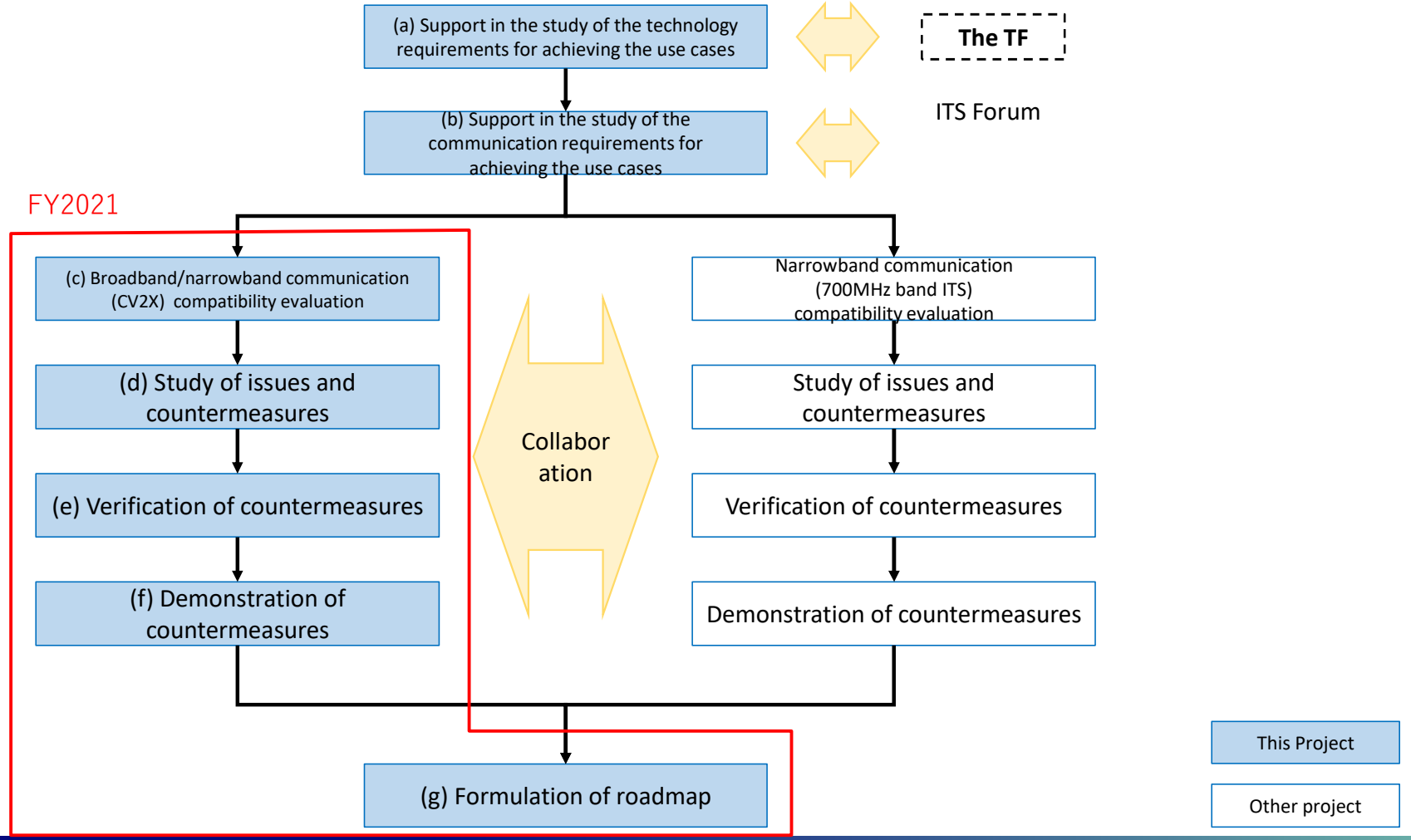
“Cross-ministerial Strategic Innovation Promotion Program (SIP) Phase 2 - Automated Driving (Expansion of Systems and Services) A Study on V2X Communication for Achieving Use Cases of Cooperative Driving Automation”
FY 2021 Results Report Overview

Apr. 2022　NEC Corporation

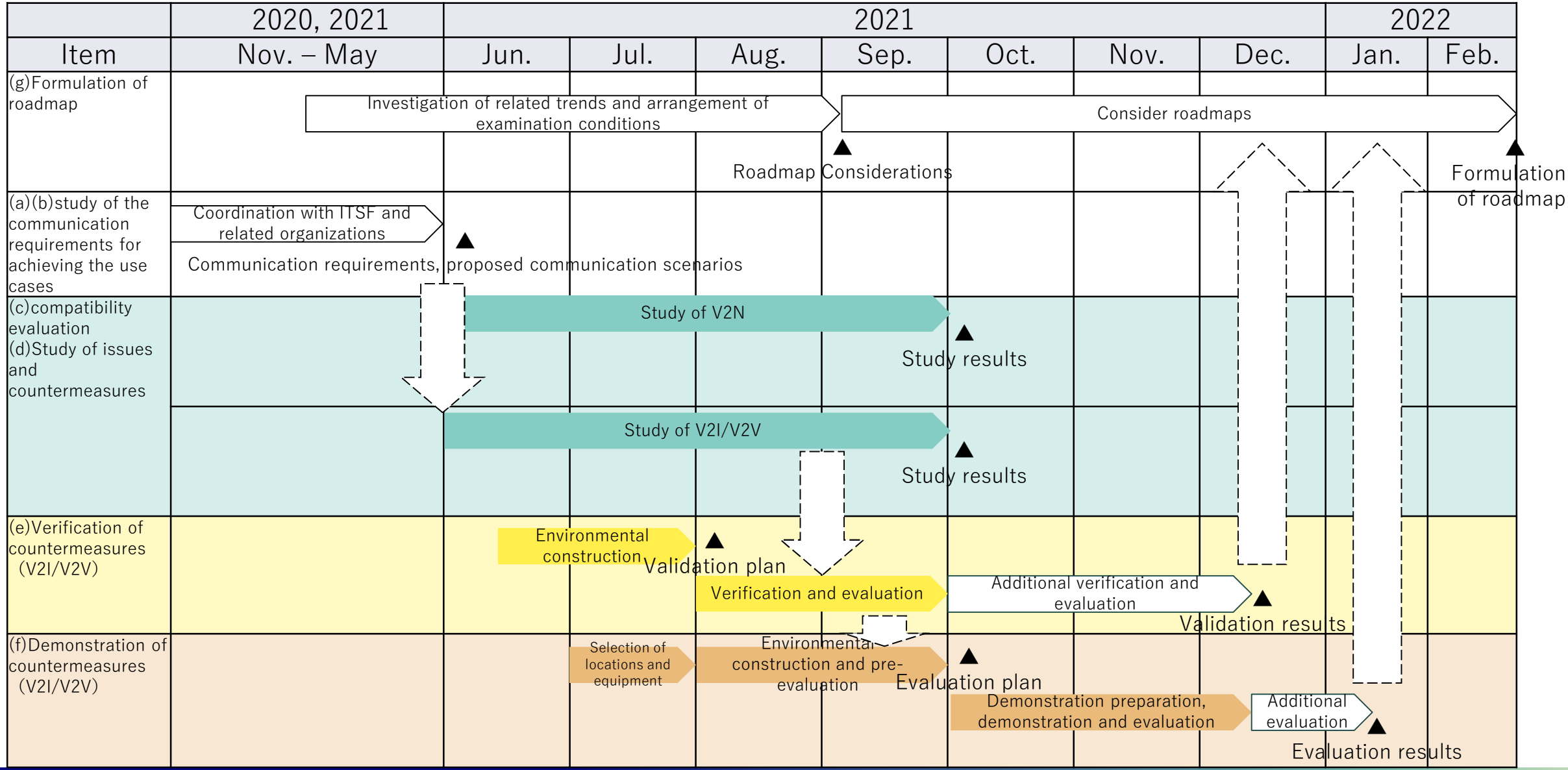
Summary

- Based on the examination results of each communication technologies for f the communication requirements for achieving the use cases, implementation items on wireless communication technology for realizing use cases were formulated as a roadmap.



Schedule

- Based on the monthly report to the TF, the study was conducted.



(c)(d)Broadband communication (V2N) compatibility evaluation (1/2)

◆ Arrangement of issues to consider for communication requirements for each use case

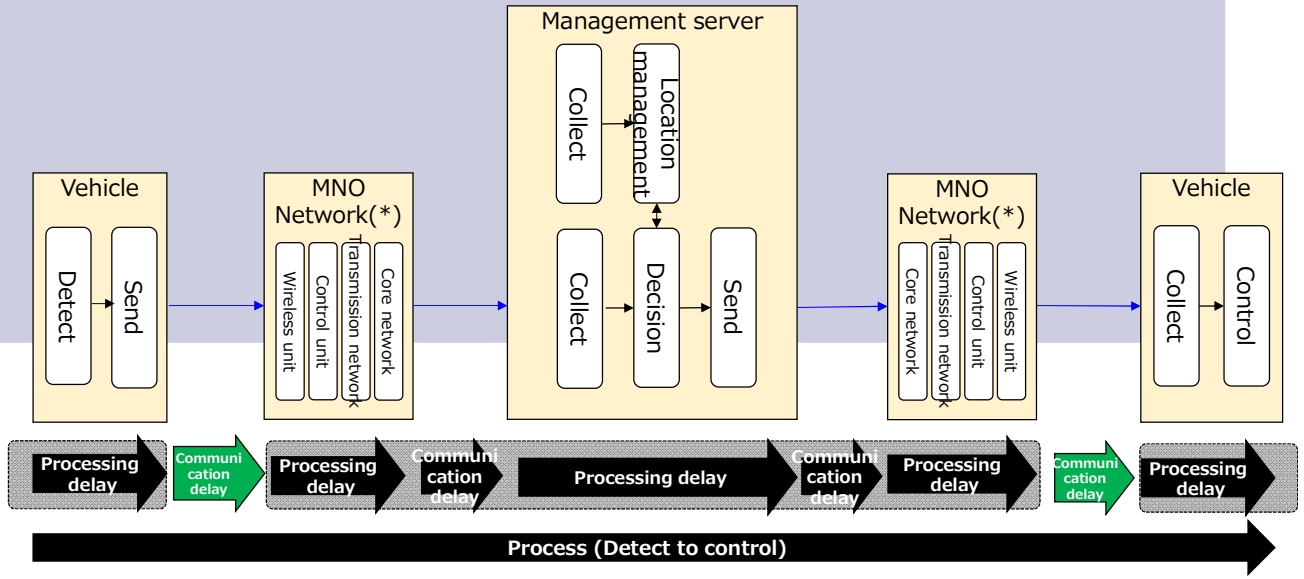
Item	communication requirements	Issues
Traffic	・Up to about 1KB (Except for the following) f-4：Distribution of dynamic map information h-1：Communication traffic between the vehicle and the center during remote control	・f-4 : Realization of communication traffic for required functions and performance ・h-1 : Realization of communication traffic for required functions and performance
Area	・Communication areas in public networks ・Use V2I in combination in areas where overcrowded communication is expected d-1,5；（Unexpected） d-2：Around approach d-3：congestion hot spot d-4：around junction, approach e-1,f-1：Around intersections	–
Delay	・Unexpected（Except for the following） h-1：Communication delay between the vehicle and the center during remote control	・h-1 : Realization of communication traffic for required functions and performance
Acceptable Number	・Up to about 600	・The feasibility of communication technologies required for achieving the use cases. ・The feasibility of the acceptable number of units corresponding to communication technologies, and of the communication frequency. Other than that, the communication technologies are necessary to consider implementation constraints by the public network.
Frequency	・Minimum 1sec	

(c)(d)Broadband communication (V2N) compatibility evaluation (2/2)

◆ Study of issues and countermeasures

Issue	Considerations	Plan
Issue 1 Communication delay during remote control	・Reduced communication delays(V⇔N)	・Priority control of wireless communications ・Securing dedicated frequency bands ・Securing dedicated bandwidth at end-to-end (slicing, etc.)
Issue 2 Communication volume during remote monitoring and operation (peripheral images, etc.)	・Reduced communication delays(V→N)	・Priority control of wireless communications ・Secure uplink (V→N) communication capacity ・Securing dedicated frequency bands ・Securing dedicated bandwidth at end-to-end (slicing, etc.)
Issue 3 Frequency of communication of location information for information transmission vehicle judgment	・Reduced communication frequency(V→N)	・Feasibility study for each communication technologies (unicast, multicast, broadcast)
Issue 4 Feasibility of communication technologies depending on the use case, acceptable number of units corresponding to communication technologies, feasibility of communication frequency	・Reduced traffic (N→V)	

[System image]



＊Multi-carrier

(c)(d)Narrowband communication (V2I/V2V) compatibility evaluation

◆ Issues to consider for communication requirements for use cases

Item	communication requirements	Issues to consider
Traffic	・Up to about 3KB	–
Area	・Up to about 300m	–
Delay	・Up to about 100msec	・Effect of communication congestion on communication delays when the number of capacity increases
Acceptable Number	・Up to about 350	
Frequency	・Up to about 100msec	

◆ Choosing use cases

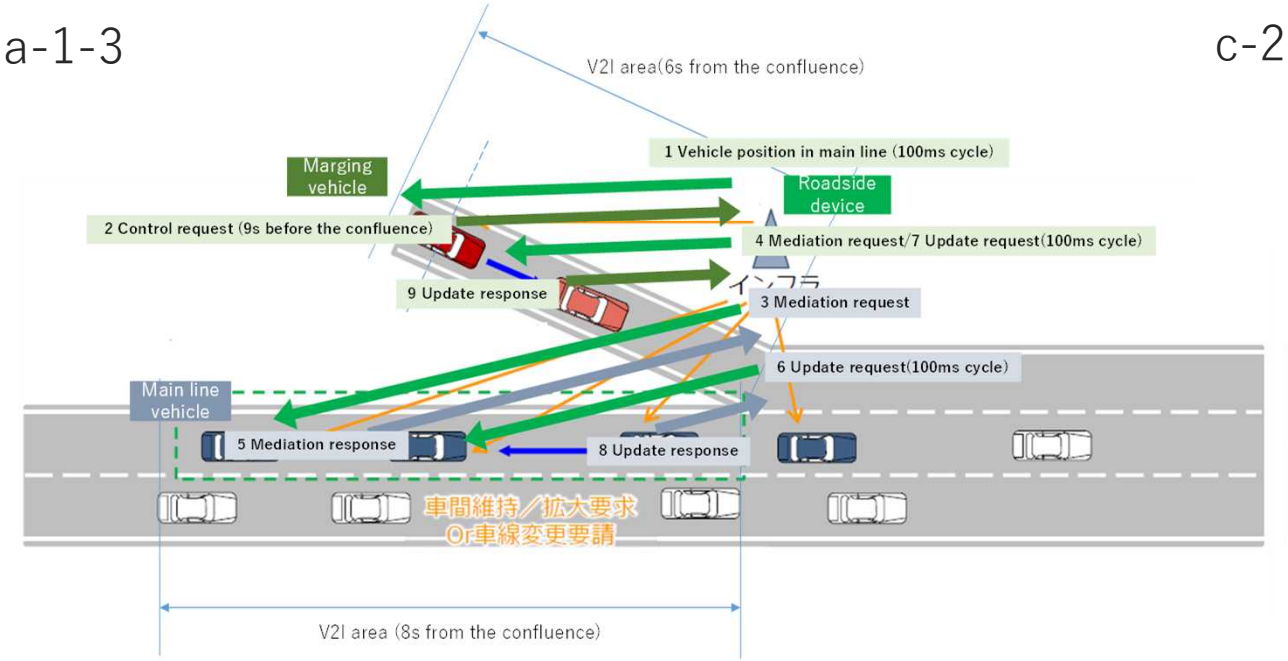
- Use cases where two-way communication occurs frequently
  → a-1-3
- Use cases are congested
  → c-2-2, etc.

(e)Verification of countermeasure (Narrowband communication) (1/3)

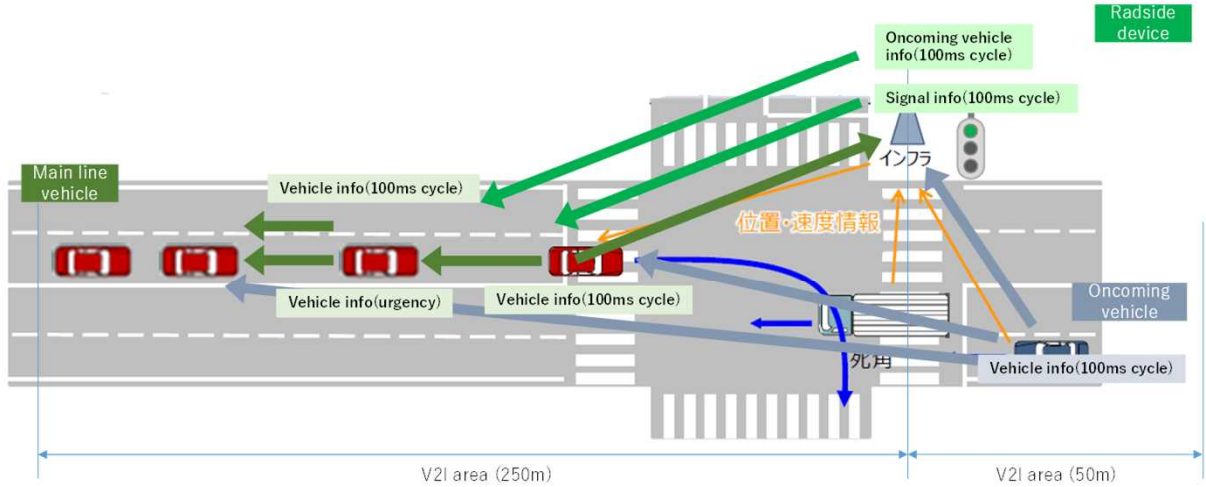
◆ Execution

- Conducted a factor analysis on the realization of communication requirements (number of vehicles, communication area, communication contents, communication sequences, and so on)

a-1-3



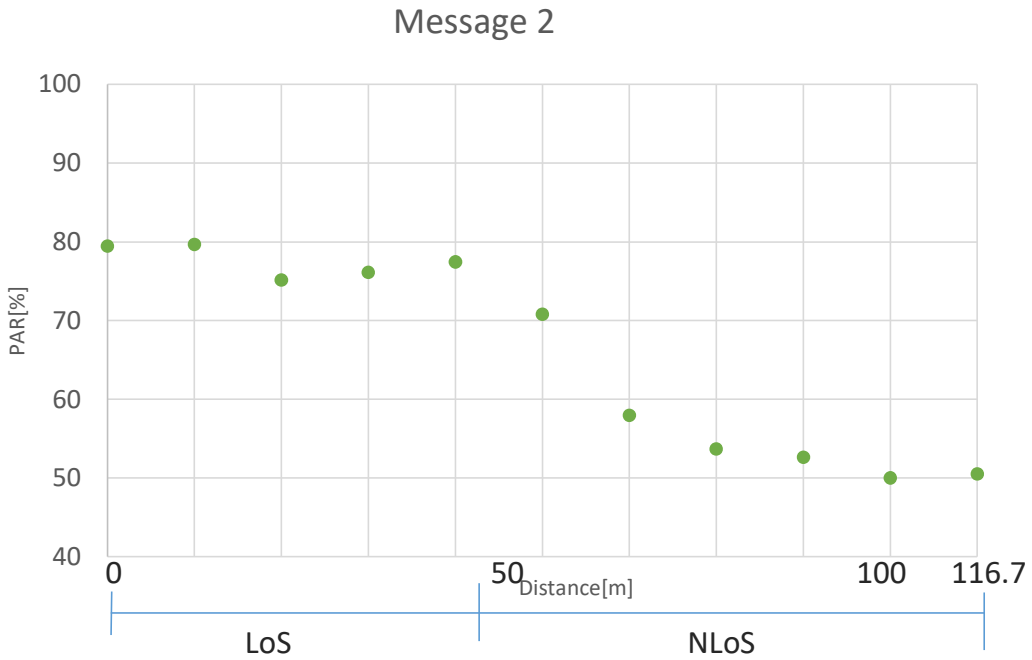
c-2-2 + b-1-1 + c-1



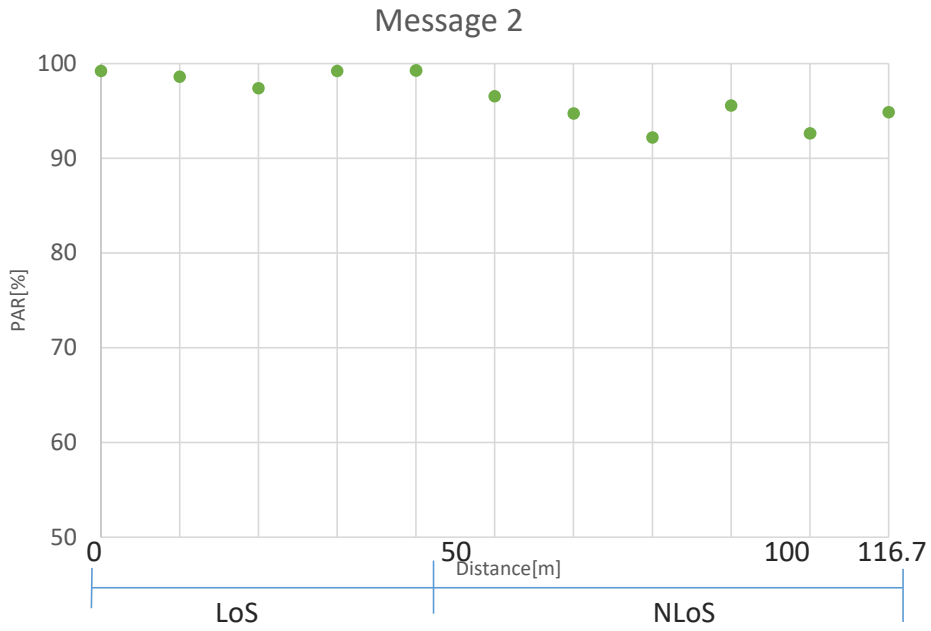
(e)Verification of countermeasure (Narrowband communication) (2/3)

Result

a-1-3



Revalidation

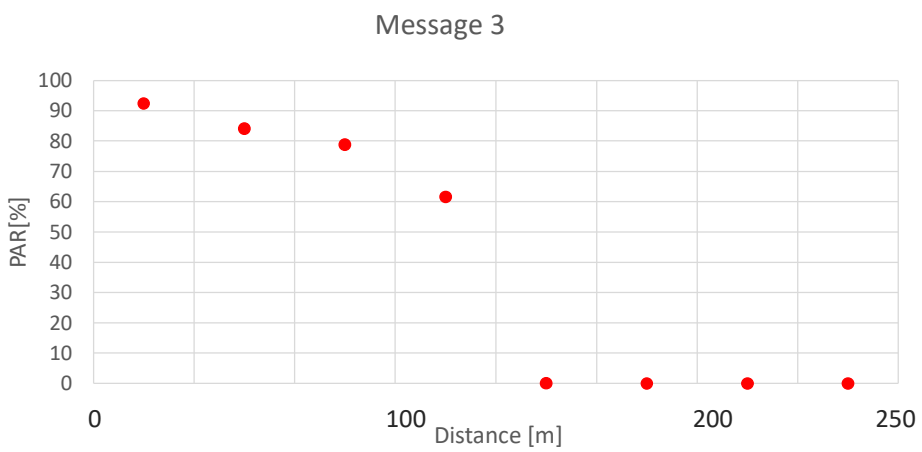


Factor analysis
- Conflict in the timing of sending and receiving of roadside machines
- Packet collisions

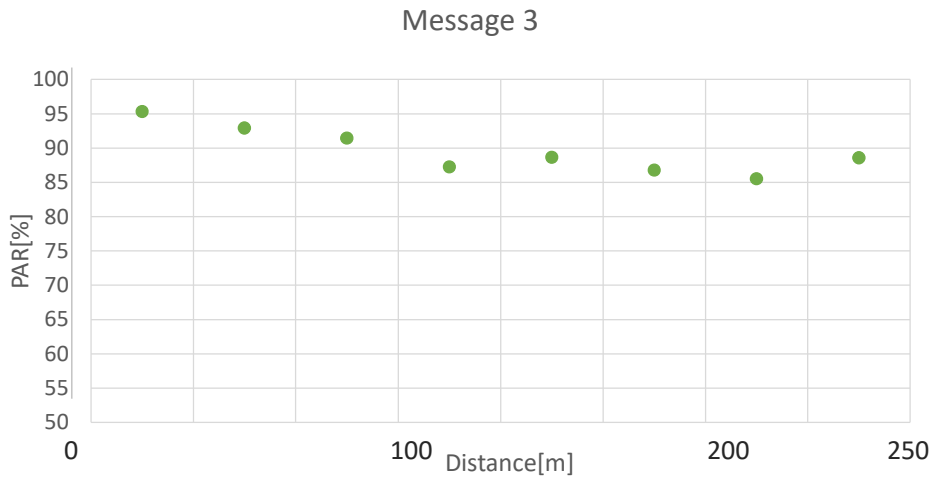
(e)Verification of countermeasure (Narrowband communication) (3/3)

Result

- c-2-2,b-1-1,c-3



Revalidation



Factor analysis
・Packet collisions

(f)Demonstration of countermeasure (Narrowband communication) (1/2)

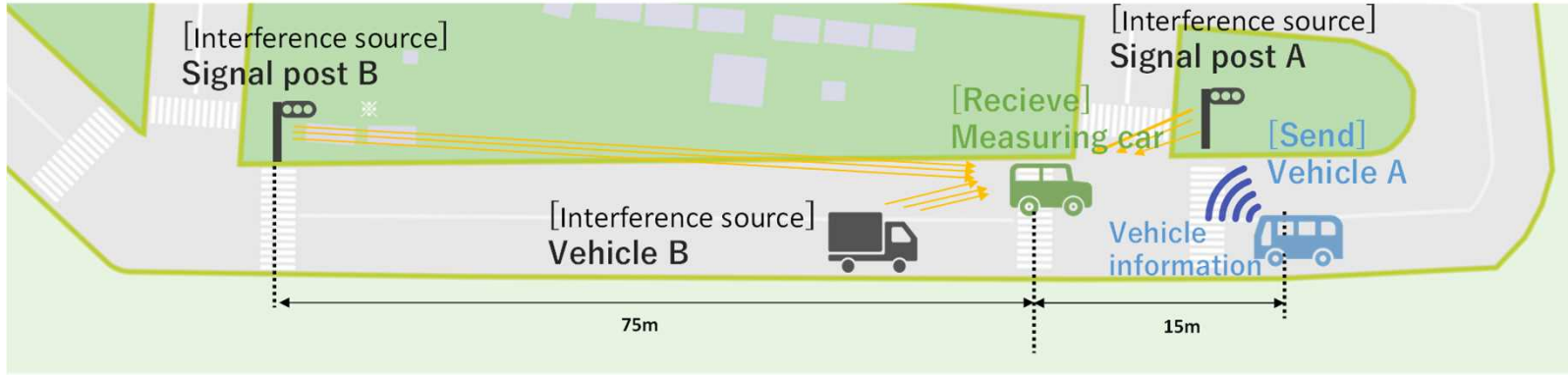
◆ Execution

■ Validate of factor analysis in validation

[**Measuring car**]

1) Effects of shadowing

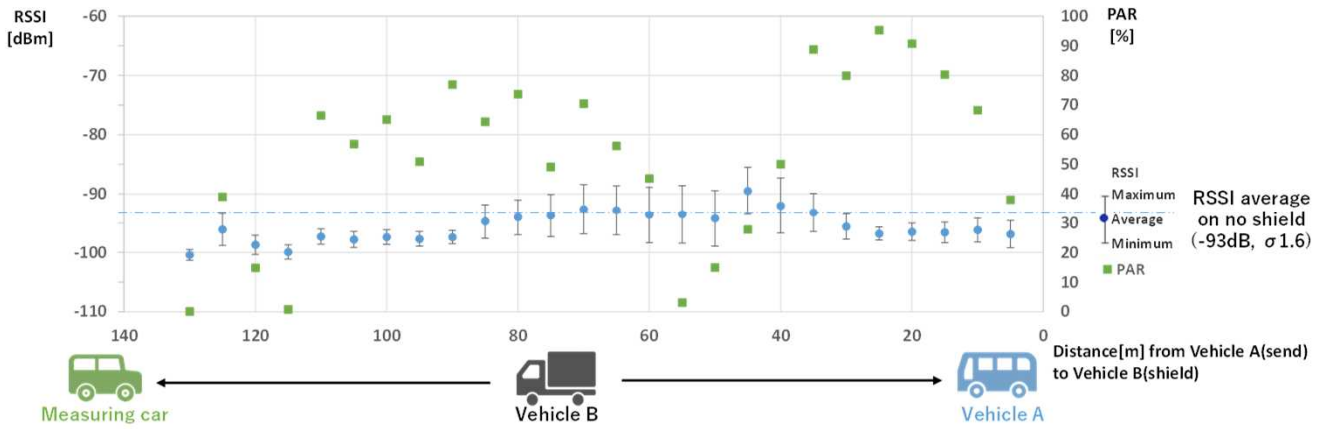
2) Effects of Communication congestion



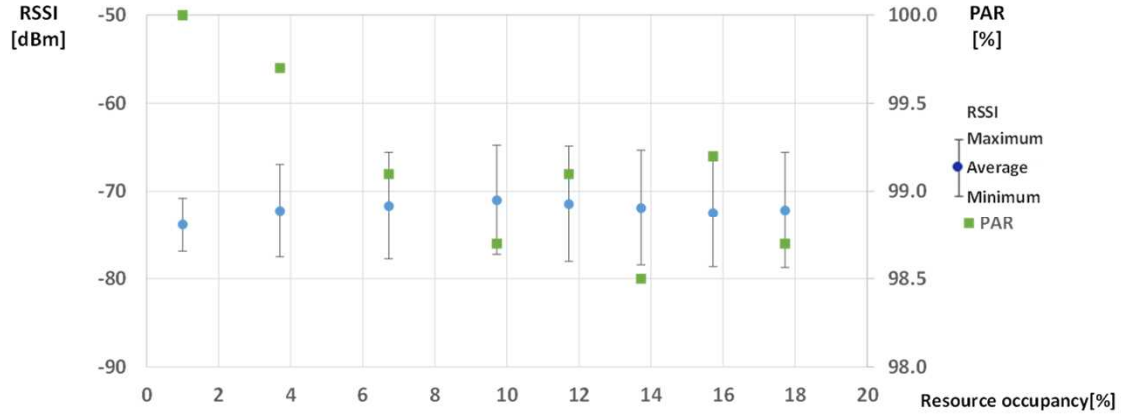
(f)Demonstration of countermeasure (Narrowband communication) (2/2)

◆ Result

■ Effects of shadowing on shielding vehicles



■ Effects of Communication congestion vehicles



[Evaluation results]
・The received level decreases when the shielding car is on the sender side or near the receiver side.
・If the shielding car is at intermediate distance, the received level decreases small, but the variation increases.

Communication control corresponding to the communication environment is required.

[Evaluation results]
・As wireless resource occupancy increases, the fluctuation range of received level increases
・Packet arrivals decrease as wireless resource occupancy increases

Communication control corresponding to the communication environment is required.

(g)Formulation of roadmap (1/4)

- Assumption: Zero traffic deaths by 2050
- Results of organizing based on discussions at TF.

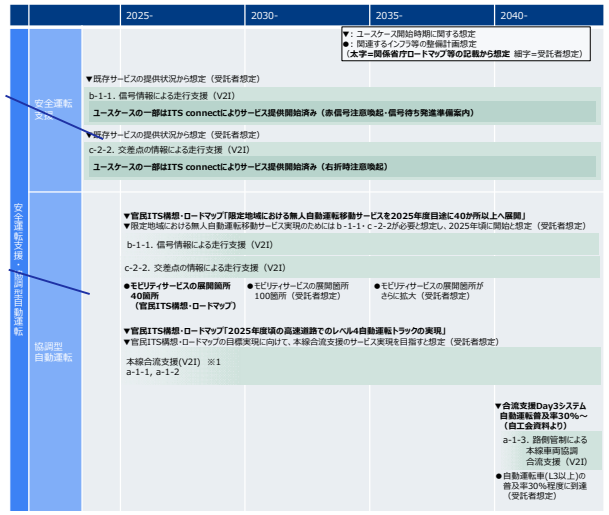
別紙－1

V2I

Safe driving support

Cooperative Driving Automation

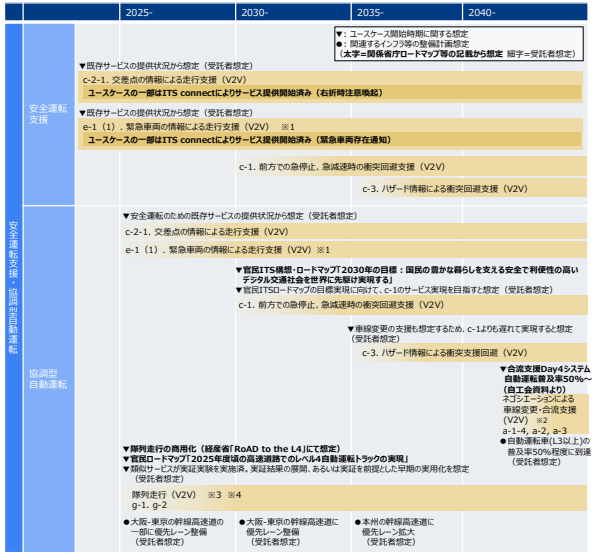
通信メディア毎の各ユースケースの展開と想定される通信要件：V2I



※1 a-1-1：予備加減速合流支援
a-1-2：本線隙間狙い合流支援

V2V

通信メディア毎の各ユースケースの展開と想定される通信要件：V2V



※1 緊急車両情報の発信は「緊急走行時」に限る想定

※2 a-1-4. 車両士の本工による合流支援（V2V）
a-2. 渋滞時の車線変更の支援（V2V）
a-3. 渋滞時の非優先道路から優先道路への進入支援（V2V）

※3 g-1. 電子牽引による後続車無人隊列走行（V2V）
g-2. 追従走行部に追従走行を利用した後続車有人隊列走行（V2V）

※4 限定車両が対象（自動運転トラック等）

V2N

通信メディア毎の各ユースケースの展開と想定される通信要件：V2N

※1 d-1. 異常車両の通知による走行支援（V2N）、d-2. 逆走車の通知による走行支援（V2N）、d-3. 渋滞の情報による走行支援（V2N）、d-4. 分岐・出口渋滞支援（V2N）、d-5. ハザード情報による走行支援（V2N）
※2 緊急車両情報の発信は「緊急走行時」に限る想定
※3 通信要件検討の際の関係団体ヒアリング結果より
※4 限定車両が対象（デマンドバス等）

1 ※各ユースケースの開始時期等は、本調査研究の検討において独自に設定したものである

2 ※各ユースケースの開始時期等は、本調査研究の検討において独自に設定したものである

3 ※各ユースケースの開始時期等は、本調査研究の検討において独自に設定したものである

(g)Formulation of roadmap (2/4)

◆ Results of organizing based on study result of 700MHz ITS/Cellular V2X.

Evaluation of 700MHz band ITS (by KYOCERA Corp.)

- The following could be confirmed by the simulation.
  - In the case of V2I/V2N communication:
    UC d-1 to d-4 and f-2 meet communication requirements (latency: within 1ms, PAR: 99% or less).
    Other UC's communication requirements (latency: within 100ms, PAR: 99% or less) due to interference are not reached.
  - The negotiation part in the negotiation UC (a-1-4, a-2, a-3) and the mediation part in the mediation UC (a-1-3) have not met yet with requirement of communication. It is necessary to think about introducing a new communication technologies.
  - The impact on existing services has been met with communication requirements.
  - Since the allowable communication delay (within 20ms) in an emergency has not been reached, g-1 cannot be handled.
- The minimum requirement of communication technologies to realize the service must be discussed (quality, distance, delay) .

→
- V2I communication can be realized with 700MHz band ITS.
- V2I/V2N communication can be realized in the 700 MHz band ITS by partial review.
- Negotiation and mediation has not met communication requirements in the 700MHz band ITS.

Evaluation of narrow band communication (5.9GHz band C-V2X（V2I/V)

- The following could be confirmed by the simulation.
  - In order to realize a single use case, communication of various requirements is mixed, and mutual influence occurs.
  - In order to realize multiple use cases in the same place, communication of various requirements is mixed, and mutual influence occurs.
- In actual operation, the wireless communication environment (shadowing, multipath, etc.) and the traveling vehicle environment (number of vehicles, between vehicles) cannot be uniquely identified or limited. When communication occurs in an environment different from the expected, communication is congested, and as a result, communication delay and communication failure can occur.

→
- It is necessary to secure the communication bandwidth corresponding to the communication amount and to divide the communication channel corresponding to the communication content.
- Communication congestion control at a higher level depending on the wireless communication environment and the traveling vehicle environment are required.

(g)Formulation of roadmap (3/4)

◆ Results of organizing based on discussions at TF/ITS Forum.

■ To realize this use case deployment plan, we need to:

	A) Activities to put use cases into practical use	B) Activities to put communication technologies (5,9GHz band) into practical use
Policy	• Various issues have been pointed out in ITS forums and TF in practical application of V2I/V/N use cases • It is necessary to clarify the direction of various issues by related parties through examination and discussion among related entities.	• It is assumed that use cases for mediation and negotiation will start from 2040, when the spread of autonomous vehicles is in full swing. • With the current 10MHz bandwidth, it is difficult to realize the use case of mediation and negotiation. • On the other hand, the 5.9GHz band is the mainstream internationally. It is necessary to put a new communication system (5.9GHz band) into practical use.
Action	A-1) Formulation of security and privacy measures A-2) Formulation of policies for sharing in-vehicle devices A-3) Formulation of policies for generational change of communication systems A-4) Establishing a business model A-5) Ensuring communication quality A-6) Clarification of responsibilities	B-1) Frequency utilization study B-2) Standardization, specification B-3) Equipment development and practical application

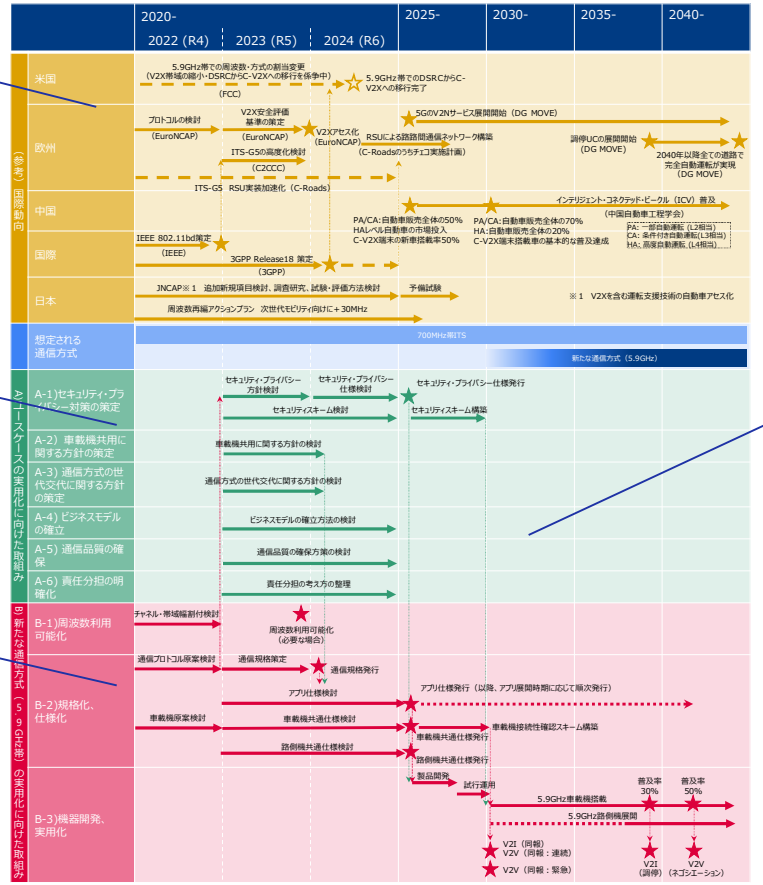
(g)Formulation of roadmap (4/4)

- Assumption : The time when new communication technologies are required to realize cooperative driving automation is around 2040.
- Organize implementation items in chronological order for realization.

International Trends in communication technologies

A) Approach to the practical application of the use cases

B)Approach to the practical application of the new communication technologies



Action item

Summary

- In this project, for the "use cases of cooperative driving automation" that is expected to use V2X created at the study by Task Force on V2X Communication for Cooperative Driving Automation in SIP Phase 2, we have formulated a roadmap for the social implementation time of communication technology necessary for realizing an autonomous driving society.
  - The 700MHz BAND ITS is currently in practical use, and communication requirements cannot be met, at least for mediation and negotiation. For this reason, a new communication method (5.9 GHz) is required to realize cooperative driving automation.
  - The practical application period of use cases requiring mediation and negotiation is expected to be around 2040. In order to achieve this, assuming that the practical application period of the new communication method will be around 2030, it will be necessary to consider the use of frequencies, standardize and specification, and work on equipment development and practical application.
  - In the practical application of the use case, it is necessary to discuss and clarify the following issues.
    - Security and privacy measures / Policy on sharing in-vehicle equipment / Policy on generational change of equipment / Business Model / Ensuring communication quality / Division of responsibilities
- In the future, we hope that efforts to realize cooperative driving automation will be promoted by sharing and examining the roles of stakeholders, including not only telecommunications but also vehicles and infrastructure, starting with the roadmap and use cases formulated, and deepening discussions and collaboration across industries.
- It is desirable that related entities continue to review this roadmap, taking into account future social trends, technological progress, and the progress of implementation items in the roadmap.

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.