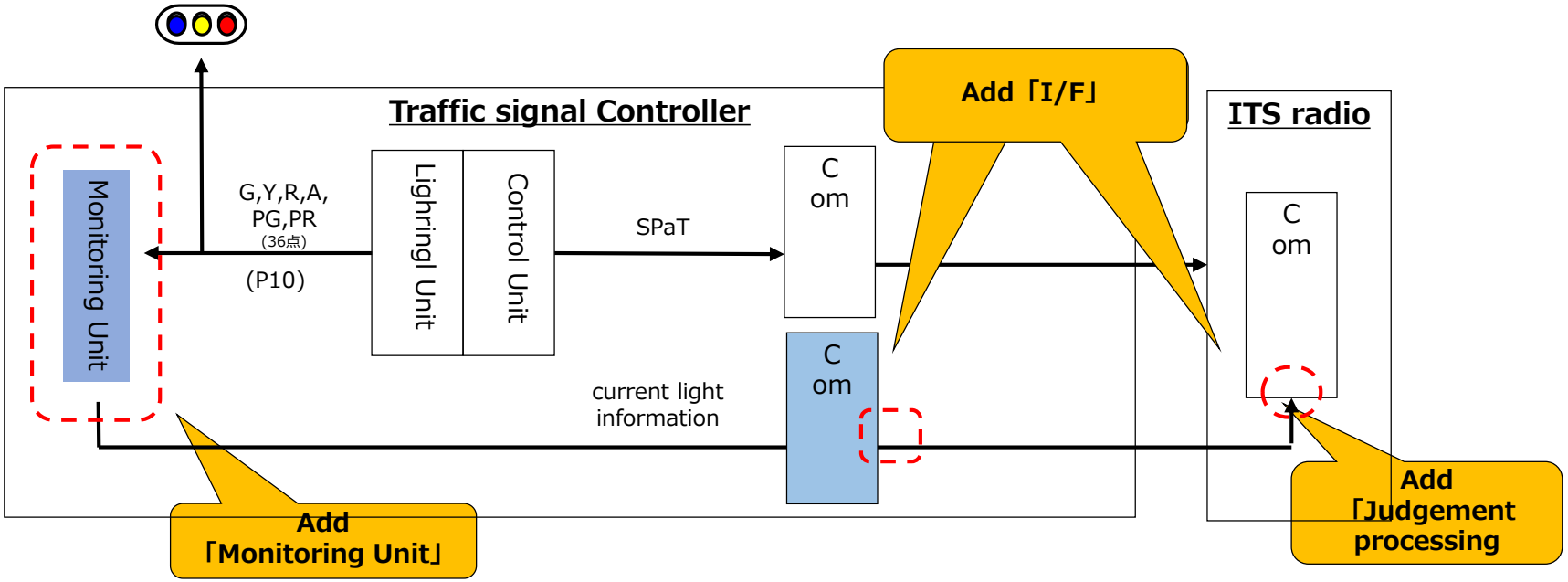
Implementation view

Data measurement device

Testbed overview

3.3 Reliability

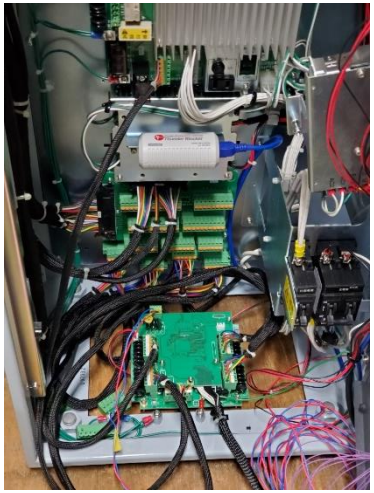
Items	Supplementary description
Fail-safe Specification	➢ Traffic signal controller: Monitors the light status (voltage) of traffic lights. The monitoring result is transmitted to the ITS radio as current light information. ➢ ITS radio: Judges the matching of signal information and current light information
Verification Results	Delay time from fail occurrence to output judgment results is 600ms → Input as design information for error handling on the vehicle side

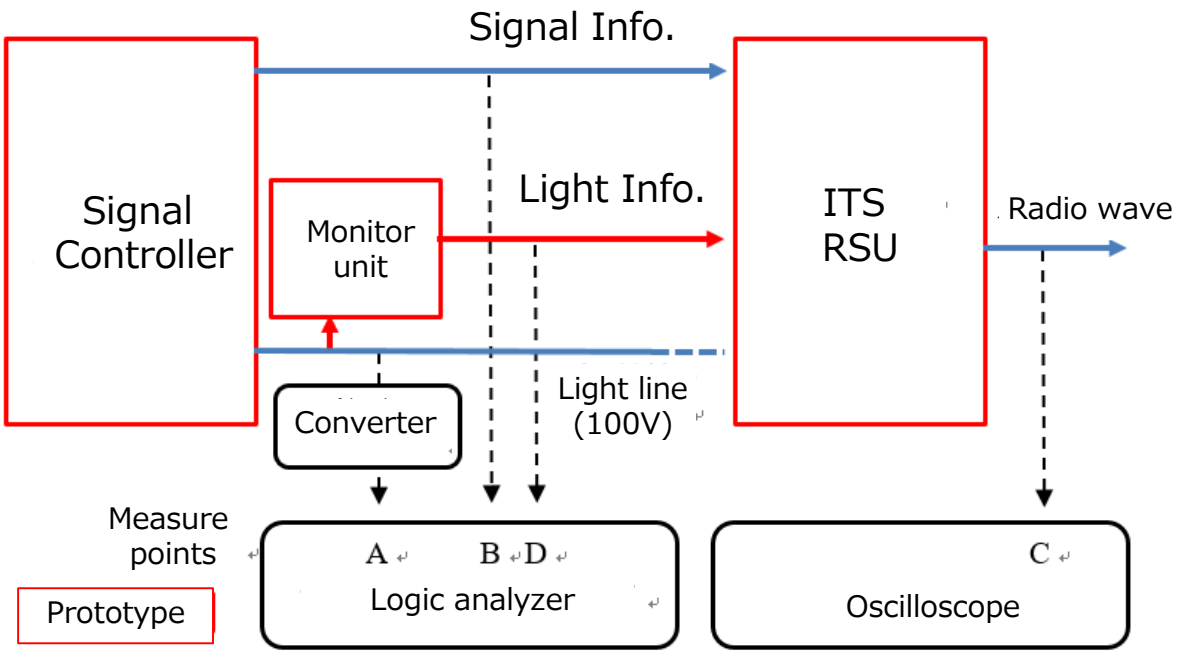


(Ref.) Fail-safe function verification experiment with 1st prototype

- Prototype the fail-safe function based on the 1st specifications
- Evaluate the delay and fluctuation time in failure detection by measuring the transmission timing of information at each part of the I/O of the prototype devices

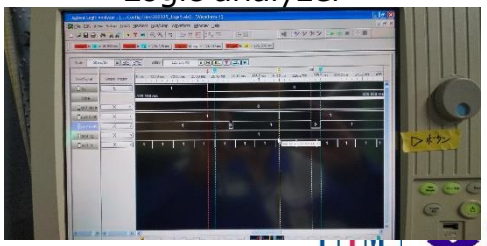
Signal Controller
(The lower board is monitor unit)





【Measurement point】
A: Timing of traffic light change
B: Signal information transmission timing to ITS RSU
C: Timing of radio wave transmission from ITS RSU
D: Light status information transmission timing

Logic analyzer



3.4 Availability

- **Consideration for improving availability**
  Extract events that affect the provision of SPaT. Consider 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	・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.	Disclosure of operational information on signal control (request for operation) Notify events with I2V message (specification revision)

3.5 Additional Data Element

◆ 「Specific control operation mode flag」

・Identify abnormalities in signal information and specific controls that behave differently than usual

・ Notify in advance that signal information accuracy cannot be satisfied.

No	Signal Control	Objects	Flag Name	Flag ON	Flag Off
1	remaining seconds fluctuates outside the range of the minimum and the maximum of seconds	FAST control	Fluctuation intersection	In operation	—
			In action	FAST signal on	FAST signal off
2	the order of traffic light color changes	・Recall control ・Status control	Order change intersection (Can be notified)	In operation	—
			Order change intersection (Can not be notified)		—
			In action	Order changing start	Certain period
3	Delay above the specified value	Actuated control	In action	Target step start	Target step end

3.6 Feedback from experiments

Sharing the issues of ITS RSU in experiments
→ Request a detailed study such as specification review to UTMS, which is in charge of standardization

No.	issues	Study items
1	Countermeasures against radio wave interference when ITS wireless roadside devices are installed densely	Confirm the necessity of revision of the existing "ITS wireless roadside device operation guideline" such as prior slot design and precautions for installation
2	GPS synchronization error	conditions and functional requirements in the operation transition from GPS synchronization to air synchronization
3	Others	Extraction of ambiguous description in existing specifications / standards

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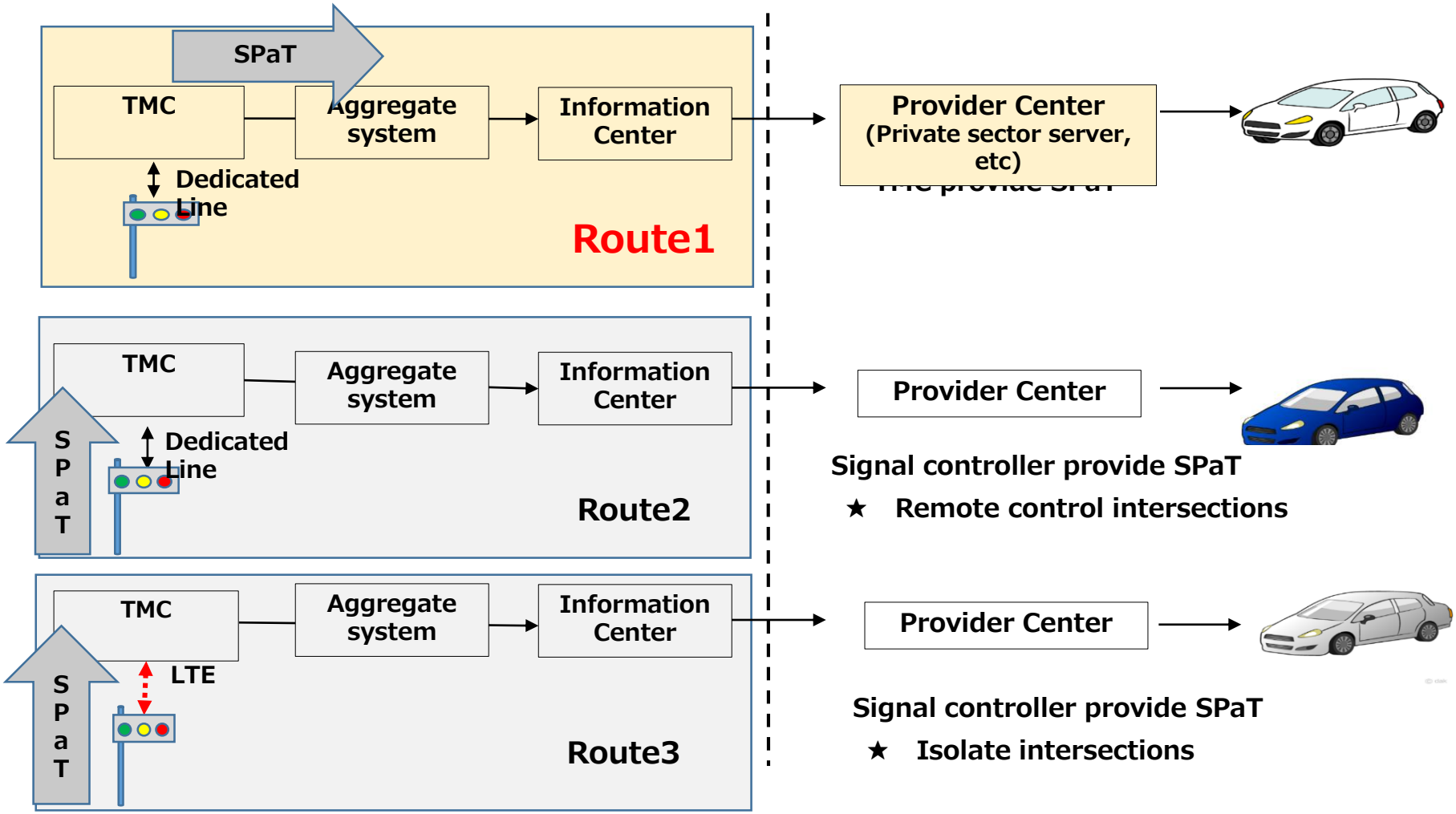
4. Provision of Traffic Signal Information via Cloud

4.1 V2N System Architecture Plans



5.1 Comparison of V2I and V2N (technical issues)

Requirements	V2I	V2N		
		Route1	Route2	Route3
Accuracy Less than ±300ms	○ Less than ±100ms 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 : ○ Remo t e (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	・Update signal controller ・ITS radio installation	・Update TMC ・Build information center (Service provider burden is not considered)	・Update signal controller ・Update TMC ・Build information center (Service provider burden is not considered)	・Signal monitoring unit installation ・Update TMC ・Build information center (Service provider burden is not considered)
Running cost items	・Communication costs ・Operation and maintenance costs ・Security key management fee	・Communication costs ・Operation and maintenance costs (Service provider, user burden is not considered)		
Issues	Measures to promote the spread of RSU ・ Drafting target route plans and process plans ・ Reducing the financial burden of prefectures ・ Operation and maintenance	・Measures to promote the spread of system ・Determining the operator of the signal information center / service operator ・Responsibility decomposition point	・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.