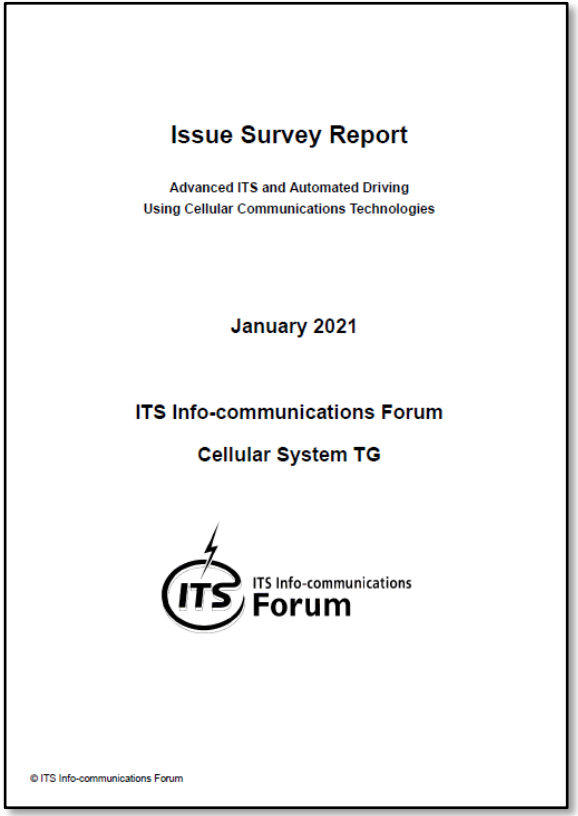
# Issue Survey Report on Advanced ITS and Automated Driving Using Cellular Communications Technologies: Update Overview

ITS Info-communications Forum
Cellular System TG

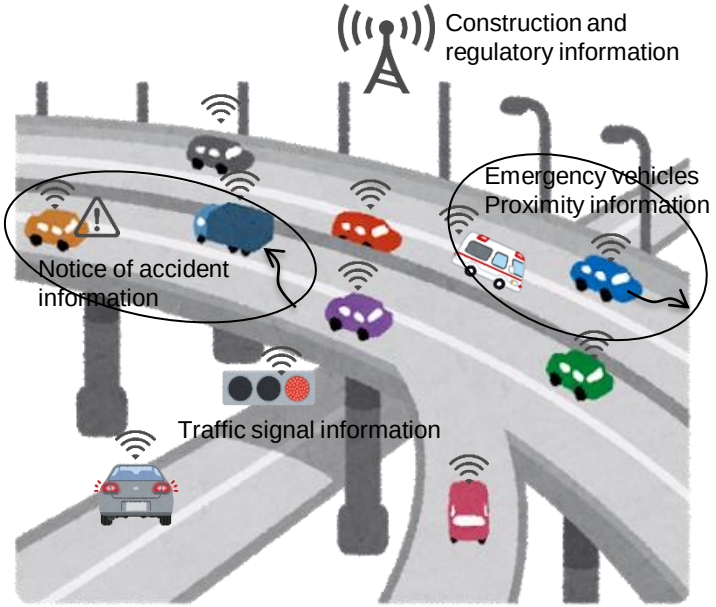



https://itsforum.gr.jp/Public/E3Schedule/p35/Cellular_system_E202101.pdf

# Background (Global)

- Research and development and policy discussions for advanced ITS and creation of an automated driving society using communications are active on a global scale.
- Based on high expectations for cellular V2X, verifications based actual operation and deployments are on going. Each region requires studies on the feasibility of business and deployment.

- **3GPP:**
  - Short range communications: LTE V2X has been specified; 5G NR V2X Rel.16 has been specified, and Rel.17 is under development.
  - Wide area communications: 5G NR specifications have been specified.
- **China:**
  - Large-scale operational tests and deployment for commercial operation are underway in various regions of China including Wuxi.
- **United States:**
  - The FCC narrowed the 5.9 GHz ITS bandwidth to 30 MHz and issued 1st R&O adopting the technology for that bandwidth for C-V2X.
- **Europe:**
  - 5.9 GHz ITS band systems and standards are technologically neutral.



# Background (Japan)

- Some services, which are under discussion globally, are already being deployed in Japan.
- The public and private sectors are now working on the use cases for future cooperative driving automation and discussing the scope of existing ITS and future V2X communication.

- **Cabinet Office, Cross-ministerial Strategic Innovation Promotion Program (SIP)**
  - Automated driving proving tests in the Tokyo coastal region, investigation of communications system for cooperative driving automation, etc.
- **Ministry of Internal Affairs and Communications**
  - Technical investigation relating to communications systems for 5.9 GHz band V2X use
  - Investigation of the scope of support for use cases of existing ITS for cooperative driving automation
- **ITS Info-communications Forum**
  - Radio System Technology TG: Investigation of wireless communication requirement use cases of SIP cooperative driving automation

**Cellular System TG**

- In order to enable advanced ITS and automated driving using cellular technology, the task group investigates entire system verification and issues other than technology like business models, infrastructure deployment, operation/management systems including interconnectivity and security, and separation of responsibilities.

# Overview of Cellular V2X and Purposes of This Report

## Overview of cellular V2X

**Wide area communications**

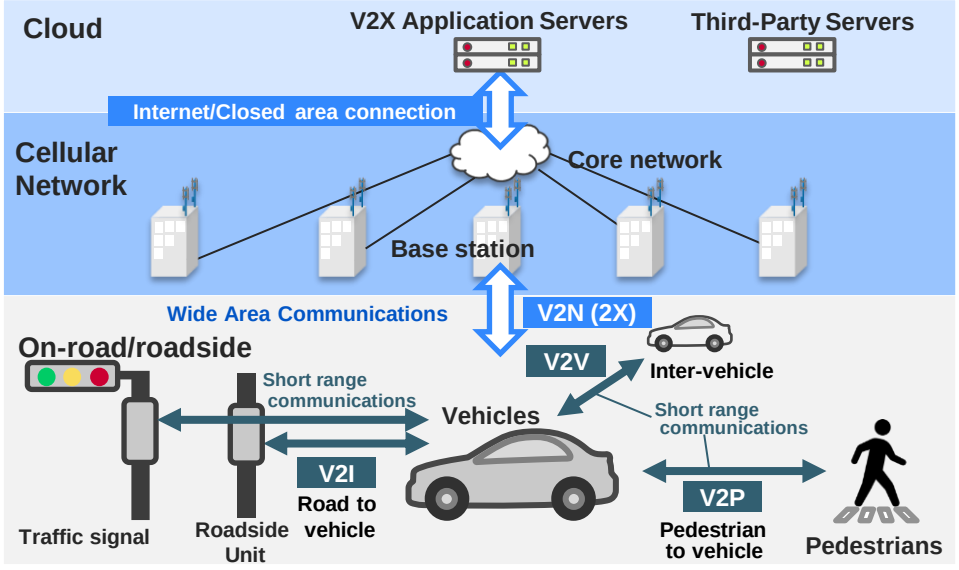
- Suitable for network/Internet connections, wide area information distribution, and non-line-of sight communication.

**Short range communications**

- Direct communications between terminals that do not go through a base station. Shorter latency compared with wide area communications. It would be used for communications that require urgency.

## Purposes of this report

This report was prepared to accelerate future investigation of effectiveness and identification and resolution of issues of cellular V2X and to organize a technical overview, anticipated use cases, communications architecture, business models, and issues.

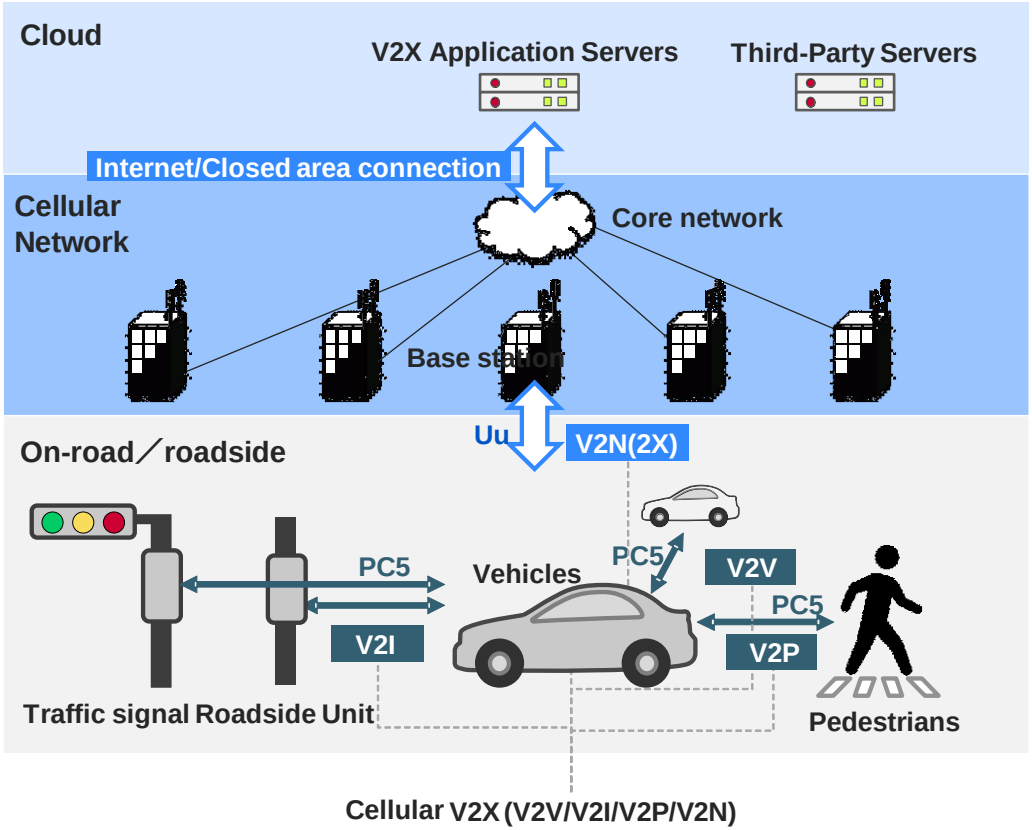


# Report Structure and Overview of Updated Content

| | Item | Overview of First Version | Updated Content |
|---|---|---|---|
| Chapter 1 | Current Status and Outlook for Cellular Communication Systems | Creation of 4G and 5G specifications, frequencies, and status of services | 5G (wide area communications) added (URLLC, Multicast, etc.), overview of NR-V2X (wide area communications), status of wide area communications and short range communications frequency allocation in each country |
| Chapter 2 | Use Cases Expected for Communications and their Roles | Detailed investigation of selection of use cases (notice of falling object, distribution of traffic signal information, etc.) with a focus on the frequency of information updates | Detailed investigation of selection of use cases that demonstrate high added value with a focus on the combination of short range communications with wide area communications |
| Chapter 3 | Communications Architecture | Investigation of communication parameters and operating methods for short range communications (PC5), wide area communication (LTE) operation, and use of MEC | Investigation of suitability of MEC installation sites in anticipated use cases of wide area communications |
| Chapter 4 | Business Models | Specification of cost factors taking into consideration stakeholders and commercialization, investigation of allocation of costs | Presentation of stakeholders and business model diagrams (automobile insurance model, tax model, MaaS/automated driving model) as formats for allocation of expenses, identification of issues for commercialization |
| Chapter 5 | Organization of Issues | Organization of issues identified in Chapters 2 to 4 | Additions based on the updated content in Chapters 2 to 4 |
| Chapter 6 | Summary | - | - |
| Appendices | - | Detailed glossary, technical overview of LTE-V2X (short range communications) communications performance, etc. | Additional content on LTE-V2X and NR-V2X (short range communications) technical overview |

# Communications Formats and Standardization Trends

# Cellular V2X System Overview

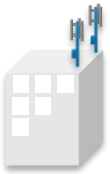



- **Wide Area Communications (V2N)**
  - Communications via base stations and core network
  - Use of existing communications infrastructure and wireless interfaces is anticipated
  - IP Communications

- **Short Range Communications (V2V/V2I/V2P)**
  - Use of frequency dedicated to ITS
  - Use of direct communications between mobile stations for V2X
  - Non-IP communications

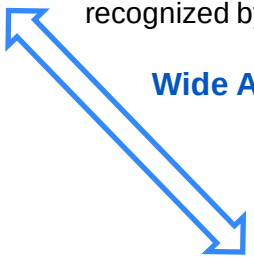
# Terminology

- **Base station, NobeB**
  - Base station means the equipment that communicates with mobile devices in the cellular network. A base station supports one or multiple cells.
  - eNodeB is an LTE base station.
  - gNodeB is an NR base station.



- **Cell**

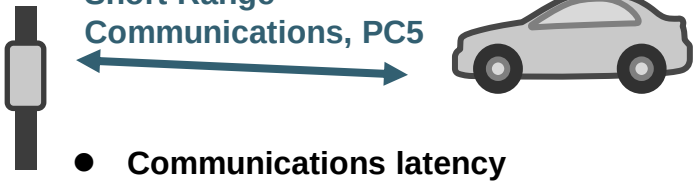
  A certain geographic area to which a base station transmits radio waves on a single frequency and is uniquely recognized by mobile devices.




- **Mobile station, UE (user equipment)**

  Devices that communicate with networks in cellular networks.

- **Roadside unit, RSU**
  - In this document, devices that use wide range communications to communicate with terminals are not referred to as roadside units.
  - A device that uses short range communications to communicate with terminals are referred as roadside units.

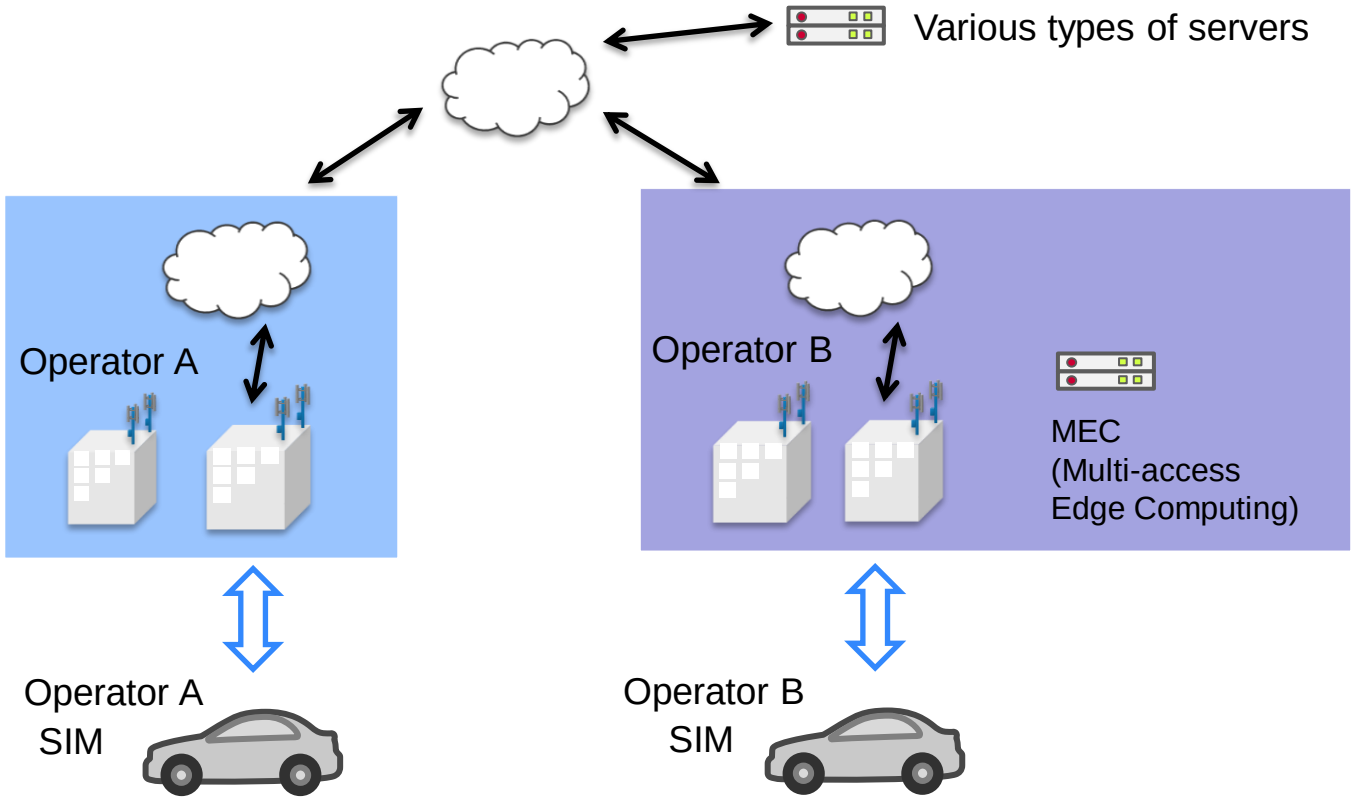



- **Communications latency**
  - It often means the shortest latency in one direction under active state and light load on communication links.
  - Further consideration is necessary of 1) data generation frequency and latency in the sensors and communication data generation units, 2) the effects and variation under heavy loads on communication links, 3) the time required for the retransmissions and 4) whether the communication units are always active or not.

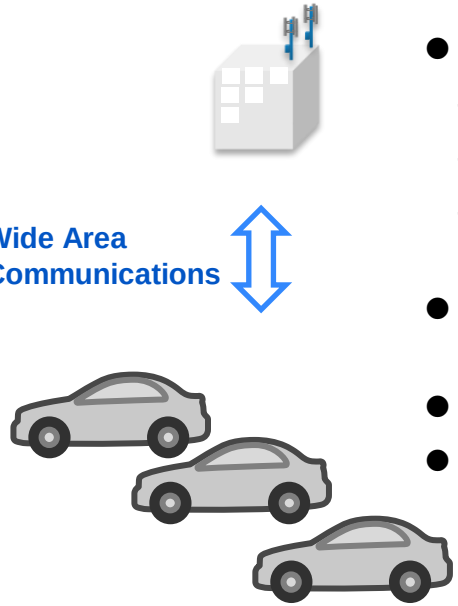
# Releases in 3GPP

| | Wide Area Communications, Uu | Short Range Communications, PC5 | |
|---|---|---|---|
| Rel-8 | LTE initial version | | |
| Rel-9 | LTE downlink broadcasts | | |
| Rel-14 | LTE downlink broadcasts (Optimization for V2X usage) | Short range communications using LTE V2X | |
| Rel-15 | NR initial version | Short range communications enhancement in LTE V2X | |
| Rel-16 | NR enhancement for URLLC | Short range communications using NR V2X | Completed in June 2020 |
| Rel-17 | NR downlink broadcasts | Short range communications enhancement in NR V2X | Scheduled for completion in June 2022 |

# Wide Area Communications (V2N) Overview

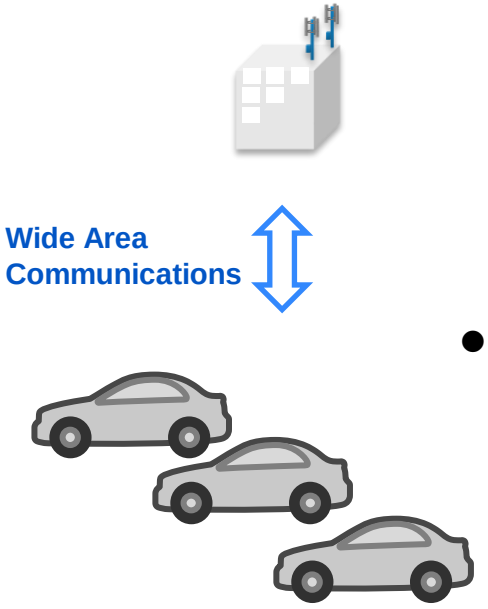


# Wide Area Communications Using NR (V2N)




- **NR: A wireless access technology standardized by 3GPP for 5G**
  - Fundamentally covers all services that can be achieved using LTE Uu
  - Backwards compatible with terminals and base stations
- **Two types of connection**
  - Non-standalone: Paging in LTE. Communication via LTE and NR
  - Standalone: Both paging and communication via NR
  - Terminals also support LTE, so LTE is used to connect the network when outside of the NR coverage area
- **Various subcarrier spacings allows use of millimeter waves and shortens the data allocation latency**
- **Latency is also reduced by the data allocation using OFDM symbol units**
- **Forward compatibility by reducing constant transmission signals**

# Wide Area Communications Using NR (V2N)

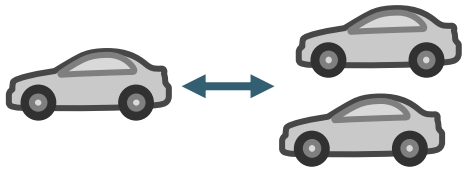



- **URLLC (ultra-high reliability, ultra-low latency)**
  - Release 16 specification aims to support remote automated driving
    - Assumed conditions: Latency is 5 ms, reliability is 99.999%, and data speeds are uplink 25 Mbps and downlink 1 Mbps
  - Flexibility and high frequency of physical layer control signals, flexibility of repeated transmission, prioritization on the physical layer, cancellation function during transmission, etc.

- **Multicast**
  - A single transmission received by multiple terminals simultaneously is being standardized in Release 17.

# Short Range Communications Using NR (V2V/V2I/V2P)

Short Range Communications, PC5



- **Short range communication using an NR, which is primarily intended to be complementary to short range communication using LTE**
  - Advanced use cases are expected to use both LTE-V2X and NR-V2X simultaneously
  - Which technologies will be used for which use cases is a decision of the ecosystem including regional standards bodies and the automobile industry
- **Various subcarrier spacing are supported**
- **Intended for low latency with aperiodic communications**
- **Supports groupcast and unicast in the physical layer**
  - In groupcast, group formation by spatial proximity and group formation by application layer decision
- **Supports error decoding results notification, MIMO, and channel status feedback**
- **Release 17 is ongoing standardiztion to cover pedestrians and others**

Issue Survey Report on Advanced ITS and Automated Driving Using Cellular Communications Technologies

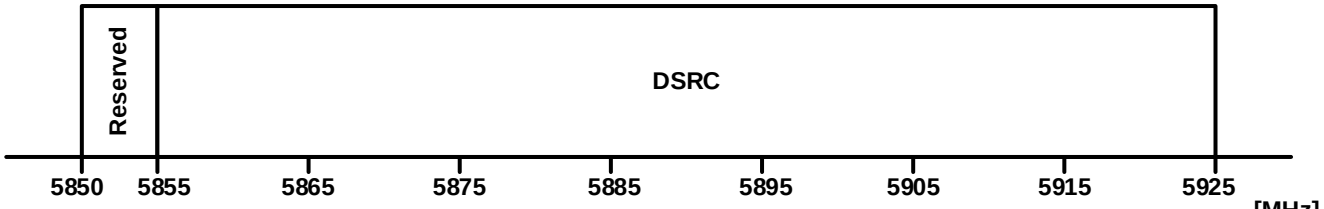
# Frequency Trends

# Contents of Frequency Trends

- ITS frequency trends in the United States
- ITS frequency trends in Europe
- ITS frequency trends in China
- ITS frequency trends in Other Countries
- Status of ITS Frequencies in Japan
- Frequencies for Wide Area Communications (5G)

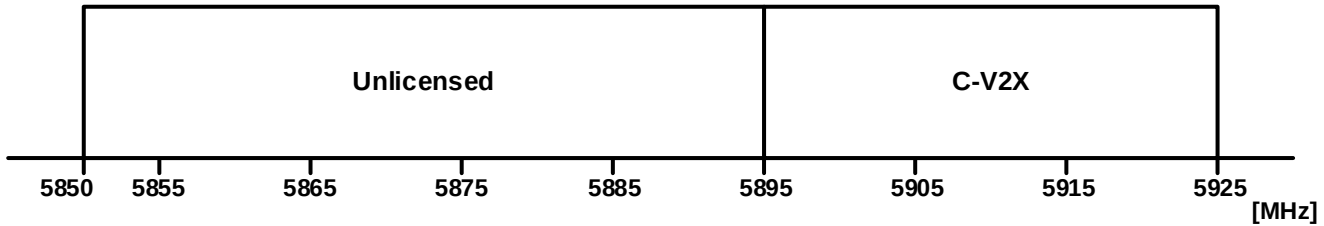
# ITS Frequency Trends in the United States (1)

- In 1999, the FCC allocated 5850 - 5925 MHz as the ITS band for DSRC (802.11p).




**Initial DSRC Frequency Allocation**

- In December 2019, the FCC proposed changes to the allocation plan. In November 2020, the FCC issued a Report and Order (R&O) allocating 5850-5895 MHz as an unlicensed band and 5895 - 5925 MHz as the ITS band for use by C-V2X.




**FCC R&O**

# ITS Frequency Trends in the United States (2)

- **Process After R&O**

  Day 0: Publication in Federal Register

  Further Notice of Proposed Rulemaking (FNPRM)

  (* It was registered and FNPRM was issued on May 3rd = Day 0.)

  *The status was updated after the workshop.

  + 60 days R&O becomes effective

  + 90 days: Comments due and Petitions for Reconsideration possible

  + 90 days: Technical rules for upper 30 MHz

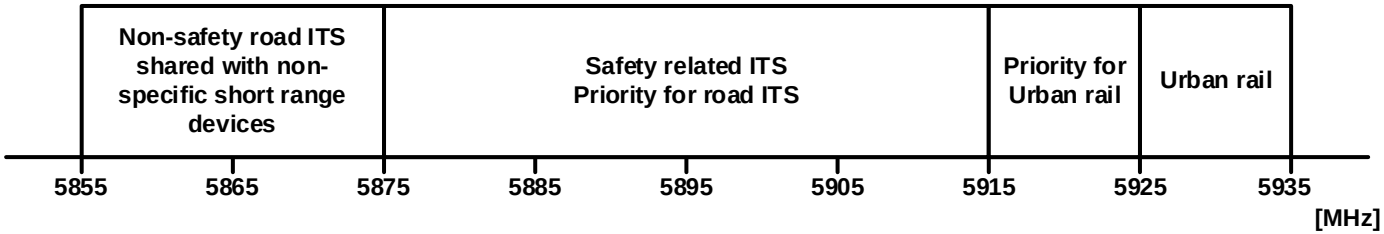
  + ? days: Final Rule, including rules for outdoor unlicensed activity

- **Main Details of the FNPRM（Further Notice of Proposed Rule Making)**
  - DSRC must be transitioned to C-V2X after a certain period, but the timing and method of transition require further study
  - Limiting unwanted emissions from added unlicensed bands
  - Outdoor use in added unlicensed bands
  - Added frequencies for ITS use

  In addition, interference from VLP (very low power) unlicensed devices from the 6 GHz band is also an issue (a system for VLP will be created in the future.)

# ITS Frequency Trends in Europe

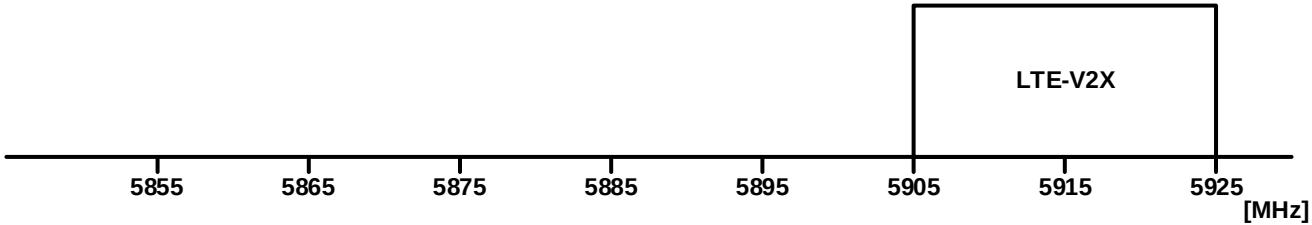
- In 2020, the system relating to frequency for ITS was revised including the addition of frequency for urban rail.
- The technology to be used has not been specified (technology neutral), but the purposes of use are specified for each band.
- Sales of automobiles equipped with ITS-G5 (DSRC) started in the second half of 2020.




**Frequency Allocation in Europe**

# ITS Frequency Trends in China

- 5905 - 5925 MHz was allocated to LTE-V2X in 2018, and commercial operation started in 2020.
- The technology used is limited to LTE-V2X.

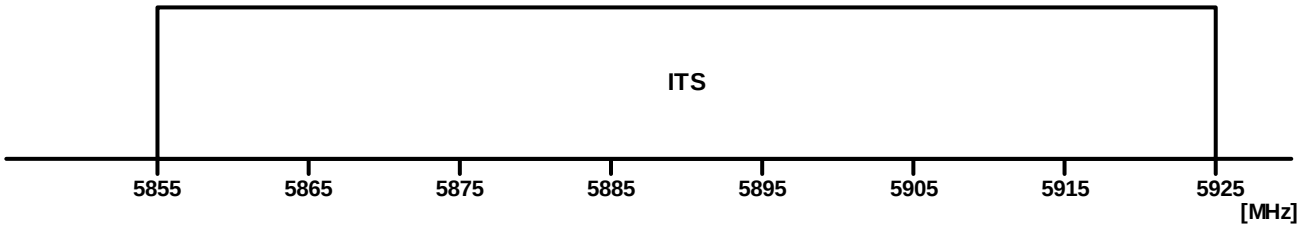



**Frequency Allocation in China**

- Studies on expansion of frequencies have started in anticipation of NR-V2X.
  - There are many opinions in industry organizations that commercial deployment will start in about 2025.

# ITS Frequency Trends in Other Countries

- South Korea, Singapore, Australia, Canada, Brazil




**Frequency Allocation**

- Allocation occurred in South Korea in 2016, and discussion is now taking place on the technologies to be used in this band.

# Status of ITS Frequencies in Japan

- 755.5 - 765.5 MHz was allocated as the ITS-exclusive frequency (V2X), and operation of ITS Connect, a drive assist system that uses road-to-vehicle and vehicle-to-vehicle communications started in 2015.

- The 5.8 GHZ (5770 - 5850 MHz) band is used for ETC to collect tolls on toll roads and to provide information services such as traffic congestion information, safe driving support, and guidance during emergencies using ITS spot in accordance with ETC 2.0.

- The frequency reorganization action plan announced by the Ministry of Internal Affairs and Communications in 2020 stated that the technical conditions necessary for introduction of V2X communications in the 5.9 GHz band will be investigated. Below is an excerpt.

  Based on the progress and importance of automatic driving systems (including safe driving support), a study is being carried out, which will finish by the end of FY 2021, into the technical conditions for frequency sharing with needed existing wireless systems, for example when introducing V2X communications, and with consideration for existing wireless systems on frequency bands being studied internationally (5.9 GHz band), in addition to the existing ITS frequency bands (760 MHz band, etc.,).

  In addition, based on the results of these studies, in cases where V2X communications are to be introduced on the same frequency band, there is a goal to allocate frequencies to V2X in FY 2023 after the necessary frequency bandwidth has been secured by migrating existing wireless systems, etc.

# Frequencies for Wide Area Communications (5G)

- Concerning the new spectrum to be allocated to operaters for 5G (licensed spectrum), both frequency bands below 6 GHz and millimeter wave bands have been allocated in various countries and regions.

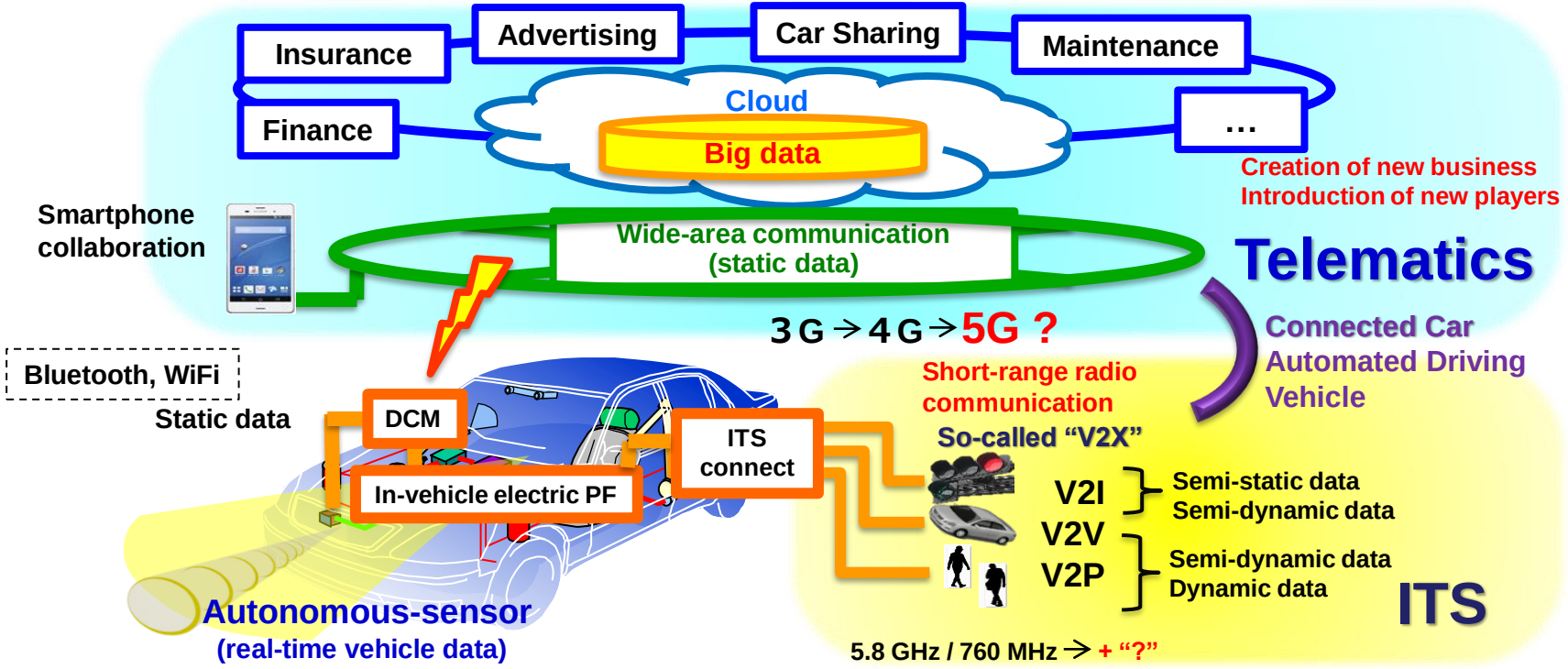
- In Japan, 5G frequencies have been allocated to four mobile phone carriers, and the system development for using 5G in the frequencies used for 4G have been completed.

| Mobile Phone Carrier | Frequencies Allocated |
|---|---|
| **NTT DOCOMO** | 3.6 - 3.7 GHz, 4.5 – 4.6 GHz (TDD)<br>27.4 – 27.8 GHz (TDD) |
| **KDDI** | 3.7 - 3.8 GHz, 4.0 – 4.1 GHz (TDD)<br>27.8 – 28.2 GHz (TDD) |
| **SoftBank** | 3.9 – 4.0 GHz (TDD)<br>29.1 – 29.5 GHz (TDD) |
| **Rakuten** | 3.8 – 3.9 GHz (TDD)<br>27.0 – 27.4 GHz (TDD) |

Issue Survey Report on Advancing ITS and Automated Driving Using Cellular Communications Technologies

# Use Cases Expected for Communications and Their Roles

# Connected Car Communications (Reproduced from slide of 5th WS)




Connected car communications are broadly divided into wide area communications (telematics) and short range communications (currently DSRC).
It is expected that in the future, services that skillfully combine these will be required.

# Approach to Use Case Organization

- **Flow of Investigation and Points**

**(1) Identification use cases to be adopted as topics** → **(2) Organization of approaches to cellular use** → **(3) Organization of issues**

Identification Perspectives

(1) Specification of subject scenarios (2) What issues are to be solved?
(3) What approaches are possible in cases where communications are not used?
(4) In cases where communications are used, what value will be generated?

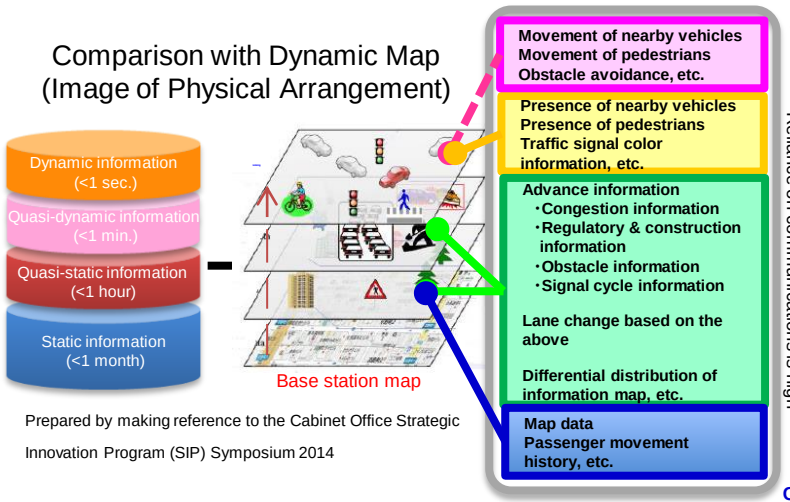
Broadly investigate issues necessary for practical application

**Review (use cases in the first edition of the report)**

- Identified use cases focused on the interval of information updates and organized issues
- Investigated replacing services that have already been put into service with existing ITS with the assumption of replacement by cellular

→ Many issues identified

Comparison with Dynamic Map (Image of Physical Arrangement)




Prepared by making reference to the Cabinet Office Strategic Innovation Program (SIP) Symposium 2014

| Examples of Issues | Examples of Use Cases Identified in the Initial Version | Short range comm | | Wide area comm |
|---|---|---|---|---|
| | | V2V | V2I | V2N |
| Frequency / Operations method | Collision avoidance and sudden braking due to falling object, etc. | ● | | |
| Information acquisition Method | Intersection transit support using traffic signal information dilemma zone avoidance, and red traffic signal warning | ● | ● | |
| Existing ITS segregation | Lane change support/route selection using information on the presence of an obstacle, etc. | | | ● |
| Server Installation location | Vehicle avoidance support using information on nearby emergency vehicles | ● | | |
| | Route re-search using construction information, etc. | | | ● |

# Added Use Cases: Identified Perspectives and List

- Looking ahead to the future automated driving society, it is expected that it will be used not only for short range communication, but also wide area and high capacity communication.
  A detailed investigation of use cases combining short range communications with wide area communications (combined wide area communications) was conducted.

**Benefits of Combined Wide Area Communications**

(1) Seamless provision of optimal information according to distance, time, etc. by the strengths and weaknesses of each complementing each other

(2) Enhanced service feasibility through sharing functions such as data exchange and vehicle identification and authentication

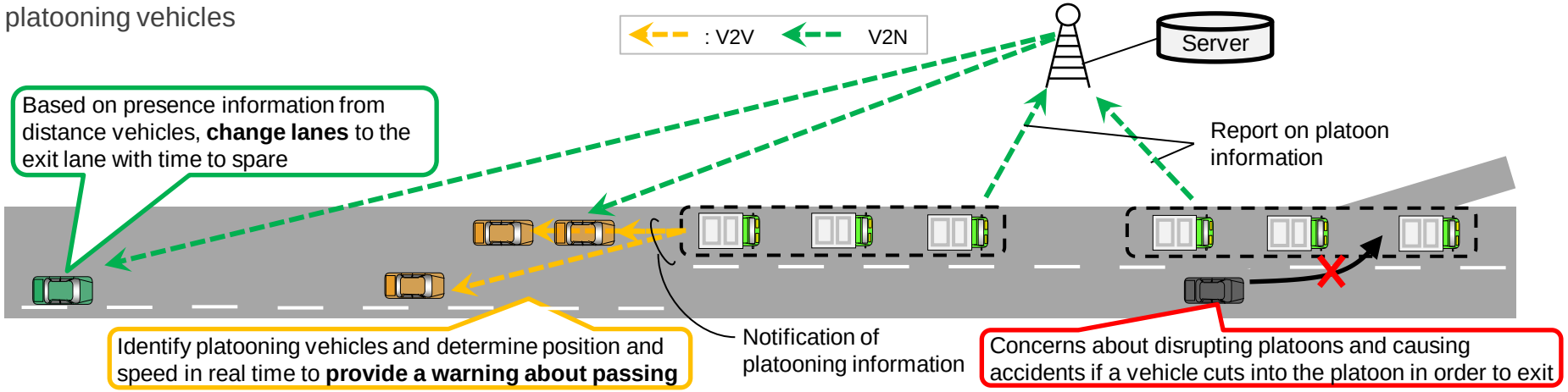
- The five use cases below are representative examples of the investigated use cases

| Use Case Name | Features |
|---|---|
| Highway exiting support using platoon information near highway exits | Wide area distribution provides information on the presence of platooning vehicles and specific passing warnings at short distances to support smooth exiting from expressways |
| Provision of warning information concerning events on the road | At short distances, prevents rear-end collisions that have skidded and so on and avoids entry into routes with dangerous sites through wide area distribution based on information from multiple vehicles |
| FAST that takes into consideration emergency vehicle travel routes | Achieves smoother emergency vehicle driving by transmitting emergency vehicle route information via wide area communications, controlling traffic lights preferentially, and communicating intentions to nearby vehicles |
| Status recording and notification services at accident sites | In addition to preventing secondary accidents at short distances when an accident occurs, timely assistance and handling are provided by recording and reporting the situation at the accident site via wide area communications. |
| Platooning security, authentication, and billing | Platoon formation using short range communications and allocation of fuel efficiency improvement by following using wide area communications |

# Use Case Example 1:
# Highway Exiting Support Using Platoon Information Near Highway Exits

**Scenario:** A platoon of vehicles is present near a highway exit, making it difficult for nearby vehicles to exit

**Support:** Support smooth exiting from highways by taking into consideration the sense of distance from the exit and the platooning vehicles




**Focus Point:**

- Wide area communications: General information on the presence of platoons that takes advance of the wide-area nature of the communications (presence of platoons near an exit that should be taken into consideration)
- Short range communications: Real-time platoon information that makes use of reliability (location, speed, identification of platooning vehicles, etc.)

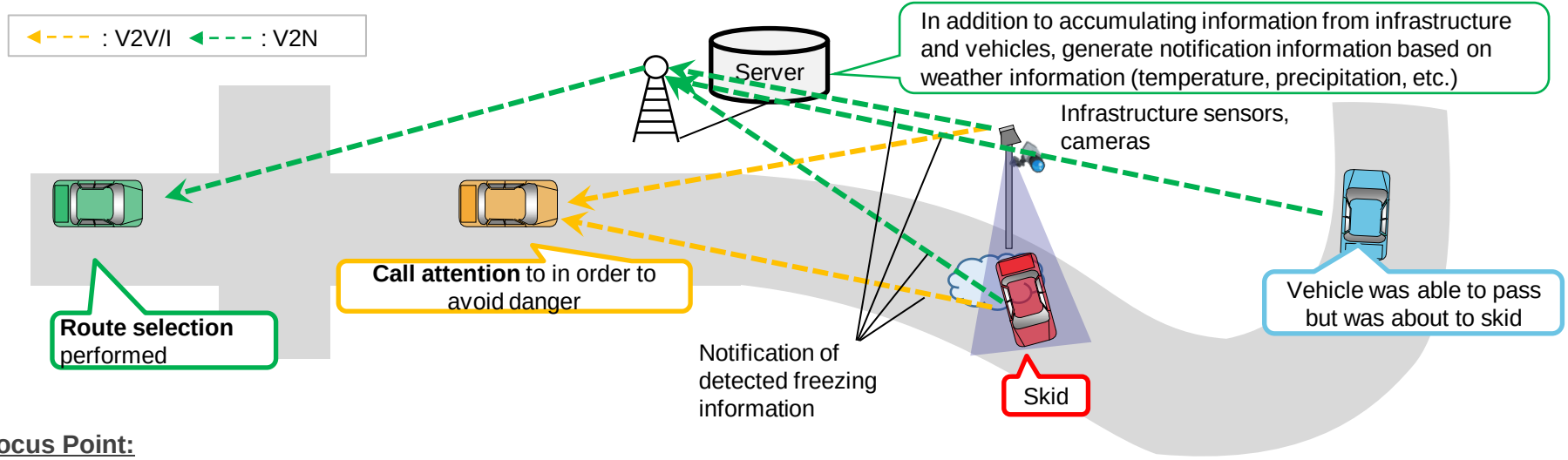
**Main Issues:**

- Method of collecting, managing, and distributing information on a server concerning the presence of platoons and information distribution area classification
- Method of mediating wide area and short range communication information on the vehicle side, impact on traffic flows over a wide area, etc.

# Use Case Example 2:
# Provision of Warning Information Concerning Events on the Road

**Scenario:** An area of the road where driving is dangerous (freezing, flooding, etc.)

**Support:** Support danger avoidance by considering the sense of distance to the dangerous site, data, etc.




**Focus Point:**

- **Short range communications:** Real-time information on road irregularities detected by vehicles
  * There is a possibility of collaboration with use case (4)
- **Wide area communications:** Specific and predictive road conditions based on use of wide area properties and big data

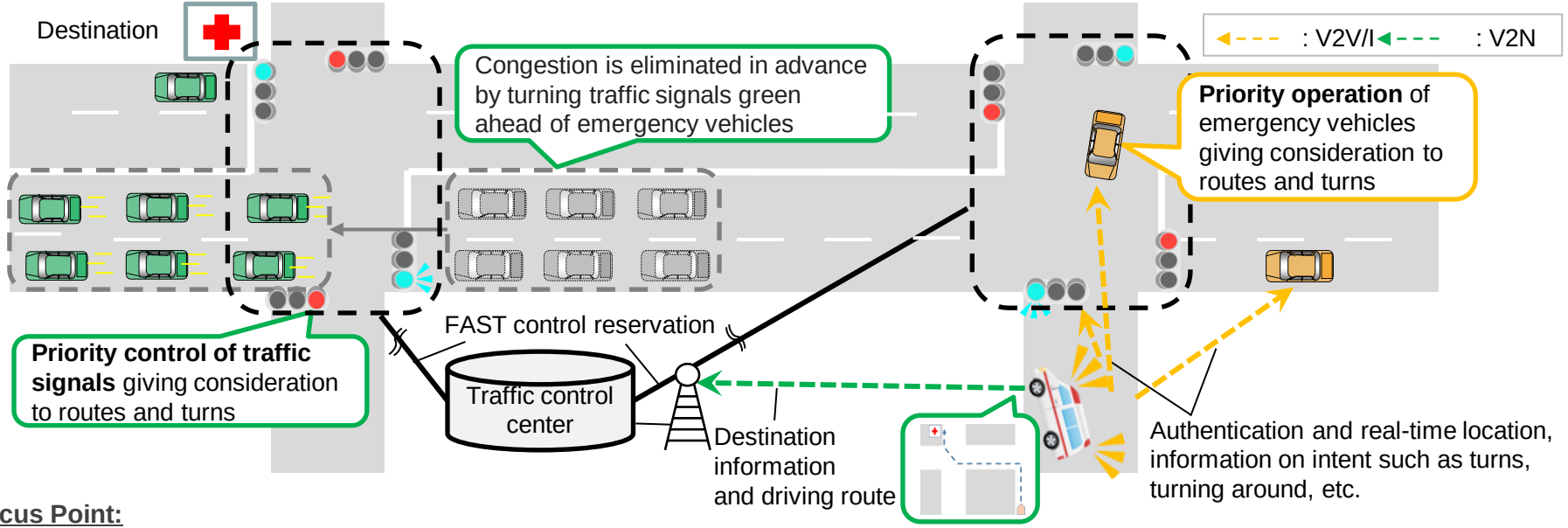
**Main Issues:**

- How to assess an event from the detection of information from each infrastructure unit and vehicle (taking into consideration differences among manufacturers)
- Authenticity of information, where responsibility lies, inconsistency between information providers and beneficiaries, etc.

# Use Case Example 3:
# FAST That Takes into Consideration Emergency Vehicle Travel Routes

**Scenario:** Emergency vehicles engaged in emergency driving should be able to pass quickly even under heavy traffic conditions

**Support:** Encourage priority control and passage of both traffic signals and nearby vehicles




**Focus Point:**

- **Wide area communications:** Emergency vehicle route information, approximate transit times, etc.
- **Short range communications:** Vehicle information (position, authentication ID), intent information (turns, etc.) of emergency vehicles utilizing authenticity

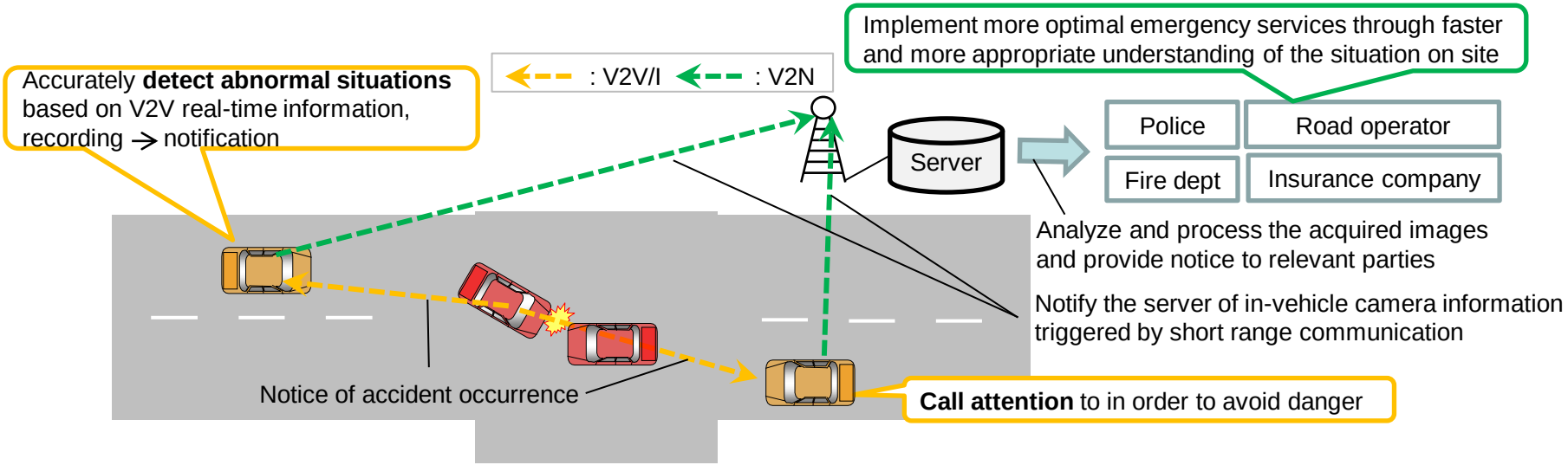
**Main Issues:**

- Protocols for FAST compatible intersection database and route generation, distribution, authentication, etc.,
  secure operation in all phases including equipment manufacturing and sales, impact on traffic flows over wide areas, etc.

# Use Case Example 4:
# Status Recording and Notification Services at Accident Sites

**Scenario:** Accident at an intersection

**Support:** Support for the prevention of secondary accidents and prompt and adequate rescue




**Focus Point:**

- **Short range communications:** Utilize reliability and immediacy to accurately detect the occurrence of accidents in real time (service trigger)
- **Wide area communications:** Use communication capacity to notify the server of large-volume data such as images and video

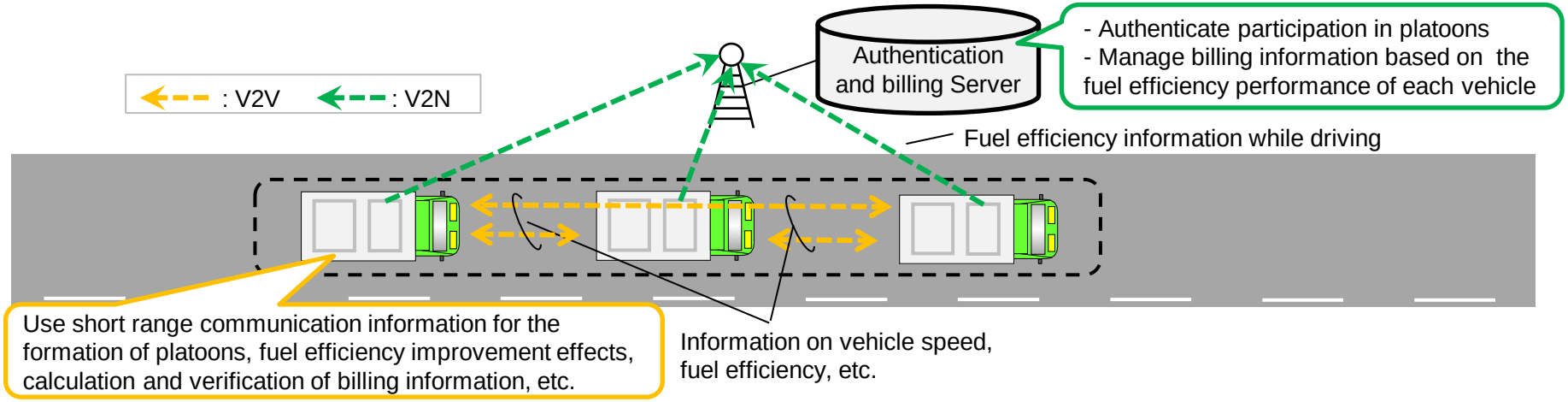
**Main Issues:**

- Communication protocols, standardization of message formats, optimal cost burdens of information providers, handling rules for image data, mechanisms for distribution of information analysis results on servers, etc.

# Use Case Example 5:
# Platooning Security, Authentication, and Billing

**Scenario:** Encourage fair platooning by trucks from different companies

**Support:** Equalize transportation costs from the improvement in fuel efficiency of following vehicles and support the formation of appropriate platoons and the exchange of money




**Focus Point:**

- **Wide area communications:** Vehicle inspection status inquiry and authentication, billing information
- **Short range communications:** Verification of the validity of information (vehicle identification, position, speed, etc.) and billing information required for formation of platoons

**Main issues:**

- Investigation concerning testing and authentication to ensure interconnectivity.
- Conditions, standards, laws and regulations, etc. for participation in platoons
  (What conditions should be met concerning vehicle sensors, brakes, automated driving programs, billing conditions, etc.?)

# Summary of Use Cases Expected for Communications and Their Roles

- **New use cases where more advanced services can be provided by combining short range communications that offers high reliability, immediacy, and authenticity with wide area communications that utilizes wide-area and high-capacity communication were selected.**

- **In cases where both short range communications and wide area communications are used,**
  - Systems and operation, relationships between information providers and beneficiaries, and so on become broad and complex
  - The movements and traffic flows of vehicles over wide areas are changed

  **It is necessary to take these factors into consideration and to conduct deeper investigation.**

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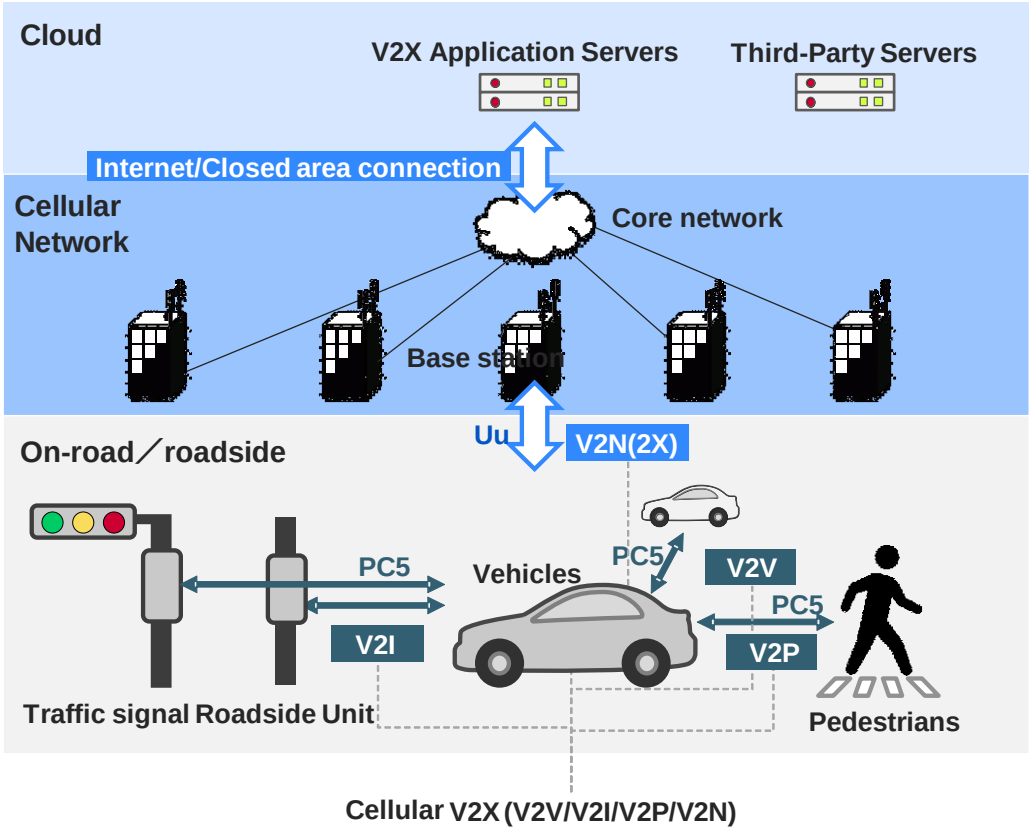
# Communications Architecture

# Cellular V2X System Overview




- **Wide Area Communications (V2N)**
  - Communications via base stations and core network
  - Use of existing communications infrastructure and wireless interfaces is anticipated
  - IP communications

- **Short Range Communications (V2V/V2I/V2P)**
  - Use of ITS exclusive frequencies
  - Use of direct communications between V2X dedicated mobile stations
  - Non-IP communications

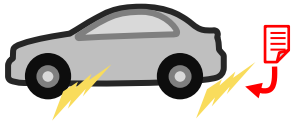
# Short Range Communications

## Parameter management and operation

**Automated operation that does not rely on networks**

- Parameter setting at time of shipment and vehicle inspection
- Communications by terminals

**Parameter management tailored to use cases is necessary**

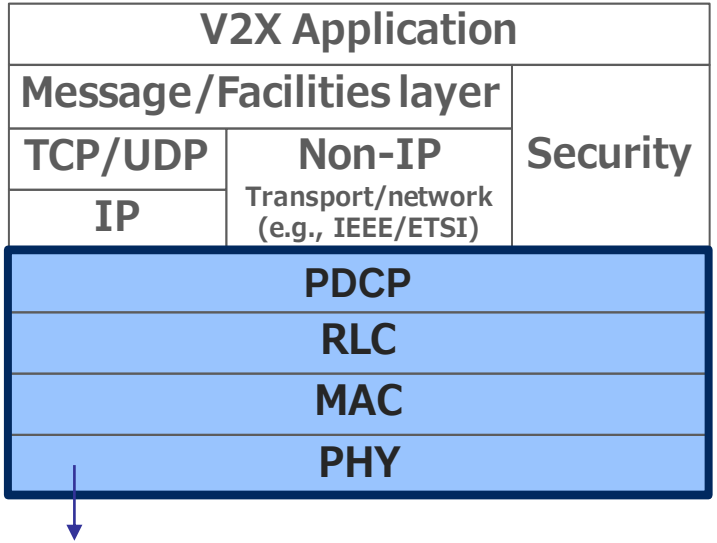


Use cases

Use regions

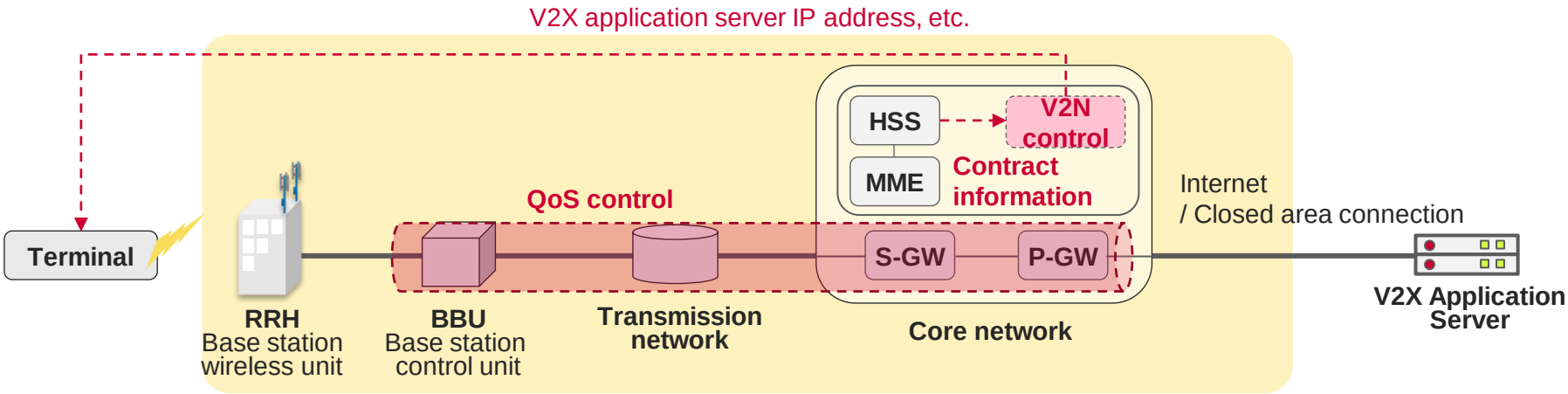
## Protocol stack

**With regard to the upper layer, it is necessary to specify domestic standards**




Wireless layer:
Specifications exist for 3GPP

# Wide Area Communications: Architecture



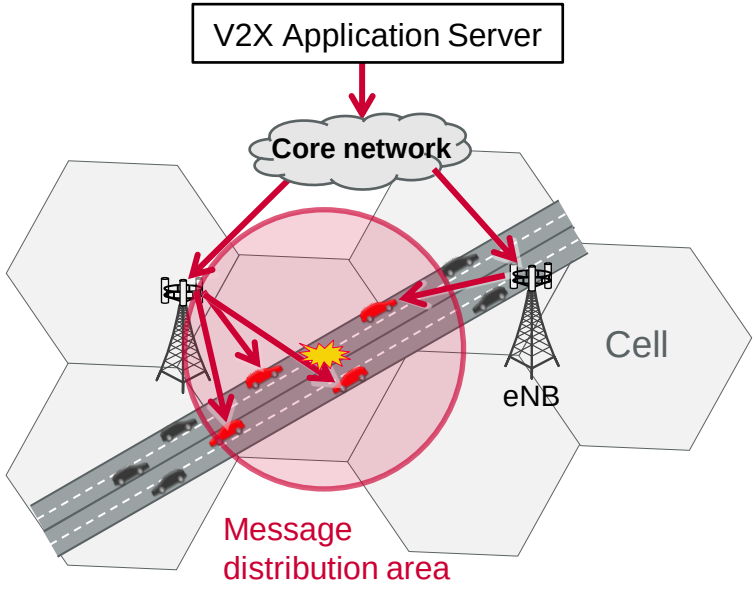

- Cellular network infrastructure → High costs for development
- An existing MNO infrastructure (unicast) architecture with high short-term feasibility is assumed
- Although there are mechanisms such as QoS control, complete quality assurance cannot be provided

**Use of existing MNO infrastructure is assumed.**
**It is necessary to consider whether infrastructure can be used as-is.**

# Wide Area Communications: Geo-messaging

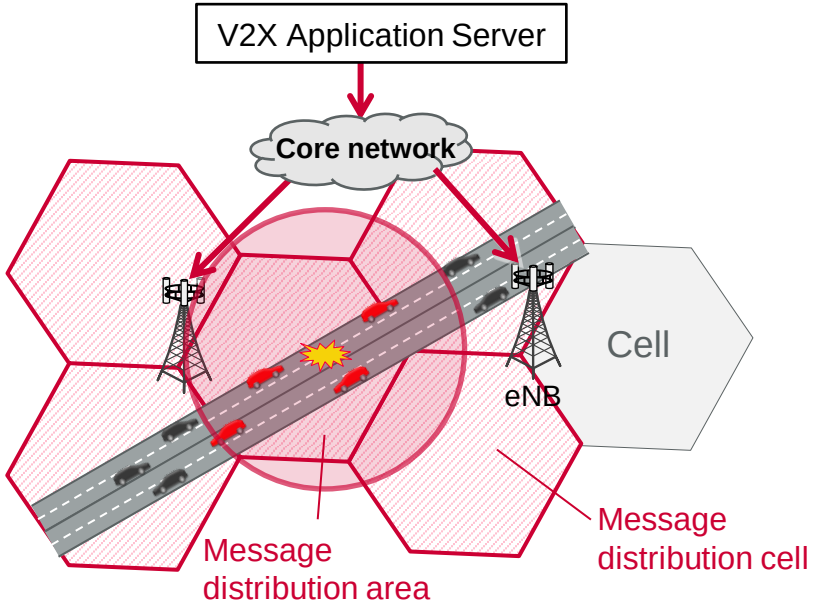
## (1) Unicast

**Distribution based on vehicle position**




## (2) Multicast

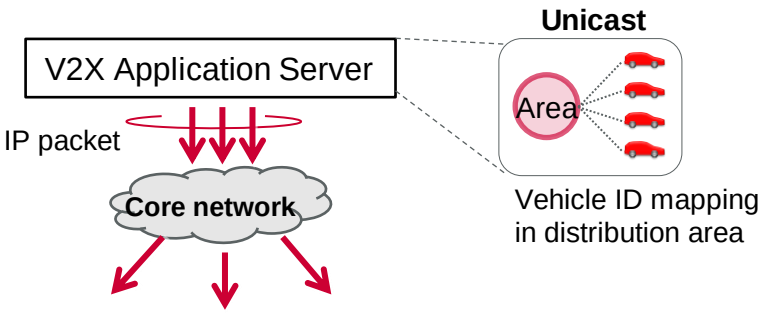
**Distribution based on base station coverage**



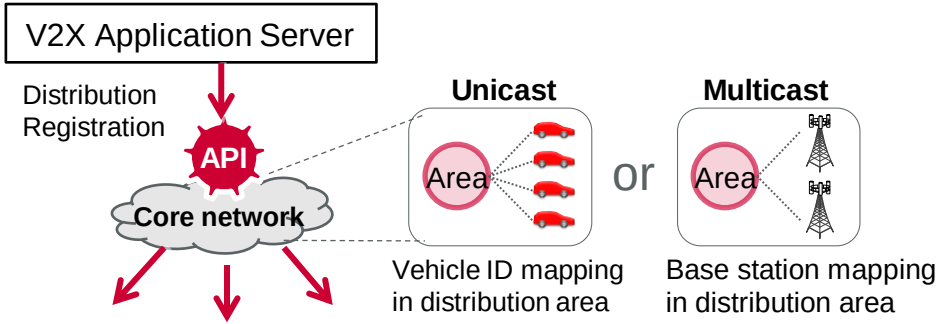

**It is necessary to investigate the information distribution methods and rules for vehicles in specific areas**

# Wide Area Communications: Recipient Management

## (1) Recipieapplicationnt management using V2X servers



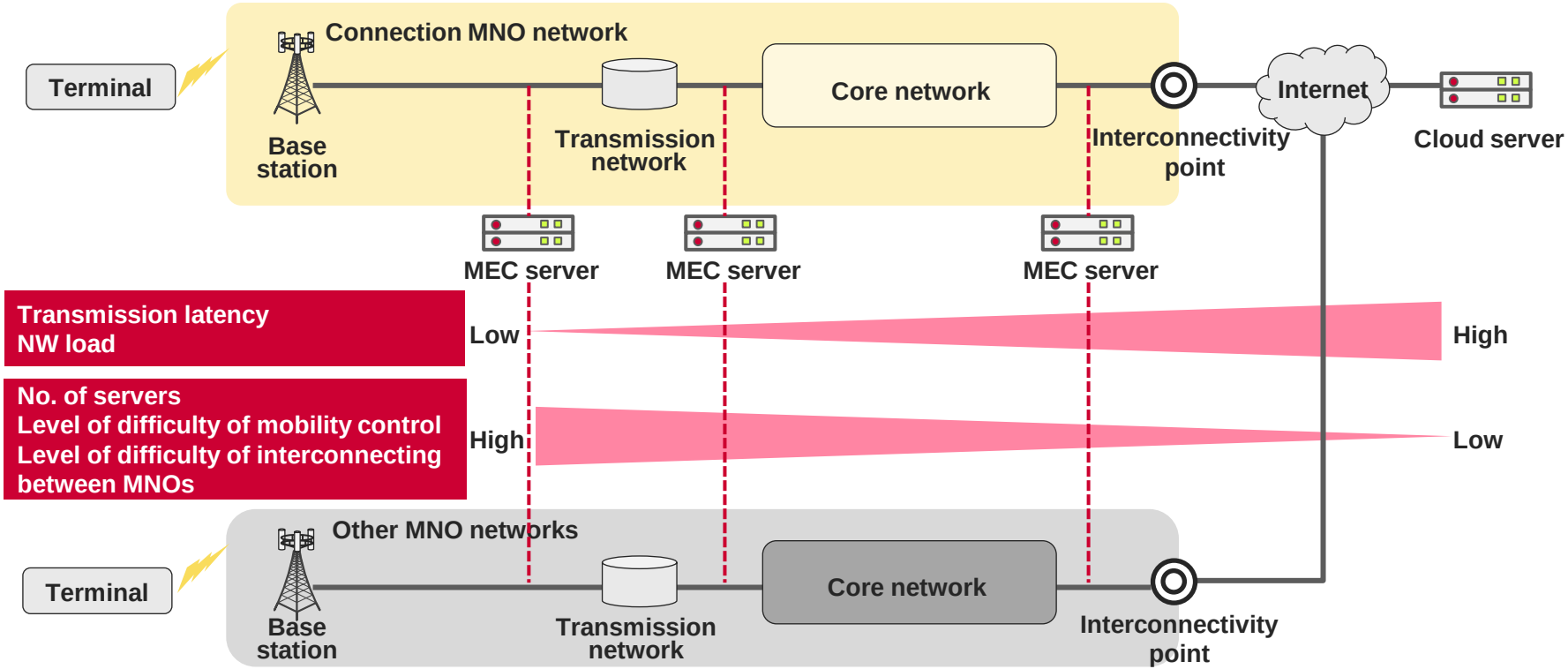

## (2) Recipient management using LTE networks




Taking into consideration scalability, efficiency, etc...

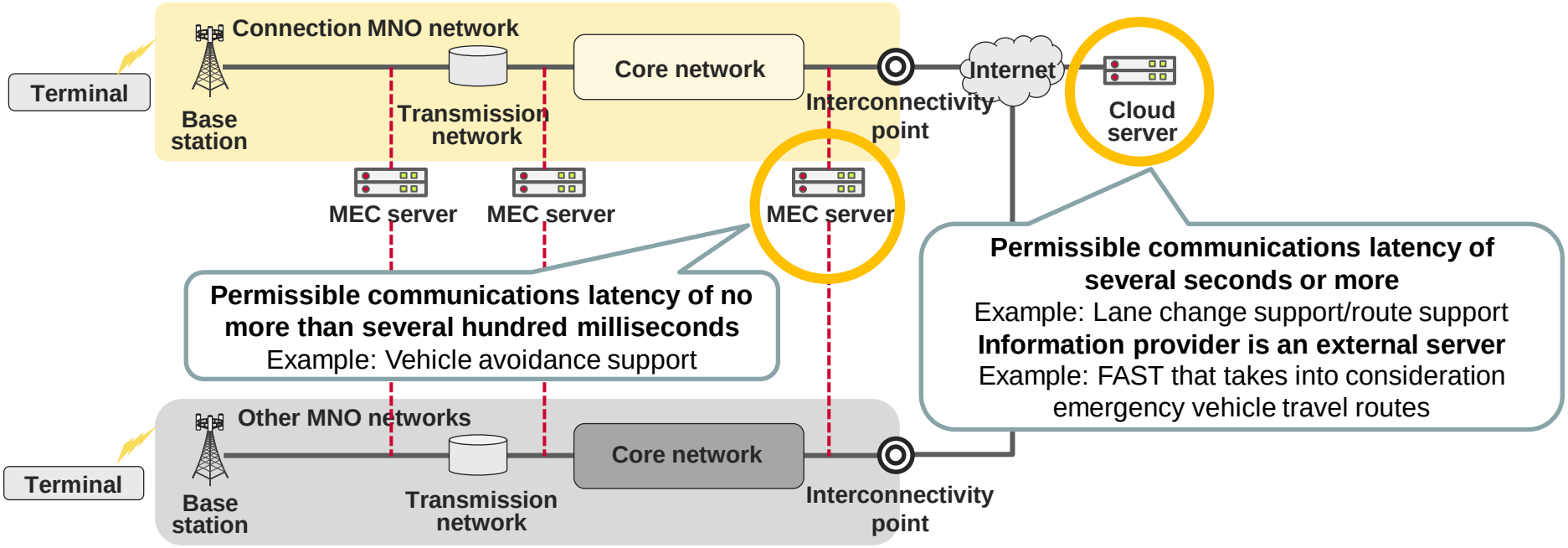
**It is necessary to clarify the division of functions for distribution processing**

# Wide Area Communications: Support for MEC and Multiple MNO



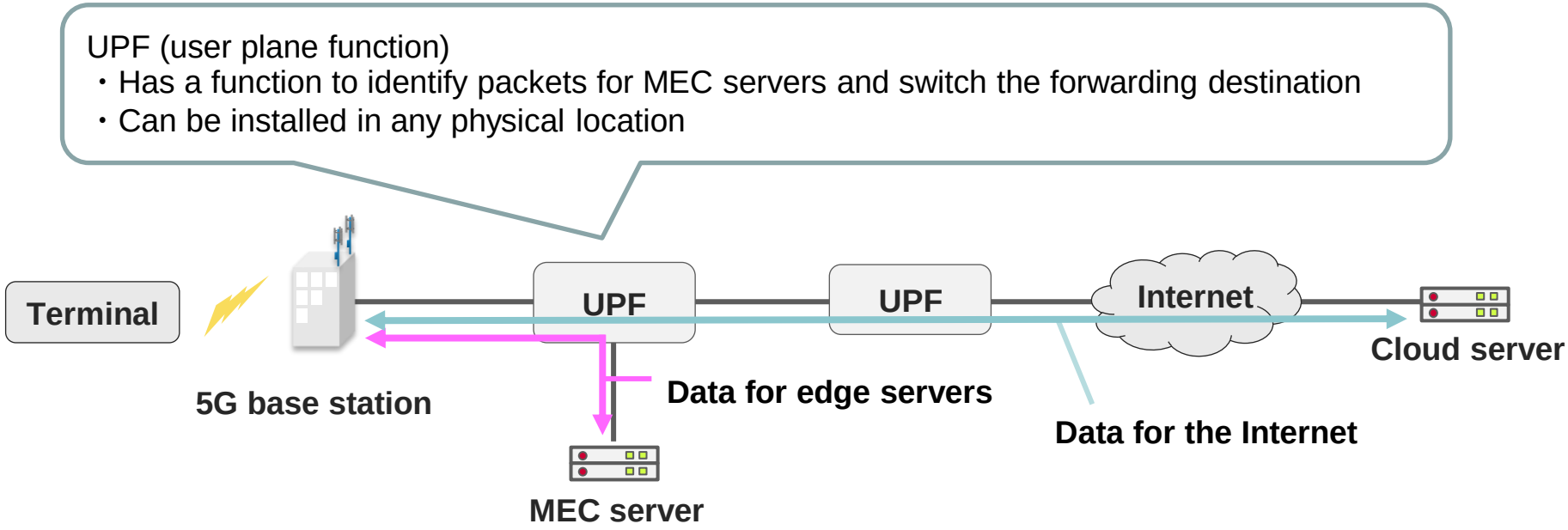

**It is necessary to investigate the effectiveness of MEC taking into consideration cost-effectiveness**

# Wide Area Communications: Applicability of MEC to the Use Cases in This Document




**When using wide area communications for the use cases addressed in this document, cloud servers and MEC servers outside P-GW are highly compatible**

# Wide Area Communications: 5G MEC




**With the introduction of UPF, MEC can be installed with a high degree of freedom using 5G.**
**The physical installation location needs to be investigated in consideration of cost-effectiveness, as in LTE**

# Summary of Communications Architecture

- Description of the wide area communications architecture and MEC were added and compatibility with MEC installation locations for the use cases in chapter 2 were examined

- Going forward, it is necessary to consider what kinds of communication requirements and network configurations will be required according to the use cases to be achieved, and based on the results, to investigate whether or not to use MEC and the installation locations

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# Business Models

# Allocation of Costs Primarily on Beneficiaries

## Stance of this Report

When implementing each of the use cases, based on the beneficiary burden principle, models that will enable costs to be borne by the beneficiaries who enjoy the value of V2X (reduction in accidents, expanded operational design area for automated driving) will be desirable.

Stakeholders are listed with a focus on beneficiaries, and cost factors and cost burdens for V2V/V2I/V2N are organized below.

## Use cases in the first version

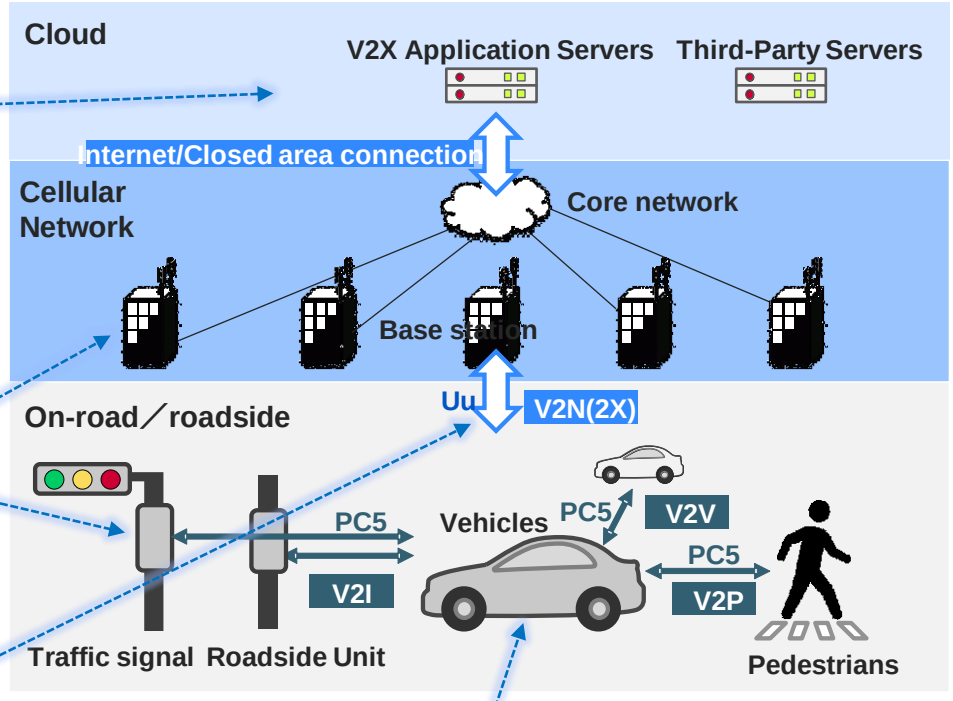
* In this revision, public organizations such as government were added as beneficiaries

| | Use cases | Beneficiaries |
|---|---|---|
| 1 | Collision avoidance and sudden braking due to falling object, vehicle involved in accident, etc. | Drivers, car owners, etc. |
| 2 | Intersection transit support, dilemma zone avoidance, and red light alert using traffic signal information | Drivers, car owners, road managers, etc. |
| 3 | Lane change support/route support using information on the presence of an obstacle, vehicle involved in an accident, etc. | Drivers, car owners, etc. |
| 4 | Vehicle avoidance support using information on nearby emergency vehicles | Drivers, emergency vehicle drivers and users, etc. |
| 5 | Route search using construction and regulatory information | Drivers, road managers, construction businesses, etc. |

# Cost Factors in Cellular V2X Business

**Costs for V2N and V2I are high because of the costs of communications infrastructure equipment and communications packets**

- Information acquisition costs — V2N
- Server installation costs — V2N, V2I, V2V
- Operational and management costs — V2N, V2I, V2V
- Communications infrastructure equipment costs — V2N, V2I, V2V
  - V2N base station and backhaul line costs
  - V2I base station and backhaul line costs
- Communications packet costs — V2N, V2I, V2V
  - V2N (Uu) packet communications costs




- Terminal equipment costs — V2N, V2I, V2V

# Approach to Cost Burdens (V2V)

## The “V2V compatible terminal buy-out” business is anticipated

- **Anticipated business formats**
  - Initial costs and running costs are lower than V2N and like existing ITS, it is ssumed that the buy-out of V2V compatible terminals by vehicle owners will be the mainstream.

- **Measures to promote spread**
  - Introduction of V2V communication with limited functions by smartphone
  - Cost reduction of onboard devices and provision of introduction incentives

# Approach to Cost Burdens (V2I and V2N)

## Continuous cost recovery business models and complementary use of V2N and V2I are anticipated

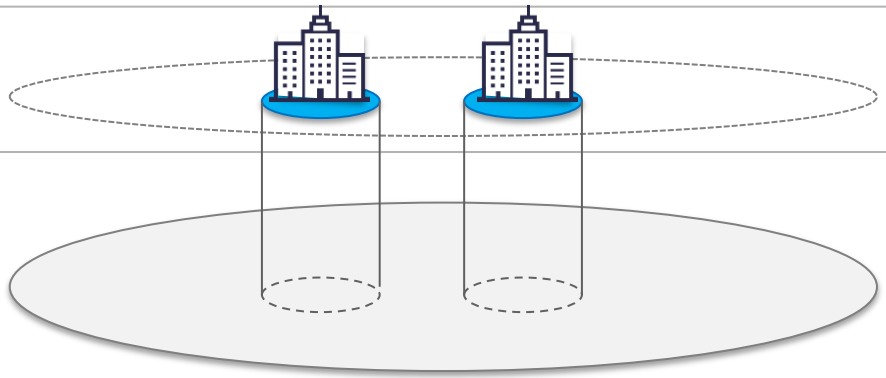
- **Anticipated business formats**

Compared to V2V, infrastructure initial costs and running costs are higher, and packet communications costs cannot be ignored in V2N.

Similar to the cellular business for smartphones, a business model that continuously recovers infrastructure costs is desirable on the premise of business continuity for a certain time.

# Examples of V2I / V2N Business Models

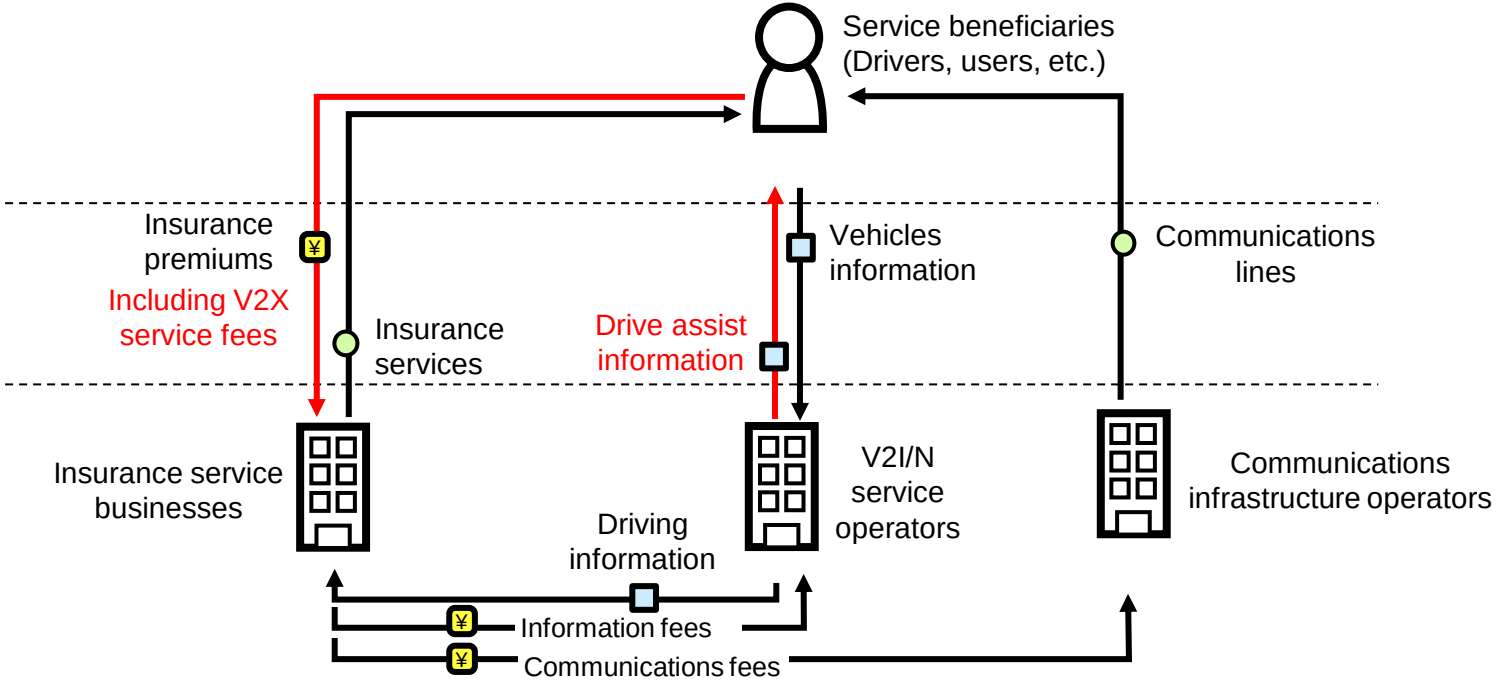
- Assumed as stakeholders are service beneficiaries, countries, prefectures, municipalities, insurance companies, V2I/N service providers, communications infrastructure providers, and so on.
- Considering the possibility that the business model may differ depending in the assumed service details and target areas, three models are considered.

| | V2X Service Target Area | Business Model |
|---|---|---|
|  | Smart city (Regional) | **MaaS/Automated driving model** |
| | Non-regional (Including smart cities) | **Automobile insurance model / Tax model** |

Combination of non-regional V2X service and regional V2X service and compatible business models

# Automobile Insurance Model

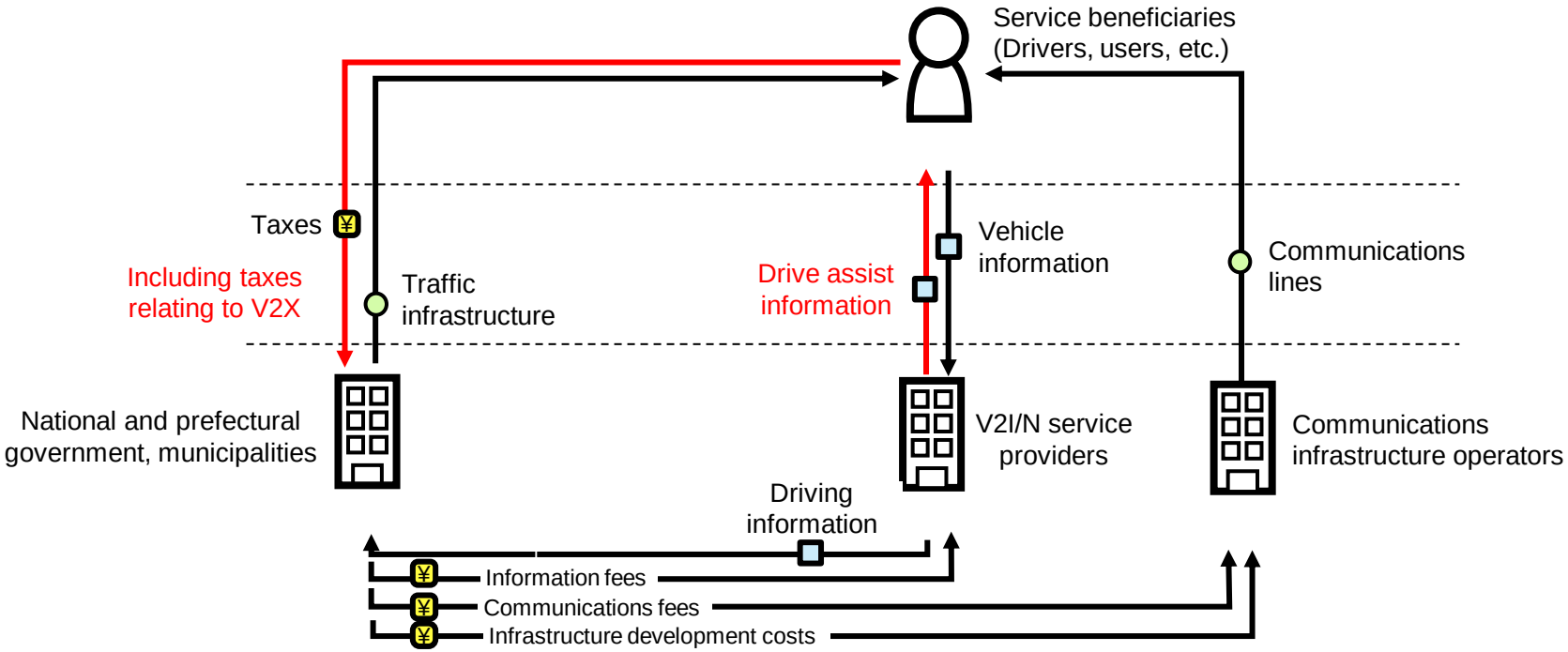
A model based on the premise that accident risk can be calculated more accurately than before providing information on the environment in the vicinity of the vehicle collected by V2X (advanced version of telematics insurance)




* Simplified version of the model in the report

# Tax Model

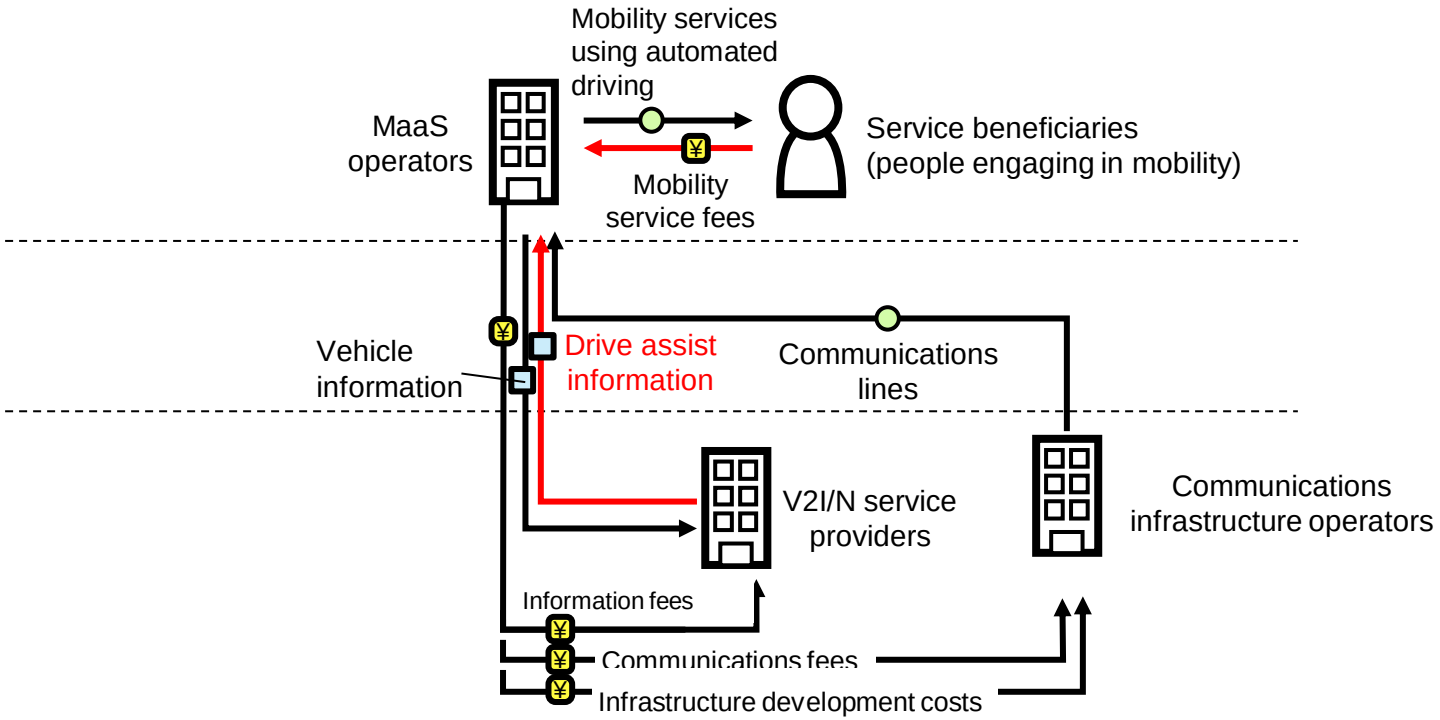
A model premised on reducing traffic congestion and traffic accidents by using taxes as a source of funds or the spread of automated driving.




* Simplified version of the model in the report

# MaaS / Automated Driving Model

A model that provides V2I/N services in limited areas such as smart cities for the early establishment of MaaS utilizing level 4 automated driving (unmanned automated driving).




* Simplified version of the model in the report

# Summary of Business Models

- Based on the beneficiary burden principle, models that will enable costs to be borne by the beneficiaries who enjoy the value of V2X (reduction in accidents, expanded operational design area for automated driving) will be desirable.

- Stakeholders are listed with a focus on beneficiaries, and cost factors and cost burdens for V2V/V2I/V2N are organized.

- Stakeholders and business model diagrams (automobile insurance model, tax model, MaaS/automated driving model) as formats for allocation of expenses are indicated.

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# Organization of Issues

# Overview of Organization of Issues

- **Issues relating to communications**
  - Short range communications
  - Wide area communications
  - Combined wide area and short range communications
- **Issues relating to acquisition of distributed information**
- **Issued relating to use of information by transmission-receiving vehicles**
- **Service and business issue**

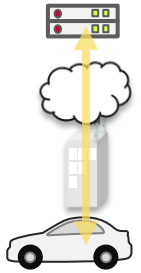
# Issues Relating to Short Range Communications

It is necessary to achieve the use cases and verify availability
in order to acquire the frequency bands for short range communications.

- Acquisition of frequency bands, standardization of communication protocols
- Establishment of communications parameters and operational methods
- Creation and maintenance of interconnectivity and security operational management systems
- Verification of feasibility (latency and reliability) and availability
- Responses in cases where performance requirements are not met and countermeasure costs

# Issues Relating to Wide Area Communications, Combined Wide Area and Short Range Communications

- Verification of the capabilities of existing cellular communication networks and responses when additional measures are needed.
- The combined use of wide area and short range communications may generate high added value, but it is necessary to clarify the division of roles.



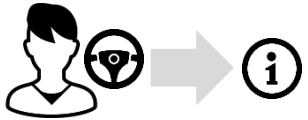
- Verification of feasibility (latency and reliability) and availability
- Investigation of communications quality improvement methods (if necessary)
- Responses (priority control, etc.) in cases where performance requirements are not met, countermeasure costs, and whether each MNO can be supported
- Responses to differences in the service areas of each MNO

# Issues Relating to Acquisition of Distributed Information

- It is necessary to consider issues in collaboration with the associations and organizations that correspond to information sources.
- There are many stakeholders up to vehicles that receive communications, and clarification of business models is difficult.

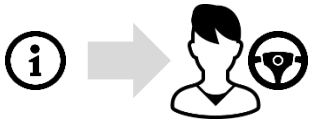
- **Acquisition from associations and organizations**
  - Obtaining approval to acquire information from associations and organizations
  - Creation of systems for acquiring information from information sources (precision, security, etc.)
  - Standardization of equipment specification, formats, etc. for acquiring information from information sources

- **Acquisition from nearby vehicles**
  - Adoption of message format and protocol specifications
  - Formulation of guidelines for controlling variations among vehicles generating information
  - Security and privacy countermeasures
  - Obtaining consent regarding the use of information from each vehicle owner



# Issued Relating to Use of Information by Transmission-receiving Vehicles

It is necessary to formulate standards and guidelines
so that the receiving side can use information reliably.



- Adoption of message format and protocol specifications
- Ensuring the reliability of received information (communications route security)
  - Communications routes for wide area communications are becoming more complex
- Formulation of guidelines on the use of received information (including consideration of latency)

# General Service and Business Issues

- Establishing operational models, promoting widespread adoption, and sustainable cost burdens are issues.
- In cases where both short range communications and wide area communications are used, the number of stakeholders increases and the number of cases where information transmitters and main beneficiaries are not the same increase.

- Formulation of service definitions and guidelines
- Development of systems from acquisition of source information to provision to vehicles
- Reducing the cost of PC5 onboard devices (to promote widespread adoption)
- Burden of Uu communications costs
- Establishment of business taking into consideration costs for information acquisition and collection and development and maintenance of distribution servers and other equipment (including acquisition of public funding and cooperation and collaboration with associations and organizations)
- Building systems and business models in cases where many parties are involved in services
- Acceptability and feasibility of business in cases where information transmitters and the main beneficiaries are not the same

# Service Responsibility Issues

It is necessary to discuss elements not found in conventional ideas, such as wide area communications and automated driving.

- Clarification of the allocation of responsibility from acquisition of information to provision to vehicles
- Formulation of response policies when services are suspended due to hardware failures, network problems, etc.
- Clarification of the scope of certification and inspection (pre-shipment inspection, vehicle inspections, etc.)

# Summary of Organization of Issues

- Short range communications and wide area communications have different cost burden formats not only from the perspective of communications but also from the perspective of services.

- The combined use of wide area and short range communications may generate high added value, but as the number of stakeholders increases, the difficulty of systems and business models increases.

- In order to achieve services, it is necessary to consider frequency allocation, operations, cost burdens, and the division of responsibility in close cooperation with the automobile industry, telecommunications industry, related organizations, and stakeholders such as the national and local governments.

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# Summary

# Summary

- **Selection of use case examples with the potential to use the benefits of cellular V2X for the advancement of ITS and automated driving using cellular V2X.**
  - In addition to use cases that focus on the interval of information updates, investigation of selection of use cases that demonstrate high added value achieved by short range communications with wide area communications complementing one another.

- **Organization of issues for achieving services based on the use cases.**
  - Close collaboration between industry-government, the automobile industry, and the telecommunications industry will be necessary from the perspectives of performance requirements, implementation formants, business models, frequency and communication specification formulation, system design, and infrastructure development.

- **It is expected that discussions will be conducted on both the creation of advantages and new value from the use of cellular V2X and the impact on legal systems and business from such creation and that investigations will proceed in a direction leading to the provision of even better ITS services.**

# Conclusion

- The Advanced Expert Committee Cellular System TG of the ITS Info-communications Forum is currently active with 52 members from 25 companies and organizations (automobile manufacturers, electronics manufacturers, telecommunications carriers, etc.).

- We are discussing the application of cellular communications technology to safe driving and automated driving support.

- We would like to deepen discussion with many parties regarding the issues raised in this report and look forward to new participation by others who can cooperate. In addition, it is necessary to engage in discussion with parties from a wide range of industries, so if you have any ideas for promoting discussion, please let us know.

- Revision of the next edition of the report will be performed giving consideration to your opinions and trends such as SIP.

- This report has been posted in recent topics on the home page of the ITS Info-communications Forum Website.