

# SIP-adus Workshop 2022



## V2X Communication for Cooperative Driving Automation and Next Step

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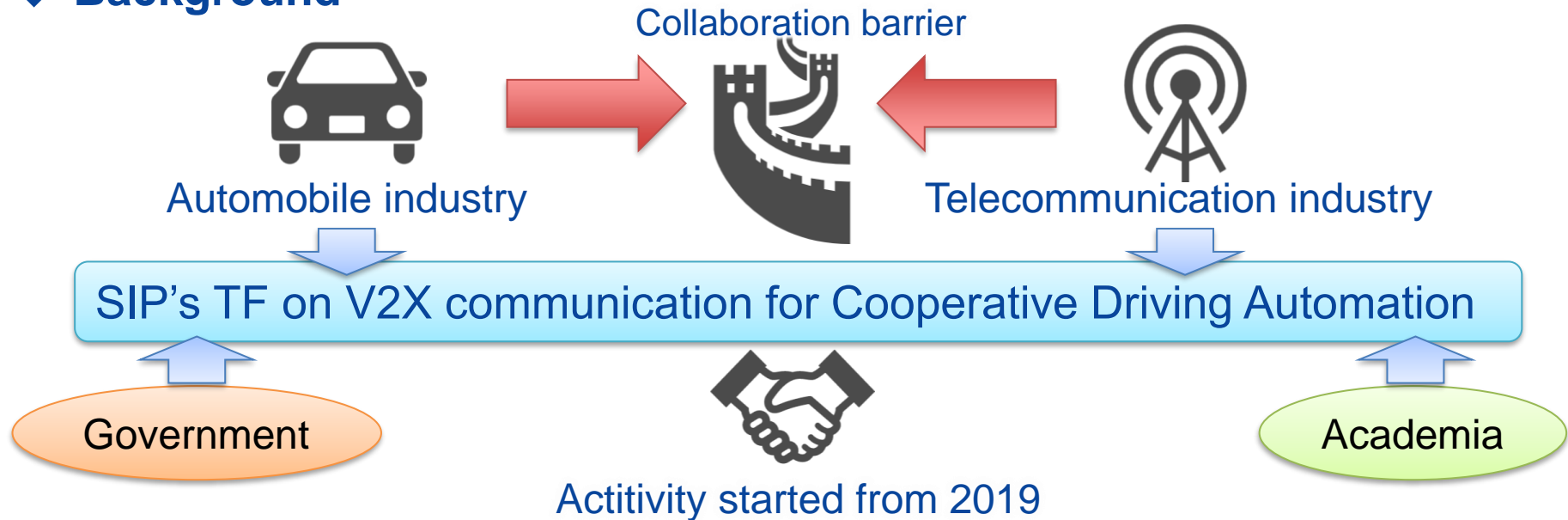
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# TF on V2X communication for CDA

## ◆ Background



### Goal

Draw an ideal form of cooperative driving automation (CDA) and its implementation roadmap considering international standards to establish the optimal and **ALL JAPAN** communication method policy.

# TF on V2X communication for CDA

## ◆ Schedule of TF activity

	FY2019		FY2020		FY2020		FY2021		FY2021		TF member	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4		
<b>Phase-1</b>	✓ Define CDA ✓ Develop use cases for CDA based on the definition										NPA, MILT, MIC, METI, CAO(SIP) JAMA Academia of communication eng.	
<b>Phase-2</b>			Define communication requirements based on use cases									Members of Phase-1, UTMS society of Japan, NIMIL, ITS-Forum, JEITA, Assignee(NEC, Kyocera)
<b>Phase-3</b>			Study of communication system and methods (freq. , bandwidth)				Proposal of roadmap for CDA					

### Goal

- Propose the optimal communication method for CDA
- Draw the roadmap for communication method (requirement)

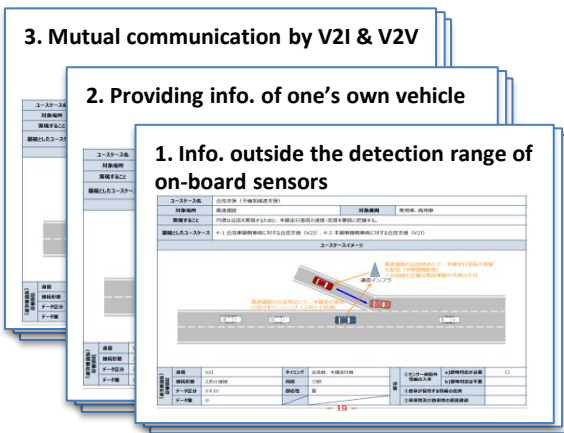
# TF on V2X communication for CDA

## ◆ Outcomes

### 3. Mutual communication by V2I & V2V

### 2. Providing info. of one's own vehicle

### 1. Info. outside the detection range of on-board sensors

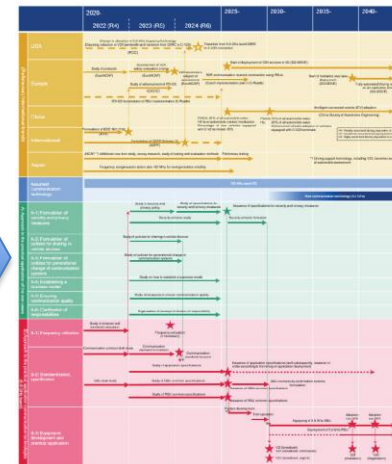


SIP Use Cases for CDA 1<sup>st</sup> edition  
(<https://en.sip-adus.go.jp/rd/rddata/usecase.pdf>)

機能分類	a.合流・車線変更支援
ユースケース	本線隙間狙い合流支援
No.	a-1-2
メッセージ名	位置情報提供
通信形態	V2I (I → V)
通信相手	非特定車両
対象エリア(最小範囲)	合流起点6秒前から合流起点まで
エリアあたり送信台数	1台
必要通信距離	66.7~116.7m
最大相対速度	連絡路：20~70km/h
最大データサイズ	1942 byte (1692+250) 想定台数：62台
周期型もしくは非周期型	周期型
送信周期	100ms
1パケット当たりPAR	PAR≧99% (仮)
無線区間許容遅延	規定しない
無線区間許容遅延	規定しない

Communication requirements for CDA

technical verification



Roadmap of communication methods for CDA

- ✓ Release “SIP Use Cases for Cooperative Driving Automation 1<sup>st</sup> Edition”
- ✓ V2X communication requirements for CDA (with ITS Info-communications Forum)
- ✓ Confirmed necessity of new communication method through technical verification of the requirements
- ✓ Propose the roadmap of communication methods for CDA



## ◆ Definition of 25 use cases for CDA

(<https://en.sip-adus.go.jp/rd/rddata/usecase.pdf>)

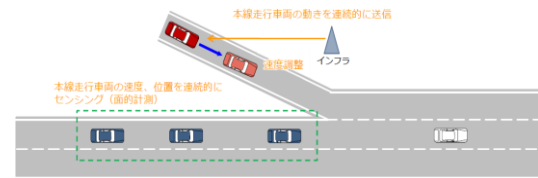
Comm. style	SIP use cases	
<b>V2I</b> • Specific location • Low latency and high reliability	a-1-1. Merging assist by prior acceleration and deceleration a-1-2. Merging assist by searching the gap on the main lane a-1-3. Cooperative merging assist with vehicles on the main lane by roadside control b-1-1. Driving assistance using traffic signal info. (V2I) c-2-2. Driving assistance using intersection info. (V2I)	
<b>V2V</b> • Everywhere • Low latency and high reliability	a-1-4. Merging assist based on negotiation between vehicles a-2. Lane change assist in heavy traffic a-3. Entry assist from non-priority roads to priority roads in congested traffic c-1. Collision avoidance assist when a vehicles ahead stops or decelerates suddenly c-2-1. Driving assist based on intersection info. (V2V)	c-3. Collision avoidance assist using hazard info. e-1. Driving assist using emergency vehicle info. g-1. Unmanned platooning of following vehicles by electronic towbar g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control
<b>V2N</b> • Latency is not critical to some extent	b-1-2. Driving assist using traffic signal info. (V2N) d-1. Driving assist by notification of abnormal vehicles d-2. Driving assist by notification of wrong-way vehicles d-3. Driving assist using traffic jam info. d-4. Traffic jam Info. prior to JCT/IC d-5. Driving assist using hazard info.	e-1. Driving assist using first responder info. f-1. Rescue request (e-Call) f-2. Collection of info. to optimize traffic flow f-3. Update and automatic generation of maps f-4. Distribution of dynamic map info. h-1. Operation and management of mobility service fleet

# Communication requirements



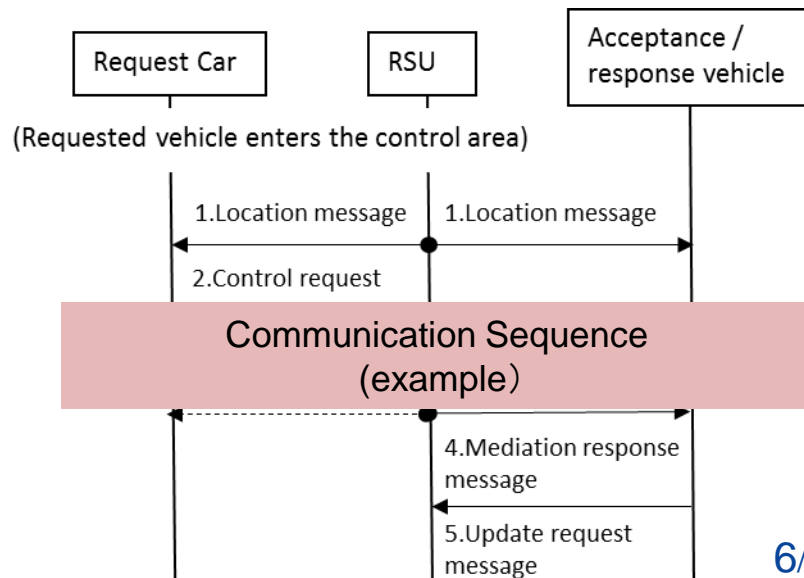
## ◆ Examination of similar cases implemented in the past or currently under consideration

- ✓ Experimental guidelines for communication systems for CDA (ITS FORUM RC-015 1.0 version)
- ✓ Experimental demonstrations by ITS-related organizations, etc.



Use case (image)

Functional classification	a. Merging / lane change support
Use case	Main line gap aiming merge support
No.	a-1-2
Message name	Location information provided
Communication form	V2I (I → V)
Communication target	Non-specific vehicle
Target	Communication requirements (example)
Number per area	
Required communication distance	66.7~116.7m
Maximum relative speed	Connection route : 20~70km/h
Maximum data size	1942 byte (1692+250) Estimated number : 62 vehicles



## ◆ Technical verification

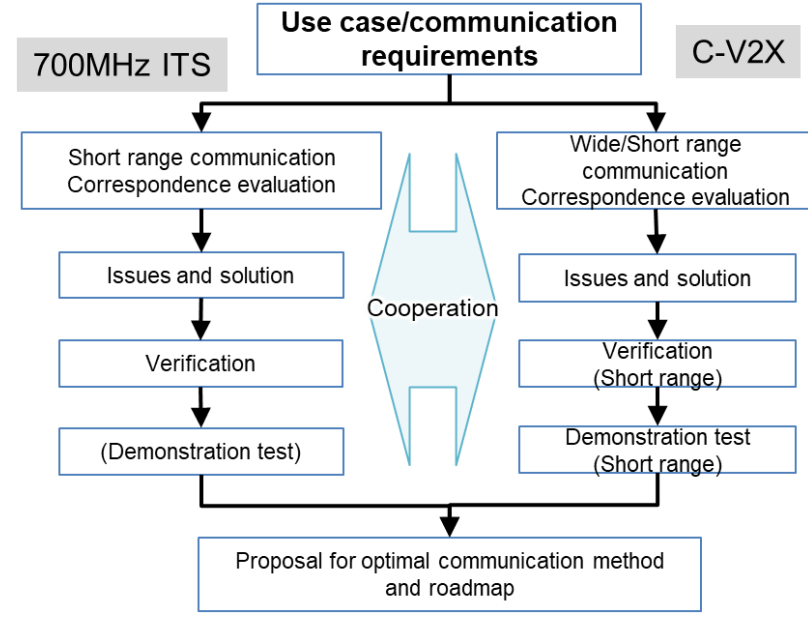
Adaptability of exiting ITS communication (700MHz DSRC) and C-V2X(5.9GHz 10MHz band) for the SIP use cases using simulation.

### Conclusion

- ✓ All use cases of I2V meet the requirements.
- ✓ A part of V2I and V2V use cases can not meet the requirements due to radio interference. However, uni-directional communication cases can meet by reconsidering the assumption.
- ✓ Use cases with negotiation and controlling from RSU can not meet the requirements.



**New Communication method needs to be studied to materialize the all of the 25 use cases for CDA**

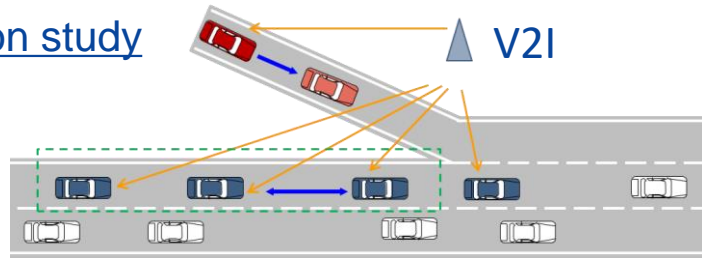




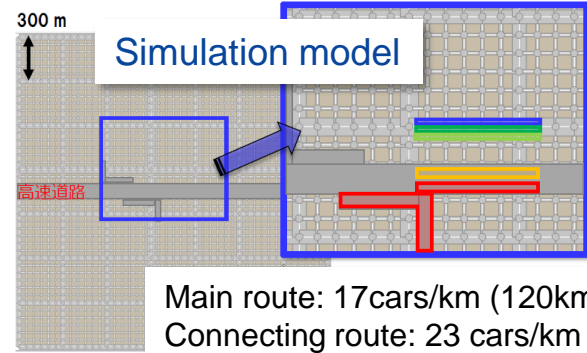
# Study of existing ITS radio (700MHz DSRC)

Evaluation on conditions where SIP-UCs and existing services can coexist

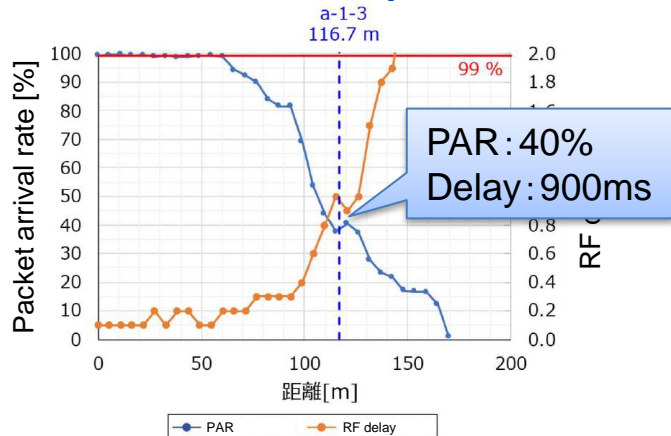
## Simulation study



Cooperative merging assist with vehicles on the main lane by roadside control (a-1-3)



Main route: 17cars/km (120km/h)  
Connecting route: 23 cars/km (70km/h)



Classification	Requirements	Results of Simulation
Required Communication distance	Main: 66.7 - 116.7m Connecting: 111.1 - 266.7m	-
PAR per packet	PAR $\geq$ 99%	Main: 48% Connecting: 40%
Allowable latency of radio communication	Less than 100 [ms]	Main: 800ms Connecting: 900ms

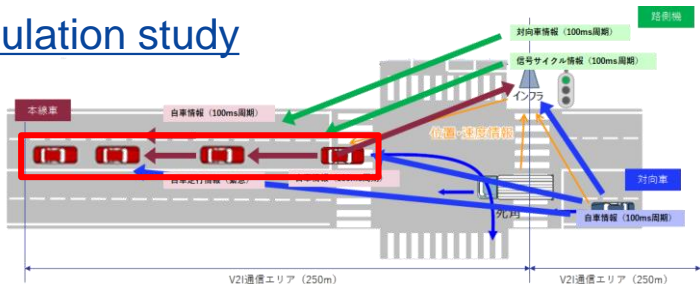
Not achieved at PAR and latency

 New communication method is required for use cases that require negotiation 8/14

# Study of C-V2X (5.9GHz 10MHz bandwidth, PC5)

Evaluation in terms of application to SIP-UCs

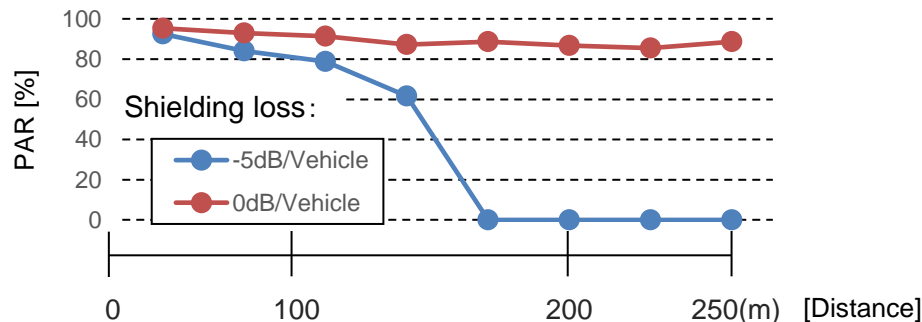
## Simulation study



## Field test

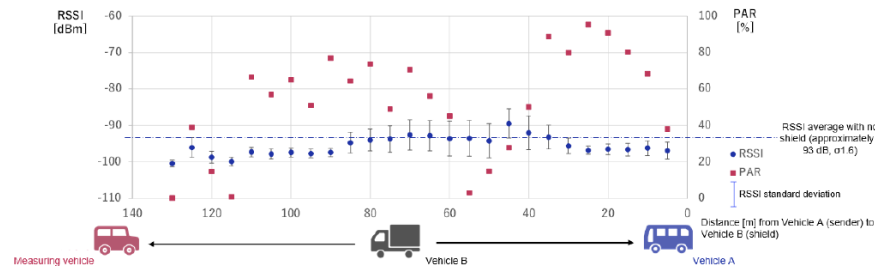


Concurrent condition for multiple use cases (c-2-2, b-1-1, c-1)



PAR is changed by shielding loss (especially at far distance)

Measurement of shadowing impact



Receiving level dropped depending on the location of the shielding vehicle



# Proposal of communication method and roadmap

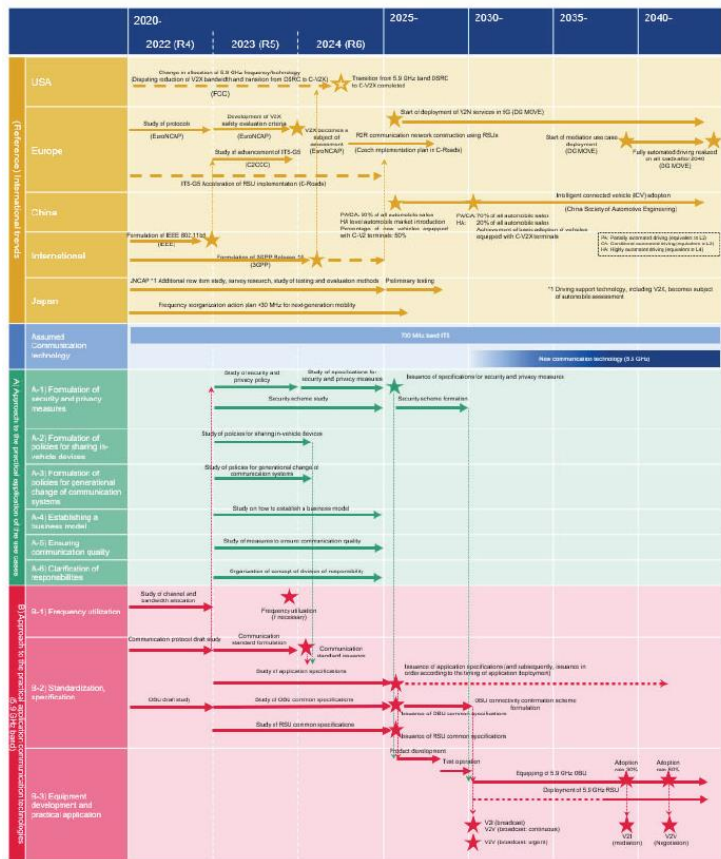
## ◆ Proposed roadmap

### Key points of roadmap

- Assume the timing when new communication methods are required is **around 2040**.
  - The timing implementing negotiation use case
  - The timing when the diffusion rate of CDA is expected to be 30%
- New communication methods **need to be introduced around 2030** due to 30% penetration of CDA around 2040.
- Use exiting ITS radio (700MHz band) for early-stage use cases.

### Issues to be solved for introduction

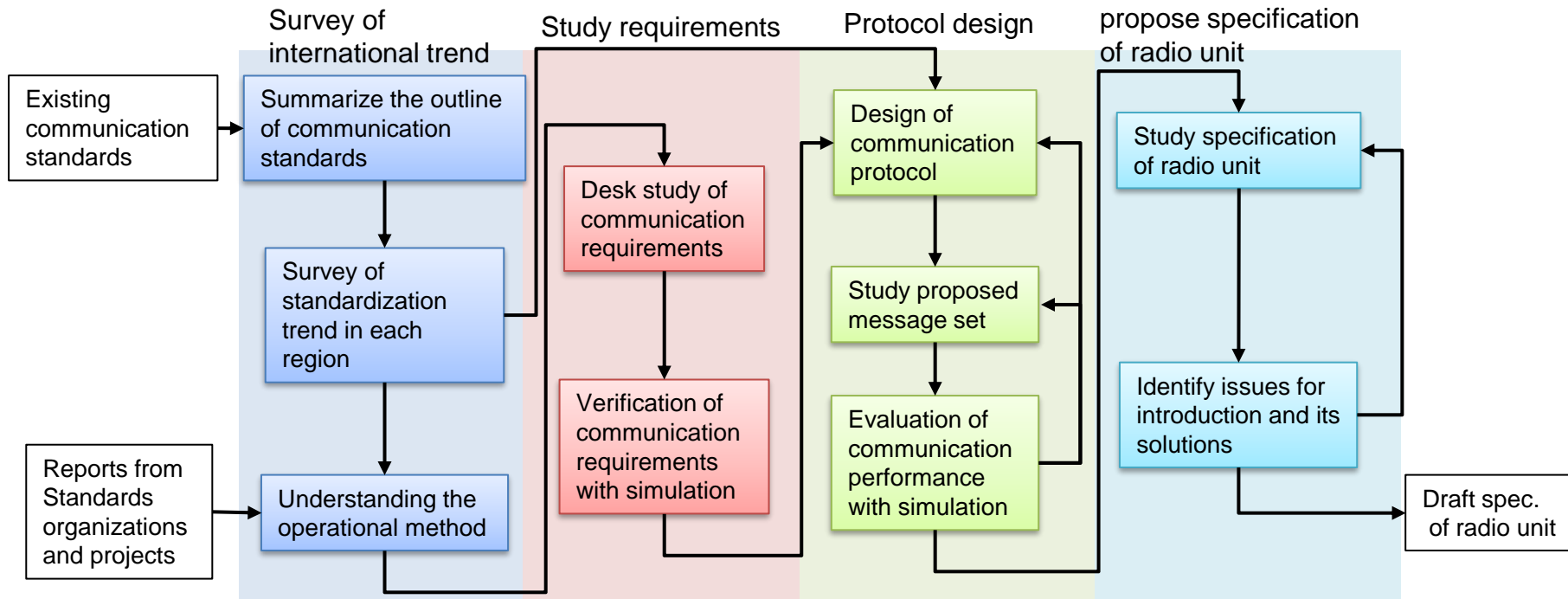
- Reserve new radio band
- Standardization of communication methods
- Security and privacy protection
- Plan for generational change of communication



Roadmap for communication methods for CDA 11/14

# Proposal of communication method and roadmap

## ◆ Start studying 5.9GHz V2X communication protocol from FY2022



The study is underway based on linkage with existing ITS radio (700 MHz band)

## ◆ Summary of TF activity on V2X communication for CDA

- Defined what the CDA should be.
- Studied and published 25 use cases for CDA.
- Formulated communication requirements to achieve the use cases.
- Clarified the need for a new communication method through verification of applicability of existing ITS radio communication.
- Made a roadmap with forecasting when the use cases will be realized
- Proposed the timing to require the new communication method based on the roadmap.

# Next step of the roadmap for practical application

## ◆ Research and Development

- Specify the requirements and issues of new communication methods for CDA on “study of V2X communication protocol on 5.9GHz band” as FY2022 SIP’s program.

## ◆ Rule making

- The roadmap will help the action plan of radio spectrum realignment in Ministry of Internal Affairs and Communications (MIC), Japan.

## ◆ Standardization

- Revise ITS FORUM RC-015 “Guideline for Experiments of Communication System for Use Cases of Automated Driving on Expressways” (by ITS Info-communications Forum).

## ◆ International cooperation

- The roadmap is helpful to reinforce international cooperation to promote internationally practical V2X application.

**Thank you**

