「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 2019 Report

UTMS Society of Japan
Sumitomo Electric Industries, ltd.

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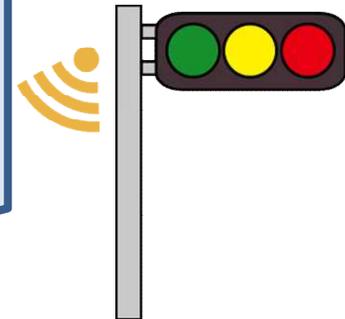
【outlines】
Based on the research in FY2019, examining technical requirements that contribute to the provision of signal light information, as well as creation and verification of prototypes. Then, determining the final specifications of the signal information provision infrastructure.

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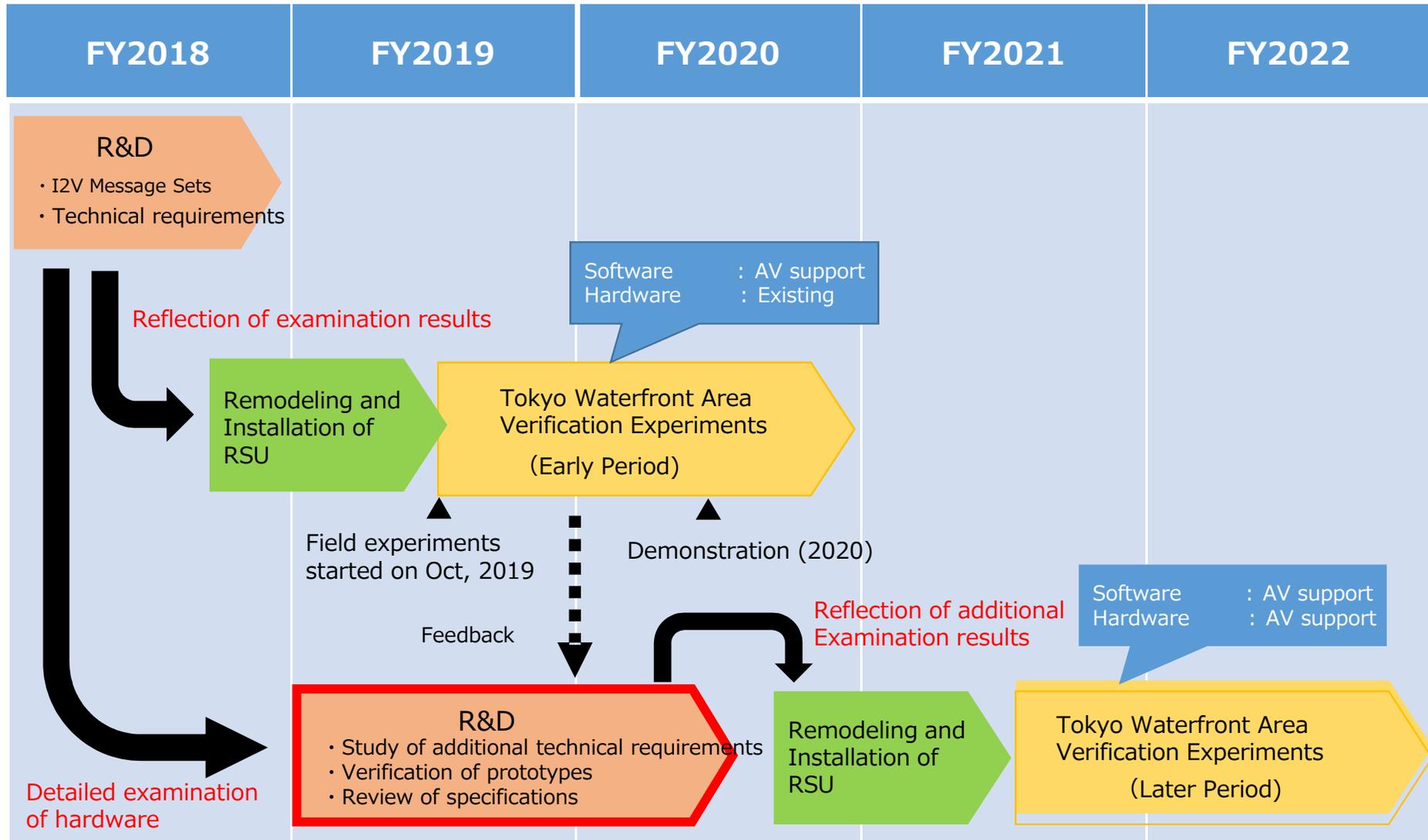
1.3　Summary of research

【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
　ex. Validity of the linking method with the dynamic map, review of specifications, etc.

Signal Controller
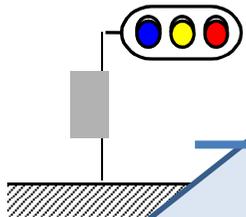
ITS RSU
（760MHz band）

AV

【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.

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

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2. Detailed function & technical requirements of ITS RSU

2.1 Requirements for Signal Information

・Four items were extracted as the main requirements for signal information in the 2018 research
・Confirmed that the functional requirements are satisfied for items 1 and 2.
・In this research, "3. Ensuring reliability of signal information" and "4. Ensuring availability of signal information" are mainly examined.

No.	Item	Outline	Requirement	Planning
1	Accuracy of signal information	Allowable time of error (fluctuation delay time of provision) in signal light switching	Within ±300ms	Within ±100ms （from 2018 research)
2	Timing to determine signal remaining time	to avoid advance deceleration at green light, green time is fixed before Δ sec of yellow start	$\Delta t=8.9s$ （Yellow=3s) $\Delta t=4.9s$ （Yellow=4s) Type: Passenger car Speed limit : 60km/h	be operated by settings changes
3	Ensuring reliability of signal information	Implementation of a fail-safe function that confirms that the signal light and signal information match and notifies immediately of any abnormality	Detect inconsistencies (Allowable detection delay time is undetermined)	2019 : experiments by 1st prototype 2020 : Determining the technical specifications
4	Ensuring availability of signal information	Signal information can be provided in various signal control methods	Signal information can be provided even in signal control that is not provided by existing system, DSSS.	2019 : requirements definition 2020 : experiments by 2nd prototype

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2.2 Ensuring reliability of signal information

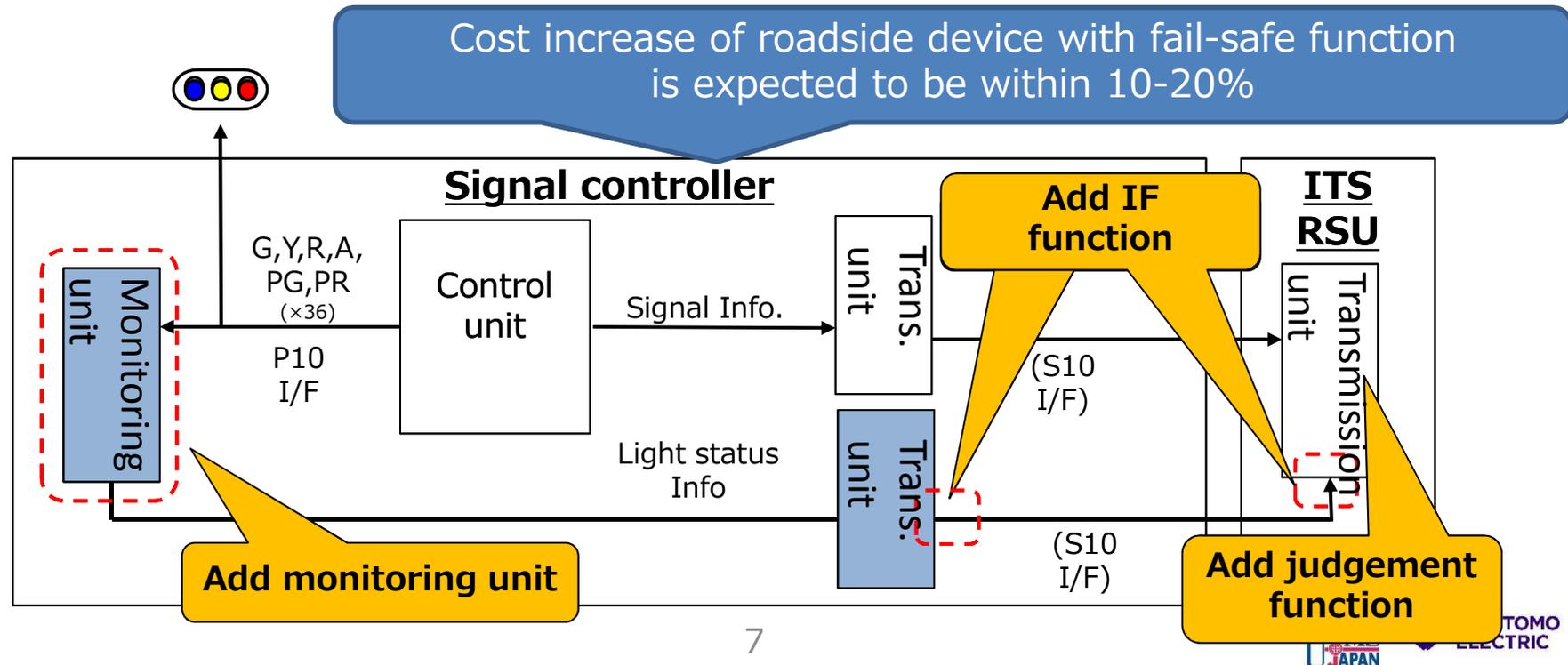**【fail-safe function specification】**

Independent of the signal information generation function, the output status (voltage) is monitored for all signal lights. The monitoring result and signal information is sent in parallel to the ITS RSU. ITS RSU make Judgments of matching of both information.
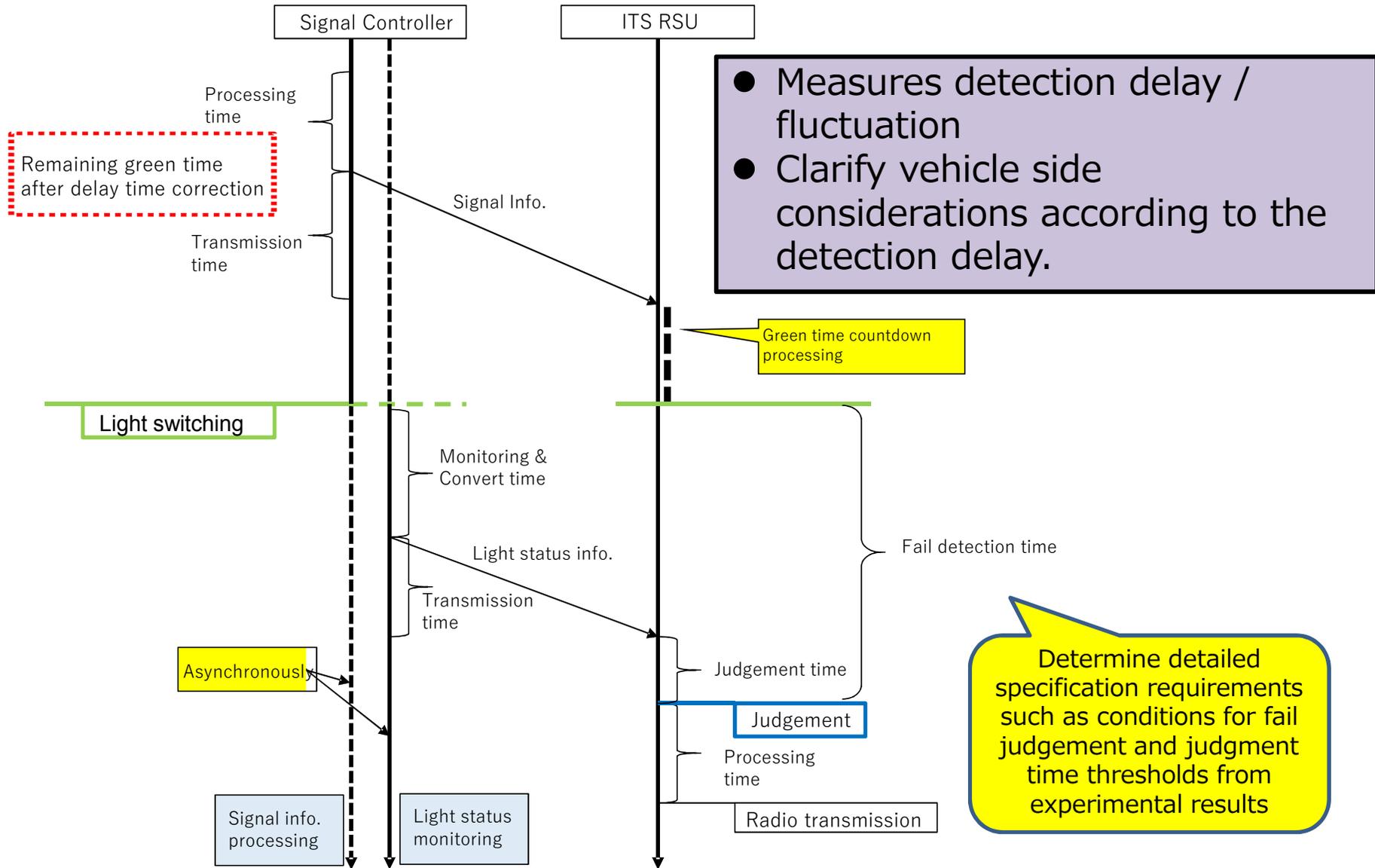
【Research results of this year】

The committee agreed on the details of the fail-safe function specification for the 1st prototype. Function confirmation and measurement of detection delay time were conducted by 1st prototype

【Final target in FY2020】

As final specifications for the infrastructure for automated driving, 1) confirmation of fail-safe specifications, 2) vehicle side requirements in consideration of delay in fail detection

Cost increase of roadside device with fail-safe function is expected to be within 10-20%

Signal controller

ITS RSU

Add IF function

G,Y,R,A, PG,PR (×36)

P10 I/F

Monitoring unit

Control unit

Signal Info.

Trans. unit

(S10 I/F)

Transmission unit

Light status Info

Trans. unit

(S10 I/F)

Add monitoring unit

Add judgement function

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(Reference) Timing Chart of fail-safe

2.3　Ensuring availability of signal information

【Study contents】

Extracts study contents by analyzing existing signal information provision system, DSS
Examining the policy from both functional and operational perspectives by questionnaire survey
with committee members

【Research results of this year】

Completion of operational requirements as well as merits and demerits of operation change
Two items are extracted as required additional functions:
1) Providing signal information during emergency vehicle priority control
2) Providing signal information at push-button request controlled intersections

【Final target: FY2020】

Verification additional functions 1) and 2) by 2nd prototype and determine final specifications for
the infrastructure for automated driving

【Example of questionnaire survey 】

| No	Items	Issues	Request comments
1	Yellow light	Dilemma zone occurs in general 3 seconds Different operation at each intersection	At intersections that exceed the prescribed speed limit, the yellow time should be 4 sec or more, or 4 sec uniformly.
2	Actuated control (common issues)	Dilemma zone occurs because yellow start cannot be confirmed in advance	At intersections that exceed the prescribed speed limit, , a certain green time is secured between the actuated green and yellow.(Enable advance notification of yellow start)
3	Push-button request control	Unable to provide	Enable to provide signal information
4	Emergency vehicle priority control	Unable to provide remaining green time	Enable to provide remaining green time
5	Information disclosure	Intersections that perform special signal control is unknown	Operational information disclosure Additional data elements to notify signal control modes

2.4 Providing signal information during emergency vehicle priority control

From examination results, it is expected that technical problems will be not big. Therefor, we focus on examination of the necessity and use of signal information while approaching an emergency vehicle.

【**Survey research policy**】

(1) Verification of signal information provision during emergency vehicle priority control in the 2nd prototype in 2020

(2) Request car manufacturers for continuous verification of the validity of the assumed scene
(outside the scope of this study)

【**Proposed scene of signal information presented by car manufacturers**】
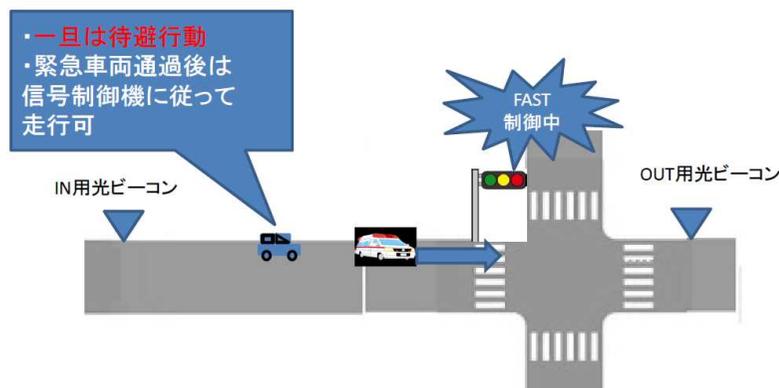
After the time when the emergency vehicle has overtaken the subject vehicle that is evacuating, it is possible to judge whether the vehicle can cross the intersection or not based on the information about the number of seconds remaining in the green time and the vehicle's position.
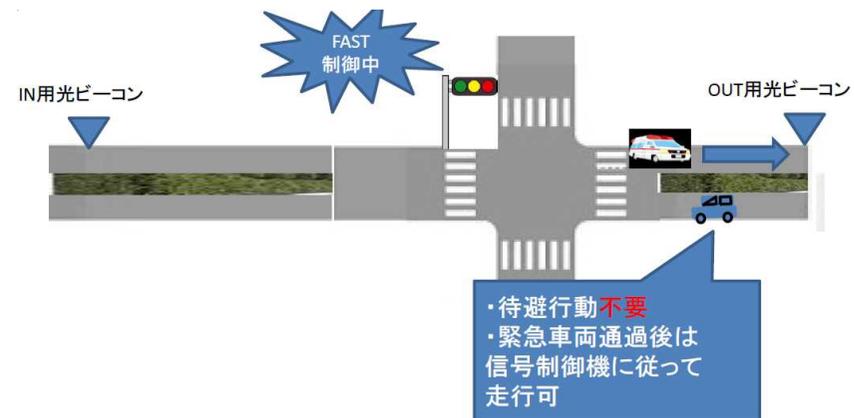
If evacuation action is not necessary, such as when the subject vehicle is in the opposite direction of the emergency vehicle, as soon as the emergency vehicle pass through the intersection, it is judged whether the vehicle can move or not based on the remaining number of green time and the position.

2.5　Providing signal information at push-button request controlled intersections

As for push button control, various control methods are used. With the cooperation of the National Police Agency, we conducted a current operational status survey.

From the survey results, the "recall-1 function" is the majority of operation.

【Survey research policy】

Conducted functional verification of signal information provision targeted for recall 1 in 2nd prototype in 2020

【Outline of signal operation in recall 1】

Normally, green light is always given on the main road, when there is a request signal from the push button, the sub road green light (recall phase) is given.
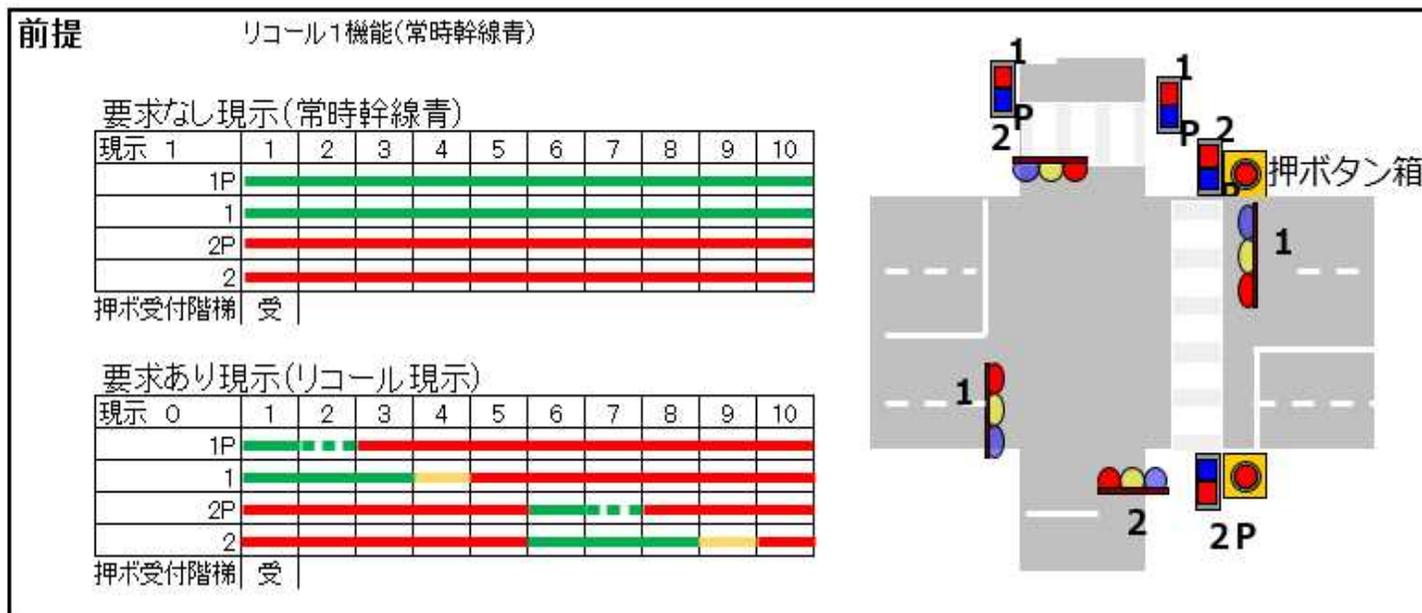
3. Prototype creation and verification

3.1 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
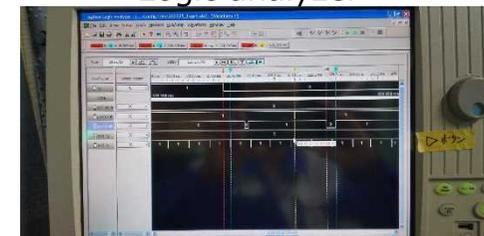

Signal Controller
(The lower board is monitor unit)
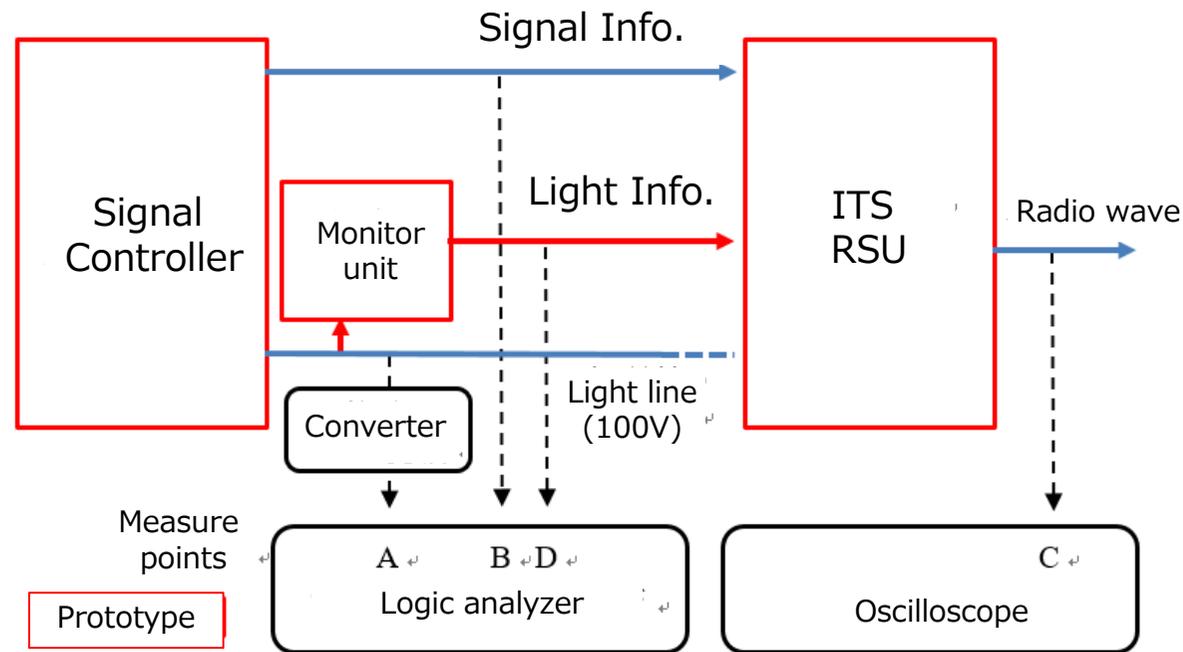
【Measurement point】
A: Timing of traffic light change
B: Signal information transmission timing to ITS RSU
C: Timing of radio wave transmission from ITS RSU
D: Light status information transmission timing

Logic analyzer

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3.2 Fail detection delay time measurement result (examples)

・Generate error information from the test tool in the monitor unit
・Measurement of the elapsed time from the point of inconsistency (A) until the signal information is invalidated by the fail-safe function (C)

【Signal information changes from red to green, but light status continues red】

実験2－1：青灯器でのフェールセーフ判定
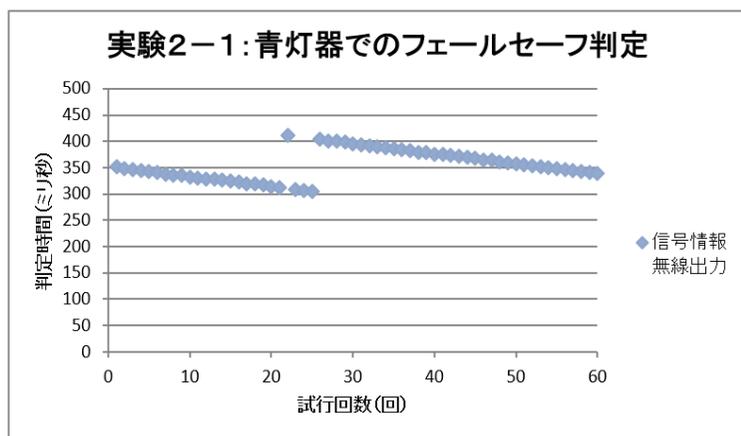
Num. of test (60)	Results （msec)		
	Ave	Min	Max
Detection time	354.4	304.6	411.1

-The transition judgment of yellow light is made with "green light extinguishing" as the trigger condition.
-The light signal detection (voltage) requires more time to transition to "extinguishing light" than "lighting up".

【Signal information changes from green to yellow, but light status continues green】

実験2－2：黄灯器でのフェールセーフ判定
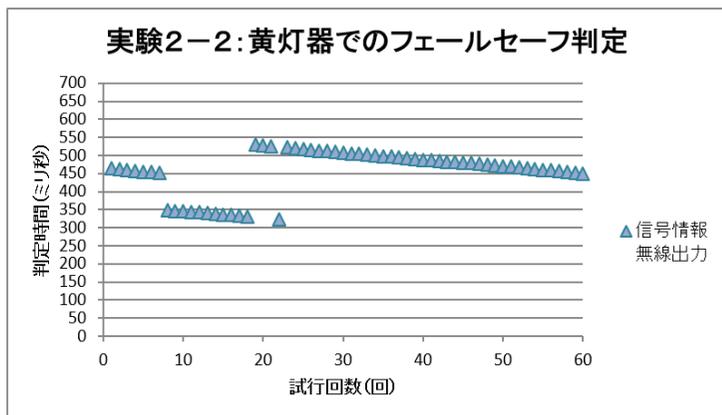
Num. of test (60)	Results （msec)		
	Ave	Min	Max
Detection time	455.4	323.7	529.2

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3.3 Experiment in field simulation environment

Testbed in Yokohama factory

【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

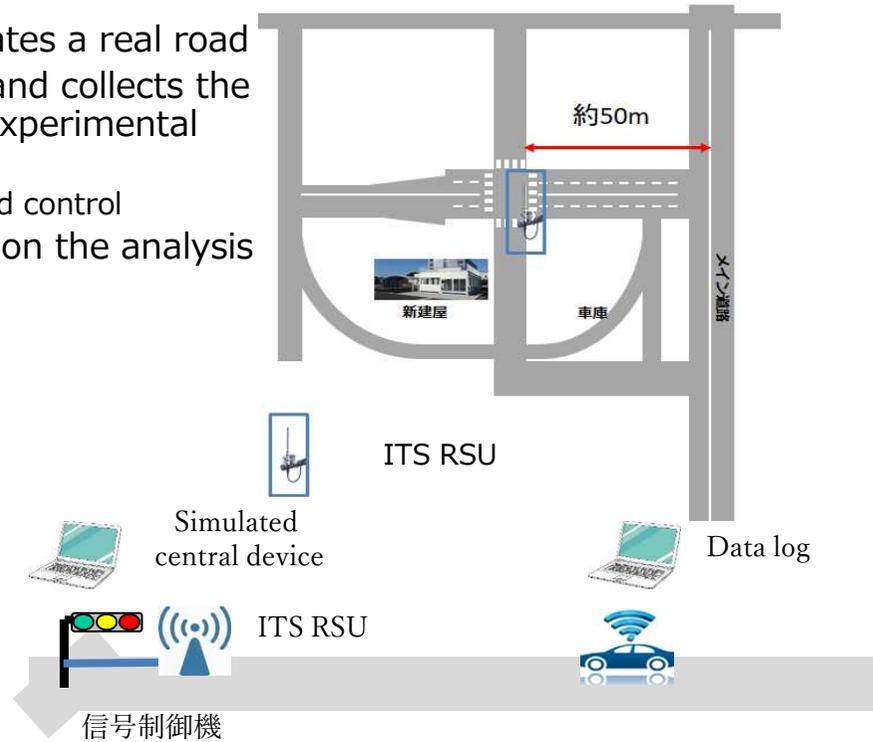【Location】

Testbed in Yokohama factory, Sumitomo Electirc

【Participants】

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

約50m

新建屋　車庫

ITS RSU

Simulated central device

Data log

ITS RSU

信号制御機

Implementation view

Data measurement device

Testbed overview

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4. Review specifications based on Tokyo waterfront area experiments

4.1　Feedback from experiments -1

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

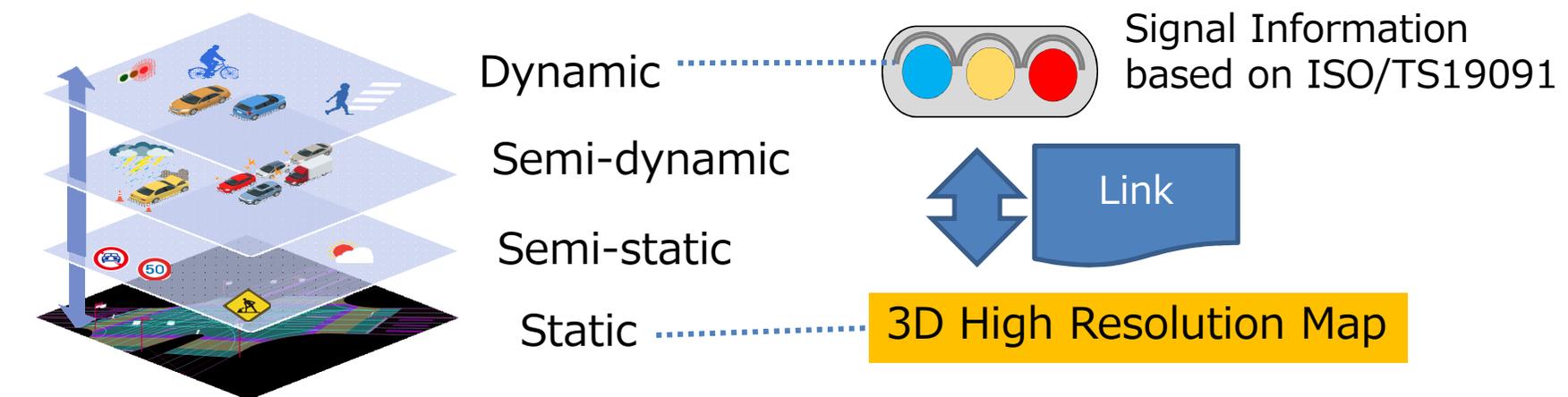| No.	issues	Study items
1	Countermeasures against radio wave interference when ITS wireless roadside devices are installed densely	Confirm the necessity of revision of the existing "ITS wireless roadside device operation guideline" such as prior slot design and precautions for installation
2	GPS synchronization 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

4.2 Feedback from experiments -2

【Outlines】
In order to verify infrastructure specifications (I2V message set), we conduct survey with the car makers of the committee members and the participants of Tokyo waterfront verification experiment.

【Survey contents】
Conducted in FY2019: Review of signal information specifications and examine additional date element "signal operation mode notification" for the purpose of distinguish between abnormalities in signal information and special signal control modes in which remaining signal seconds and phase order change discontinuously
FY2020 planning: Validity and issues of the method used for linking the dynamic map and signal information

【Expected results】
Final specifications of I2V message set for automated driving

Dynamic ········· Signal Information based on ISO/TS19091

Semi-dynamic

Link

Semi-static

Static ········· 3D High Resolution Map

Concept of "Dynamic Map"

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5. Planning in FY2020

5.1 Study items in FY2020

◆ Detailed function / technical requirements based on the results of the verification in FY2019 and the Tokyo waterfront area verification

Based on the results of fail-safe function verification and test course experiment results, the committee will examine the details of the specifications of the infrastructure for automated driving. In addition, we will exchange information on the Tokyo waterfront area test and, if necessary, consider reviewing the road-vehicle message set.

◆ Examination of specifications for 2nd prototype

Regarding the provision of signal information during emergency vehicles priority control, provision of signal information at intersections operating recall-1 and so on, 2nd prototype specification are examined by the committee.

◆ Creation & verification of 2nd prototype

Create a prototype based on 2nd prototype specifications and verify its function.

◆ Final infrastructure specifications for automated driving

Based on the above examination results, the committee will determine the final technical specifications of the signal information provision infrastructure that will realize automated driving, and draft specifications as a outputs of this research.

◆ Comparative study of signal information provision methods

Comparing with this research and the results of the research "Research and development related to the provision of signal information by methods other than road-to-vehicle communication such as ITS wireless roadside devices" carried out in FY2019

5.2 Schedule