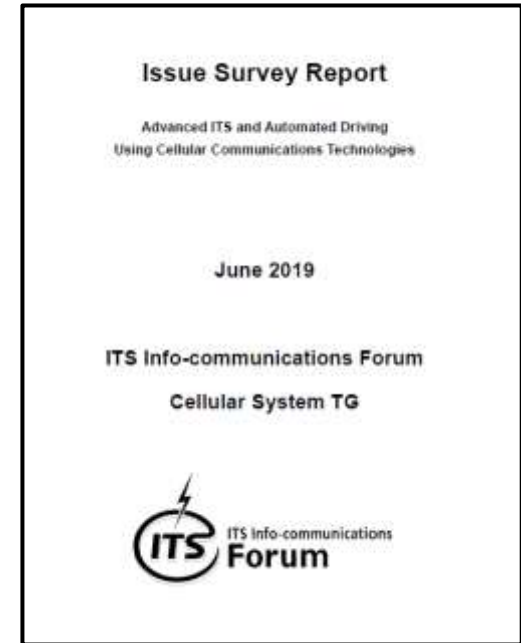# Advanced ITS and Automated Driving
Using Cellular Communications Technologies
- Issue Survey Report -

ITS Info-communications Forum

Cellular System TG

Issue Survey Report

Advanced ITS and Automated Driving
Using Cellular Communications Technologies

June 2019

ITS Info-communications Forum

Cellular System TG

ITS Info-communications
Forum

Background

・R&D and policy discussions on automated driving using communications are becoming more active globally.
・Using of cellular communication technologies (conventional telematics + V2V, V2I, V2P, etc.) to automated driving are expected. Such expectation tends to consider the communication performance and function only, but investigation on actual required operation to realize the expectation is essential.

● **3GPP:**
  – LTE V2X(short-range)/5G NR(wide-area): Specification Done
    5G NR V2X(short-range): Specification in progress

● **CHINA:**
  – 5.9GHz frequency allocated for ITS
    Field test using LTE V2X(by Wuxi, etc.)

● **US/EU:**
  – For LTE V2X(short-range comm.) feasibility, discussion is being undertaken. However, 2 different opinions exist.
  – Regarding the communication performance "5GAA" tested, C2CCC comments further verification is required.

Road Maintenance Info

Emergency Vehicle Info

Accident Info

Signal Info
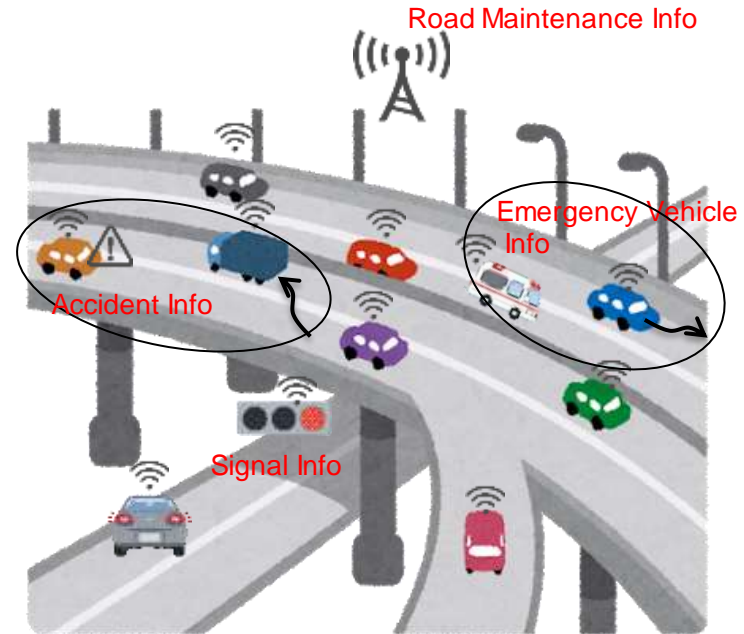
Background（in JAPAN）

・ **Some of the services are already deployed on the basis of existing ITS techniques.**
・ **Top-end ITS needs to be maintained and upgraded for the benefit of the nation.**
 Continuously, some projects are being carried out as government-private joint work.

● **Strategic Innovation Program(SIP) by Cabinet Office, Govt. of JAPAN.**
 - Theme: Autonomous driving, focusing on system & service expansion, together with Dynamic map & V2X(w/ already deployed ITS, etc.)

● **Technical Research & Test by MIC(Ministry of Internal Affair & Communication)**
 - Theme: New wireless system for new connected-car society

●ITS Information Communication system committee
 - Wireless System TG
      ※V2X test guideline（application of already deployed ITS for autonomous driving)
 - **Cellular System TG**
      ※**For the purpose of ITS & autonomous driving**
   **TG is discussing on the themes of business models, infra-structures, inter-connections and securities**
        as well as technical matters.

Concept of Cellular V2X

Wide-area ：**Broadcast to all vehicles in wide-area via Cellular Network**
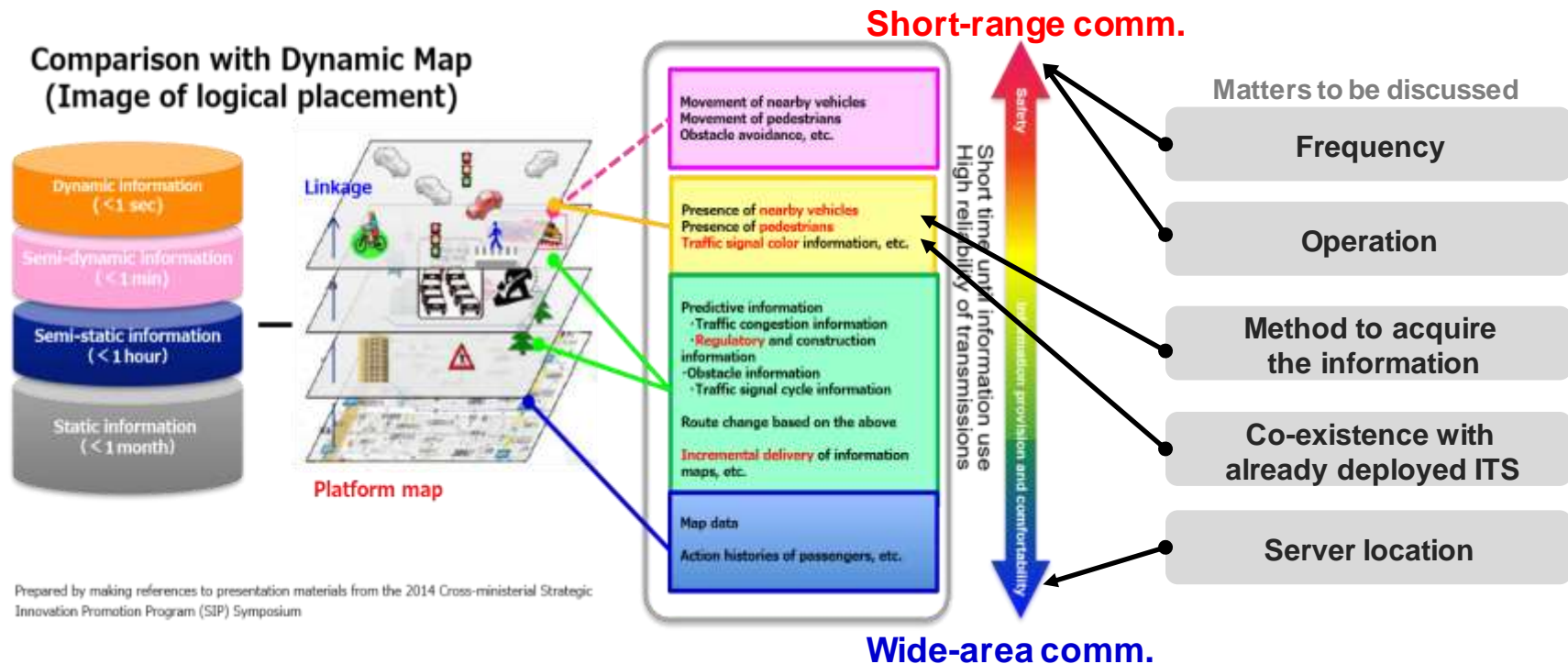**Short-range**：**Vehicle-to-Vehicle direct communication (not through BS) with "Low Latency"**
→**assuming "Emergency Communication"**

Cellular V2X (V2V/V2I/V2P/V2N)
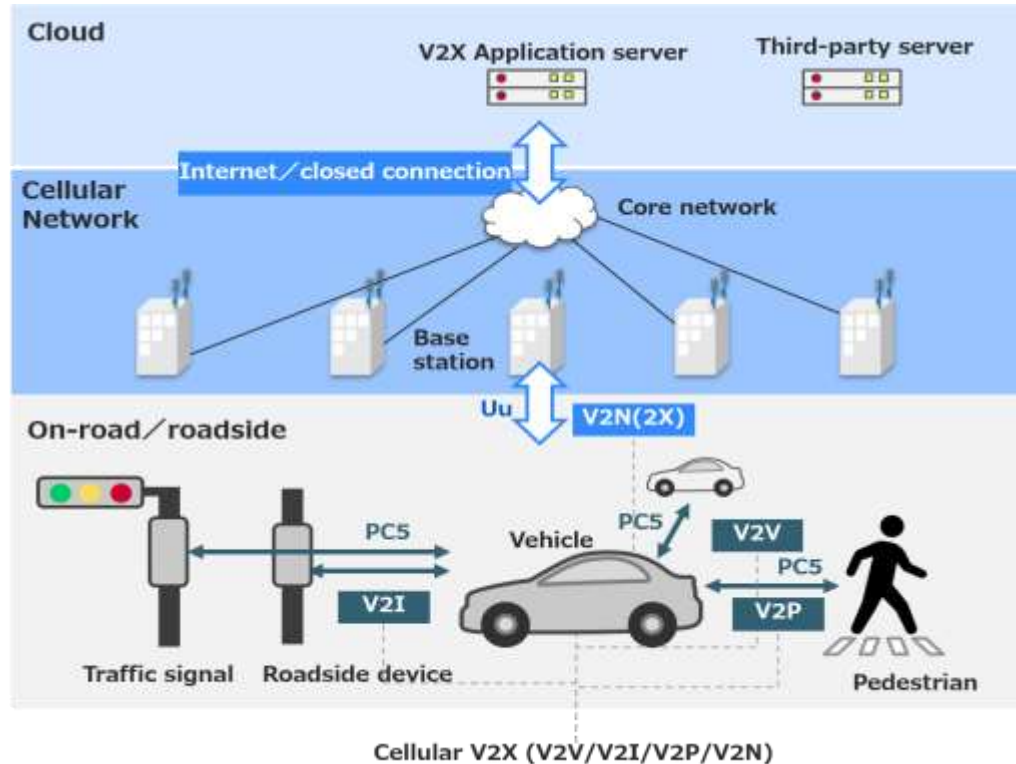
Purpose of the report

For the purpose of "Acceleration of Cellular V2X evaluation & Discussion on technical issues", Cellular System TG has issued the report.

CONTENTS: concept, use-case, communication architecture, business model, etc.

Short-range comm.

Comparison with Dynamic Map (Image of logical placement)

Dynamic information (<1 sec)
Semi-dynamic information (<1 min)
Semi-static information (<1 hour)
Static information (<1 month)

Linkage

Platform map

Prepared by making references to presentation materials from the 2014 Cross-ministerial Strategic Innovation Promotion Program (SIP) Symposium

Movement of nearby vehicles
Movement of pedestrians
Obstacle avoidance, etc.

Presence of nearby vehicles
Presence of pedestrians
Traffic signal color information, etc.

Predictive information
·Traffic congestion information
·Regulatory and construction information
·Obstacle information
·Traffic signal cycle information

Route change based on the above

Incremental delivery of information maps, etc.

Map data
Action histories of passengers, etc.

Short time until information use
High reliability of transmissions

Matters to be discussed

Frequency

Operation

Method to acquire the information

Co-existence with already deployed ITS

Server location

Wide-area comm.

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Contents

Chapter	Contents
1	Current status and outlook of cellular communication systems -Trends in Standardization, Planned Frequencies and Service Deployment in Japan
2	Use case expected for communications and its roles -Collision avoidance and emergency braking due to falling object, vehicle involved in accident, etc.
3	Communications architecture -Short-range communications (V2V/V2I/V2P) -Wide-area communications (V2N)
4	Business model -Stakeholders under each use case -Cost factors in cellular V2X business
5	Issues
6	Summary

Wide-area Communication

Cellular V2X Architecture

Cellular V2X (V2V/V2I/V2P/V2N)
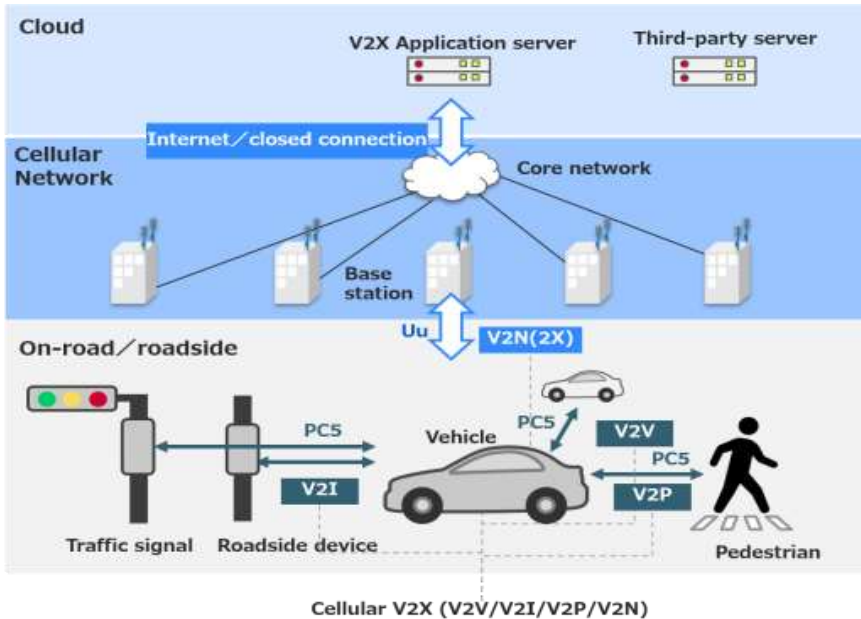
- **Wide-area Communication(V2N)**
  – Communication via BS/Core-NW
  – Existing Communication Infra-structures & Wireless interfaces
  – IP Communication

- **Short-range Communication(V2V/V2I/V2P)**
  – Designated frequency for ITS
  – Direct communication among V2X-special User equipment("UE")
  – Non-IP Communication

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(Ref.) Technical Terms

- **Base Station, NodeB**
  - Base station means the equipment that communicates with mobile devices in the cellular network. A base station supports one or multiple cells.
  - NB (node B) is a WCDMA base station.
  - eNB (e node B) is an LTE base station.
  - gNB (g node B) is an NR base station.

- **Cell**

  The part of a cellular network that does not rely on wireless access technologies such as WCDMA, LTE, and NR. It includes S-GW and P-GW.
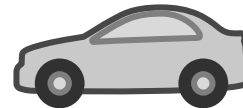
Wide-area Communication, Uu

- **Roadside unit (RSU)**

  Roadside units mean terminal-type devices that communicate with mobile stations using short-range communications. RSU can connect to networks using wide-area communications.

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

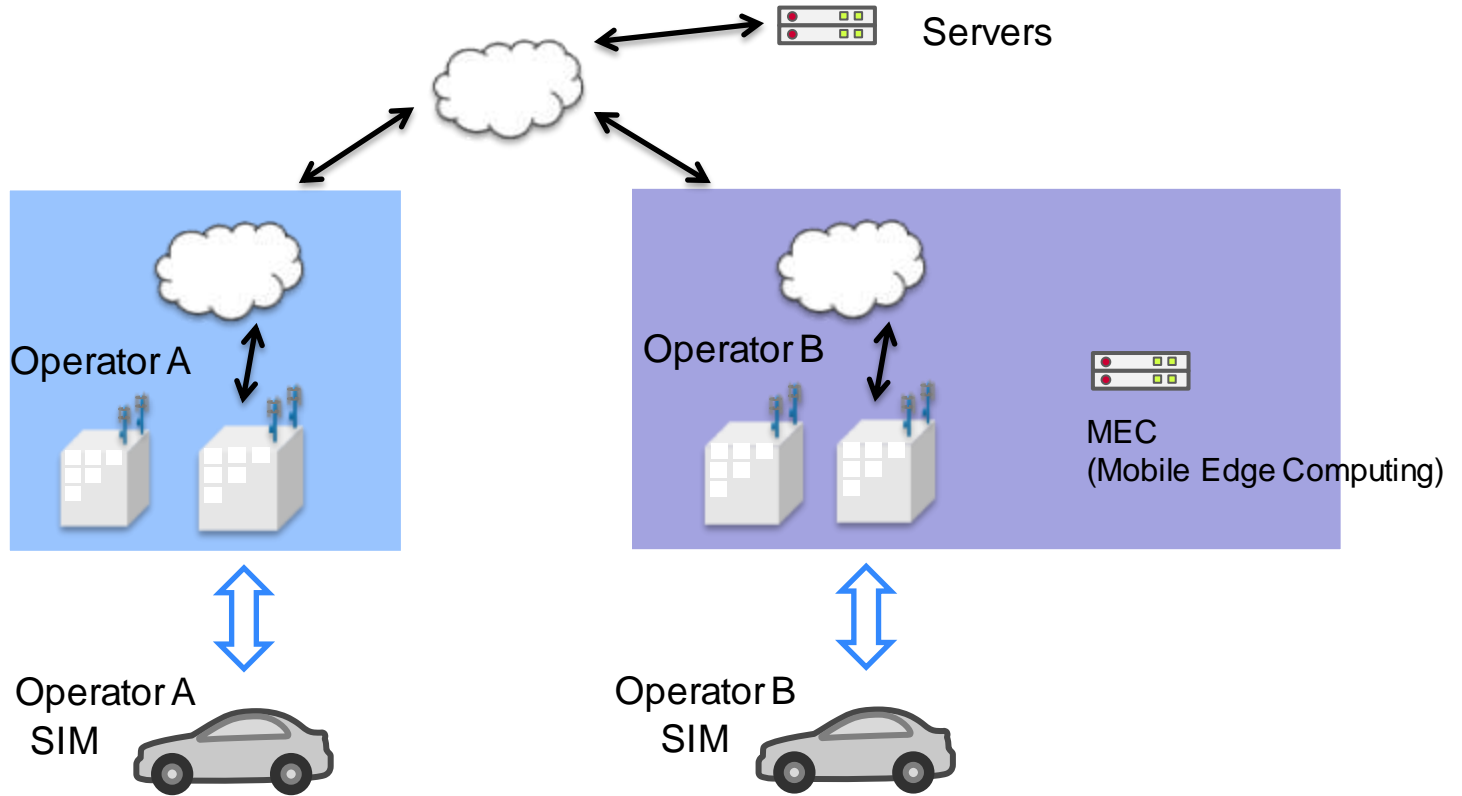 Devices that communicate with networks in the cellular network.

Short-range Communication,PC5

(Ref.) Release by 3GPP

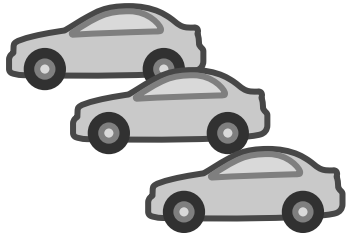|	Wide-area Comm.	Short-range Comm.
Rel-8	LTE	
Rel-9	eMBMS (DL Broadcast)	
Rel-12		D2D （for Public Safety）
Rel-13	SC-PTM (DL Broadcast)	
Rel-14	SC-PTM for V2X	D2D Spec. for V2V/V2X
Rel-15	NR	D2D Spec. for V2V/V2X(modified)
Rel-16		D2D Spec. for V2V/V2X(NR)

Wide-area(V2N)

Servers

Operator A

Operator B

MEC
(Mobile Edge Computing)

Operator A
SIM

Operator B
SIM

Wide-area(V2N)

- **QoS (e.g., Priority Control)**

  -Specified and already deployed commercially.

  -Due to BS location and/or bandwidth of installed core NW, neither call initiation,
   bit-rate nor latency is not guaranteed even if "Priority Control" is enabled.

- **UE which does not support short-range communication is available.**

- **Multi-cast（eMBMS*, SC-PTM) is standardized.**

  *eMBMS: On-field trial in JAPAN

  Commercially launched in other counties

Wide-area(V2N)

Backward Compatibility

- **UE supporting multiple standards for BS-dependent connectivity**

BS compliant with standard A

BS compliant with standard B

Supported Communication. (LTE, GSM, WCDMA, HSUPA/HSDPA)

- **Multi-type UEs co-existence under a single BS.**

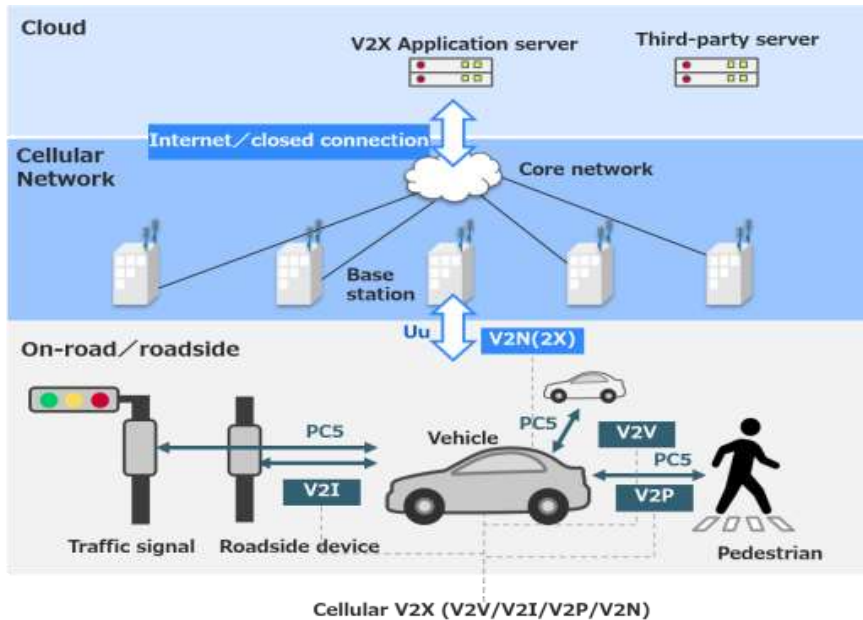BS needs to be controlled for respective different UEs performance.

Short-range Comm. Multi-bands(ex. Rel-14)

Non-support Short-range Comm. Single-bands(ex. Rel-8)

PC5 Interface

Cellular V2X Architecture

Cellular V2X (V2V/V2I/V2P/V2N)

- **Wide-area Communication(V2N)**
  - Communication via BS/Core-NW
  - Existing Comm. Infra-structures & Wireless interfaces
  - IP Communication

- **Short-range Communication(V2V/V2I/V2P)**
  - Designated frequency for ITS
  - Direct comm. among V2X-special User Equipment("UE")
  - Non-IP Communication

  →PC5 supports short-range communication.

Characteristics of PC5 Interface

Direct Communication among UEs, not via mobile operator network

- 2 Types: Mode 3(associated with cellular network for its control), Mode4(no association)
- Communication coverage is limited.
- Low latency is expected, compared with wide-area communication
- GNSS Time synchronization
- ITS-specialized band (5.9 GHz assumed by 3GPP)
- Low data rate(approx. hundreds-thousands bps)
- Broadcast operation, mainly

- Mode 4 Properties
  - No SIM(= No cellular network subscription)
  - Autonomous distributed system in Frequencies
  - Priority Controls
  - Congestion Control
  - Wireless parameters need to be configured, in advance("Pre-configuration")

- Technical Characteristics
  - Power increasing per bit
  - Longer-range communication by implemented HARQ & Turbo code
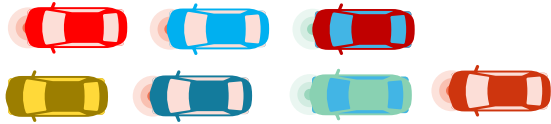 - Security implemented in application layer, such as IEEE1609.2

Common Band for ITS
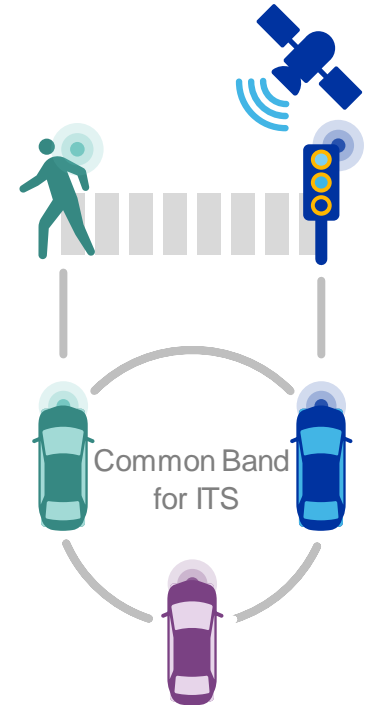
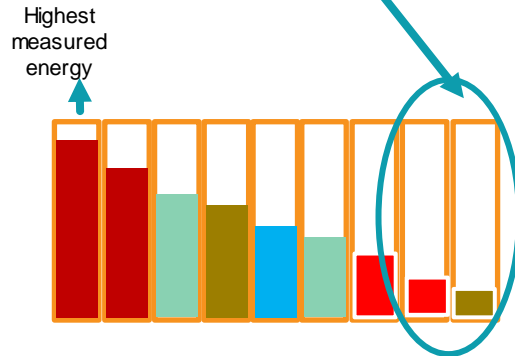# Deterministic access control and resource scheduling

Chooses blocks with lowest energy levels to meet latency requirements

1 **Measure relative energy of next "n" resources**

2 **Rank the resources by measured energy**

3 **Choose one of the lowest energy blocks for transmission**

Resource Pool (Conceptual)

Resource Pool (Conceptual)

Frequency

Rx Power

Time

Highest measured energy

Choose among the 20% lowest energy resources

Choose one of the lowest measured energy resources

Resource Pool

Frequency

Relative Energy

Time
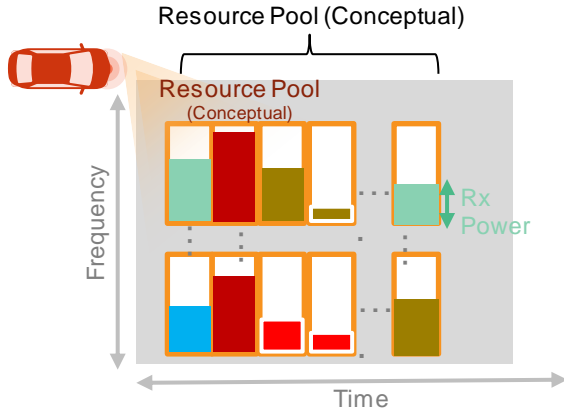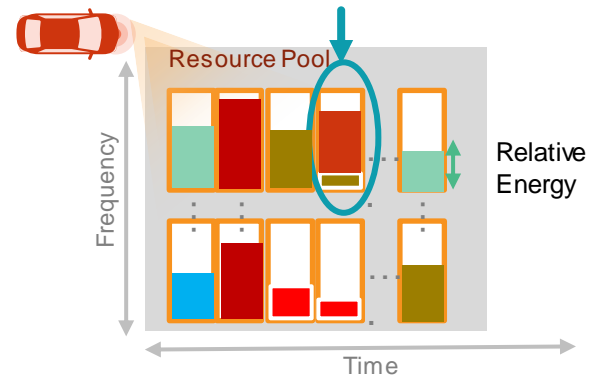
PC5 Trials

Test on communication performance & Demonstration on safety use case

North America
Ford

Europe
Audi • BMW •
PSA

SAIC

China

Japan
Nissan

Korea

Australia
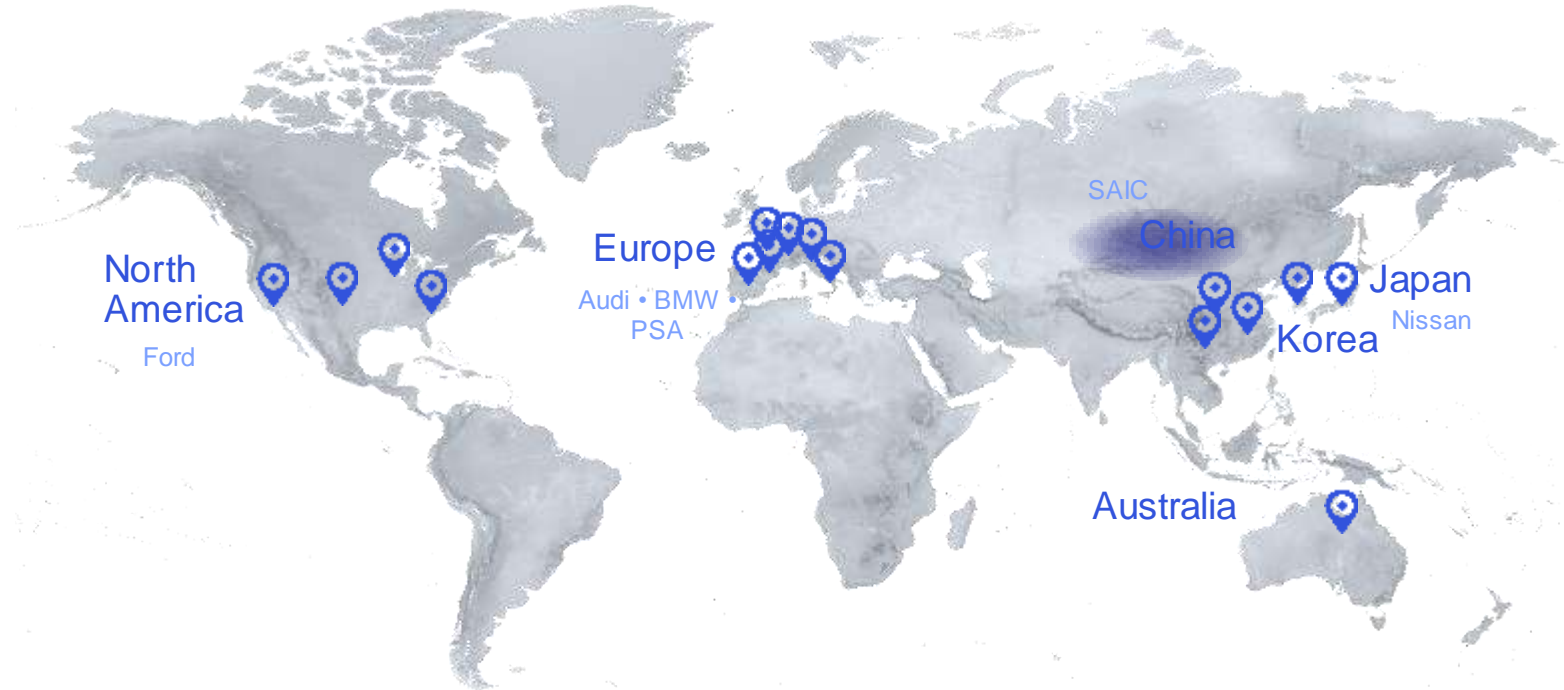
Commercial launch, targeting in Y2020-2021, is announced in China.

Use case

Communication for Connected Vehicles

Insurance

Advertising

Car Sharing

maintenance

Finance

Cloud

Big data

· · ·

New business
New player

Smartphone

wide-area communication
(static data)

Telematics

$3G \Rightarrow 4G \Rightarrow 5G$?

Connected Car
Autonomous Driving

Bluetooth, WiFi

Static data

DCM

ITS connect

In-vehicle electric PF

Short-range communication

「V2X」

V2I

Semi-static data
Semi-dynamic data

V2V
V2P

Semi-dynamic data
Dynamic data

ITS

Auto-sensor
（**real-time vehicle data**）

Now
5.8GHz/760MHz ⇒ **5.8GHz/760MHz** + 「**?**」

Future

<Note> Already deployed DSRC in Japan
 -760MHz have been assigned to ITS Connect
 that provide safety/signal information via V2V and V2I.
 (760MHz is ITS frequency band of ITU-R M.2121)
 -5.8GHz have been assigned to ETC 2.0 that provide
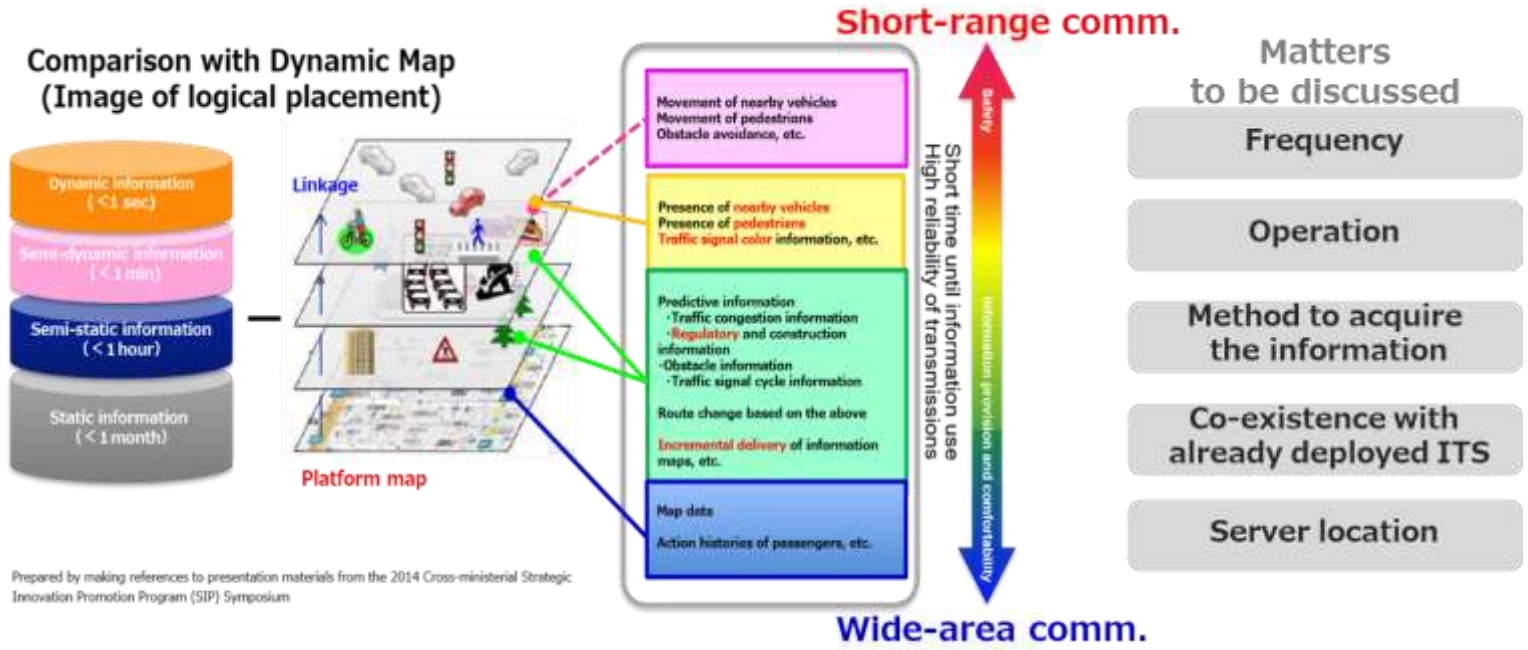 ETC service, traffic information, etc. via V2I.

Two categories exist in connected-vehicle communication.
 (1)wide-area comm.(ex. Telematics), (2)short-range comm.(ex. DSRC))

In future, new services in combination of (1) and (2) are to be required.

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Way of thinking about use cases

Cellular network adaptation is summarized by:
-considering information update interval
-comparison with Dynamic Map, as discussed broadly
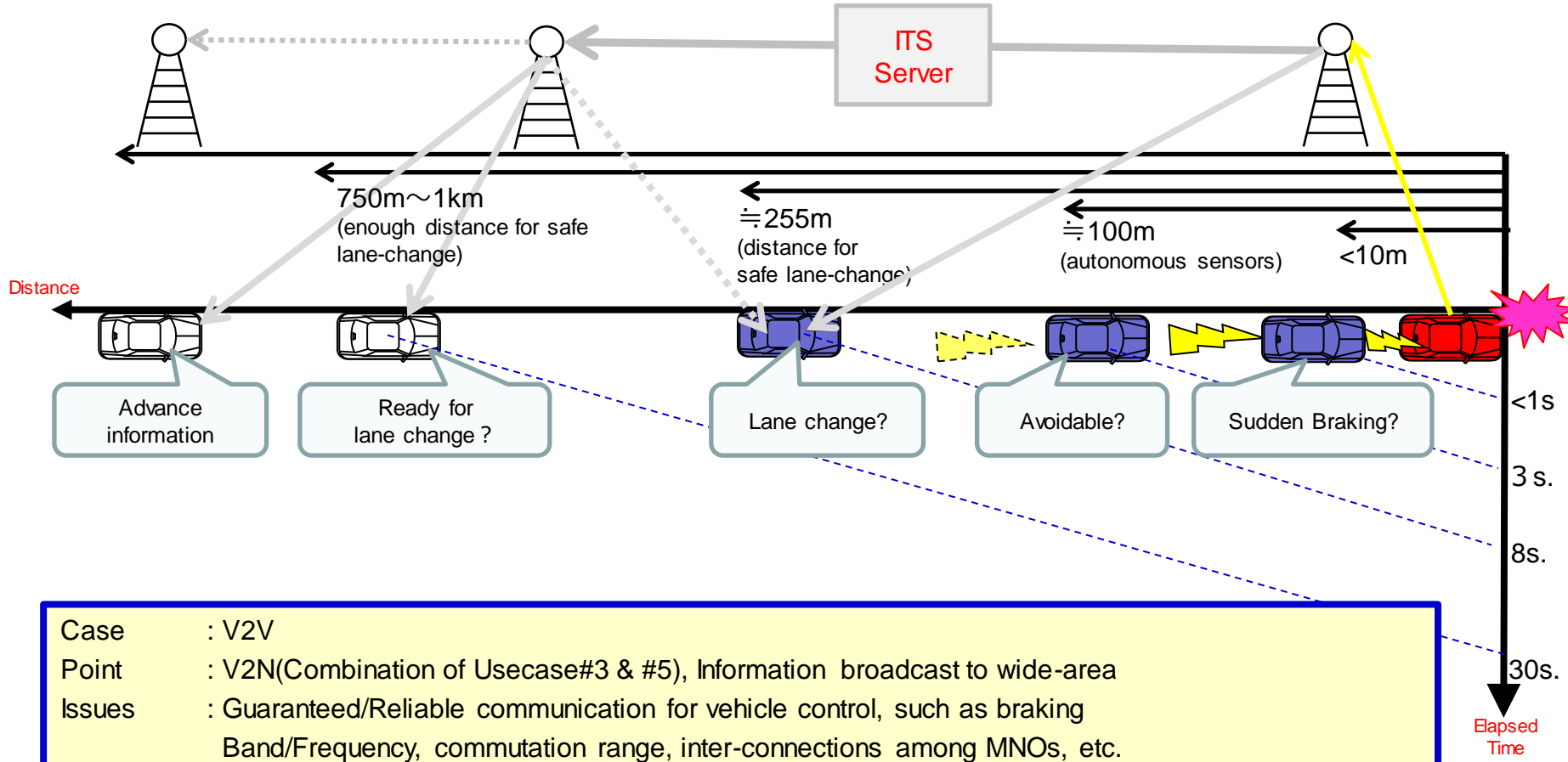-services already deployed and announced in public

Comparison with Dynamic Map (Image of logical placement)

Dynamic information (<1 sec)
Semi-dynamic information (<1 min)
Semi-static information (<1 hour)
Static information (<1 month)

Linkage

Platform map

Prepared by making references to presentation materials from the 2014 Cross-ministerial Strategic Innovation Promotion Program (SIP) Symposium

Short-range comm.

Movement of nearby vehicles
Movement of pedestrians
Obstacle avoidance, etc.

Presence of nearby vehicles
Presence of pedestrians
Traffic signal color information, etc.

Predictive information
·Traffic congestion information
·Regulatory and construction information
·Obstacle information
·Traffic signal cycle information
Route change based on the above
Incremental delivery of information maps, etc.

Map data
Action histories of passengers, etc.

Short time until information use
High reliability of transmissions

Wide-area comm.

Matters to be discussed

Frequency

Operation

Method to acquire the information

Co-existence with already deployed ITS

Server location

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Examples of Use Case (from the view of data & services)

- Under the assumption of "Information update interval ≒ How to use the information", the likelihood applications are listed in the table below.
- 5 applications are to be discussed for further details in order to find out "key factor of the service".
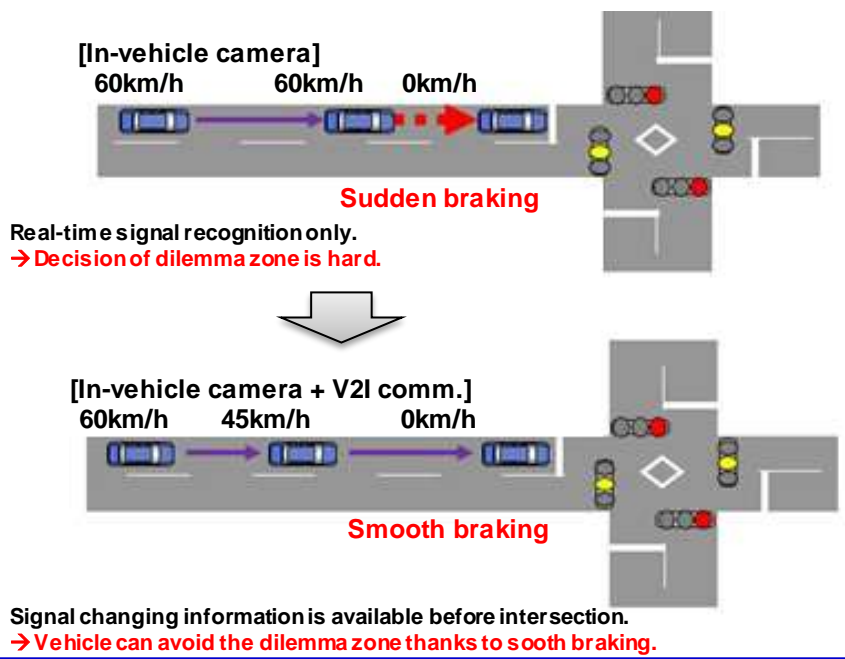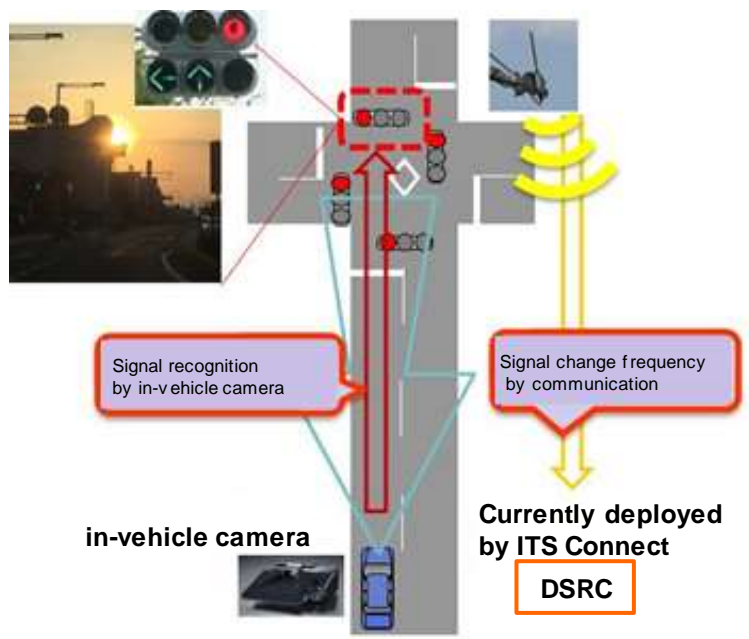
Information update frequency		Examples of handled information	Application	Use level (application)	Anticipated applications	Site where information is used	Reference
Dynamic	Reflected in automated driving as one of multiple sensors (multi-system)	Presence of pedestrians or bicycles	Safety	Control intervention/warning	Prevention of pedestrian accidents	General road	In this area, there is a possibility that a system can be created by using communication as one of the multi-system sensors in combination with other sensors. Depending on the application, ensuring reliability is the key
		Presence of nearby vehicles (including motorcycles)	Safety	Control intervention/warning	Prevention of collisions between vehicles crossing paths, lane change support	General road/vehicle-only road	
		Broken-down vehicle or fallen obstacle (immediately ahead)	Safety	Control intervention	Rear end collision avoidance, emergency braking (1)	General road/vehicle-only road	
		Emergency braking by vehicle ahead	Safety	Control intervention		General road/vehicle-only road	
		Real time operation information from vehicle driving ahead	Traffic facilitation, comfort	Control intervention	Convoy traveling	Vehicle-only road	
		Vehicle information on the main vehicle-only road	Traffic facilitation, comfort	Control intervention/warning/information provision	Merging support	Vehicle-only road	
		Signal color (display) information	Safety, comfort	Control intervention/warning	Intersection passage support (2)-1	General road	
		Presence of oncoming traffic or crossing pedestrians at intersection	Safety	Control intervention/warning	Prevention of collision with oncoming vehicle when making a right turn, collision with bicycle, etc. when making a left turn, accident involving crossing pedestrians	General road	
		ETC gate opening/closing information	Safety, comfort	Control intervention/warning/information provision	Prevention of collision during rapid closing, gate selection, lane change	Vehicle-only road	
Semi-dynamic	Predictive information Level for use in safe stopping and lane changing	Signal cycle information	Safety, Comfort	Warning/information provision	Avoidance of dilemma, red traffic light warning (2)-2	General road	Depending on the requirements of the vehicle, there is a possibility that cellular communications can be used with other communications or individually.
		Information on presence of obstacle or broken-down vehicle	Safety, traffic facilitation	Information provision	Lane change support, route selection (3)	General road/vehicle-only road	
		Nearby emergency vehicle	Safety, traffic facilitation	Information provision	Vehicle avoidance support (4)	General road	
		Lane-specific traffic congestion information	Safety, traffic facilitation	Information provision	Lane change support, route research	General road	
Semi-static	Predictive information Level for use in advance route changes, etc.	Updated map information (partial update while traveling)	Traffic facilitation	Information provision		General road	There is a possibility that it can be used with the same performance and mechanisms as conventional cellular communications.
		Regulation information	Traffic facilitation	Information provision	Route research (5)	General road/vehicle-only road	
		Construction information	Traffic facilitation	Information provision		General road/vehicle-only road	
		Traffic congestion information	Traffic facilitation	Information provision		General road/vehicle-only road	
		Traffic congestion end information	Traffic facilitation	Information provision	Turn-off support, automated → manual determination	Vehicle-only road	
		Air bag, etc. deployment information		Information provision	HELP	General road/vehicle-only road	
Static	Level for use in route preparation for automated driving	High-precision map			Route search	General road/vehicle-only road	This is use of what is referred to telematics and is outside the scope of this investigation.
		Updated map information (acquisition during stoppage)				General road/vehicle-only road	

① "Collison Avoidance & Emergency Braking" refrain from falling objects, broken-down vehicles

ITS Server

750m～1km
(enough distance for safe lane-change)

≒255m
(distance for safe lane-change)

≒100m
(autonomous sensors)

<10m

Distance

Advance information

Ready for lane change ?

Lane change?

Avoidable?

Sudden Braking?

<1s

3 s.

8s.

30s.

Elapsed Time

Case : V2V
Point : V2N(Combination of Usecase#3 & #5), Information broadcast to wide-area
Issues : Guaranteed/Reliable communication for vehicle control, such as braking
Band/Frequency, commutation range, inter-connections among MNOs, etc.

②-1 Signal color information "Intersection Passage Support"
②-2 Signal cycle information "Avoidance of dilemma/Red traffic light warning"

Signal recognition by in-vehicle camera

Signal change frequency by communication

in-vehicle camera

Currently deployed by ITS Connect

DSRC

[In-vehicle camera]
60km/h   60km/h   0km/h

Sudden braking

Real-time signal recognition only.
→Decision of dilemma zone is hard.

[In-vehicle camera + V2I comm.]
60km/h   45km/h   0km/h

Smooth braking

Signal changing information is available before intersection.
→Vehicle can avoid the dilemma zone thanks to sooth braking.

Case: V2I + V2N

Points: Collaboration with Traffic Control Center

Issues: V2I···Communication reliability, Service differentiation from already deployed ITS Connect,

Installment to cover all signals at intersection

V2N···Latency, Network structure to satisfy the requirements, like fail-safe mechanism.

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③Lane change/Route selection support by information on obstacles/broken-down vehicles

ITS Server

750m～1km
(enough distance for safe lane-change)

≒255m
(distance for safe lane-change)

≒100m
(autonomous sensors)

<10m

Distance

Ready for lane change ?

Lane change in progress, safely?

Lane changed, already?

8s.

30s.
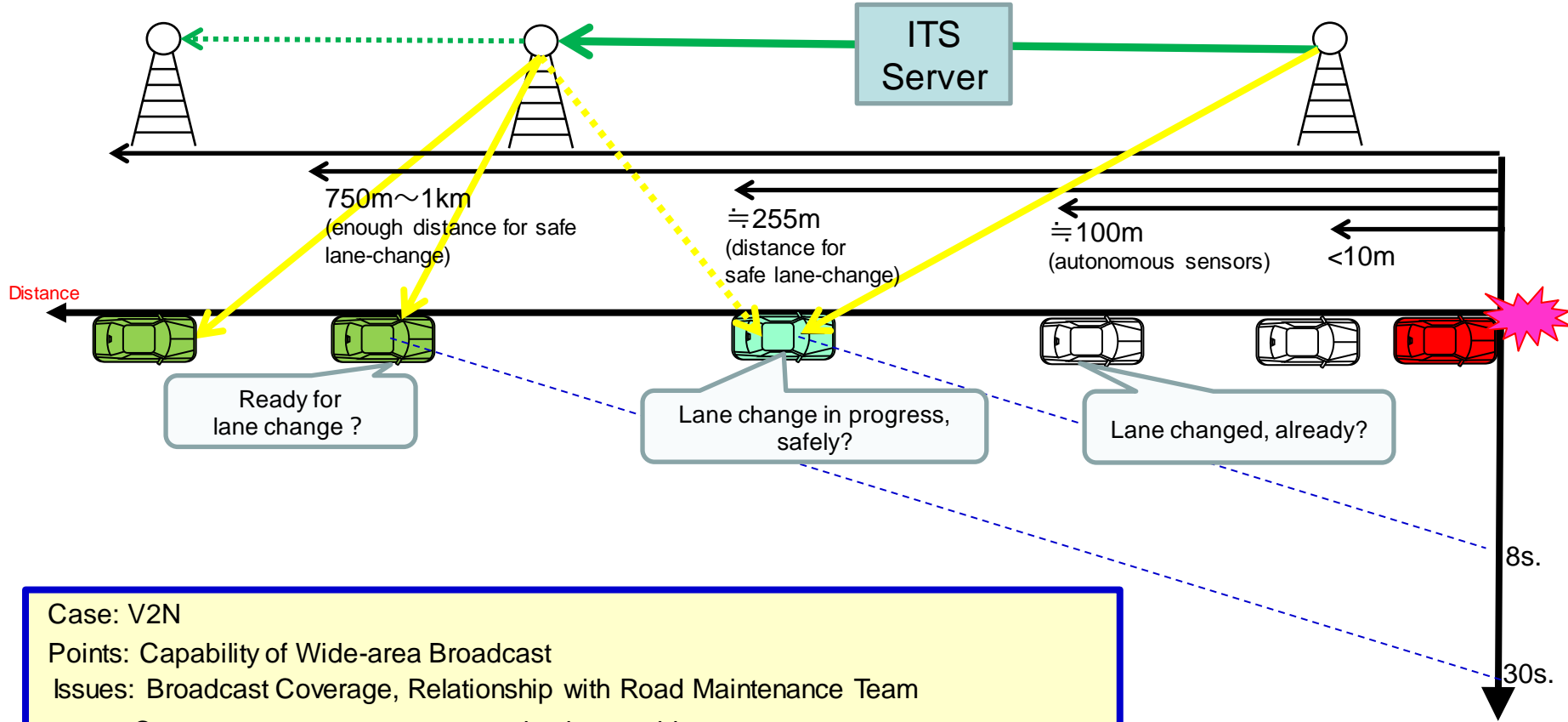
Case: V2N

Points: Capability of Wide-area Broadcast

Issues: Broadcast Coverage, Relationship with Road Maintenance Team

    Countermeasures upon communication trouble

Elapsed Time

④Vehicle avoidance support for nearby emergency vehicle

Communication range (>150m)
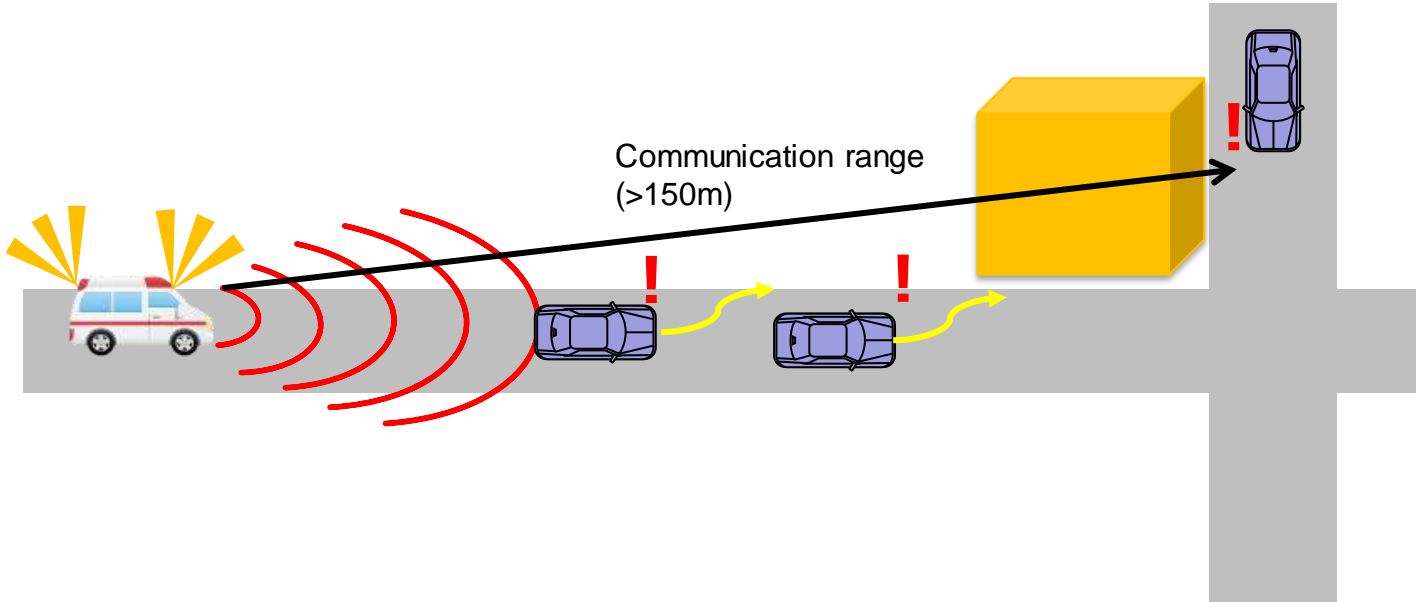
Case：V2V (+V2N)

Points: Possibility of relationship with new services using V2N, such as re-routing.

Issues：Guaranteed communication, especially for information delivery to autonomous vehicles.
Inter-connection among MNOs

⑤Re-routing caused by road maintenance/traffic congestion

Traffic congestion by accident.

Normal road advisable.

Express way
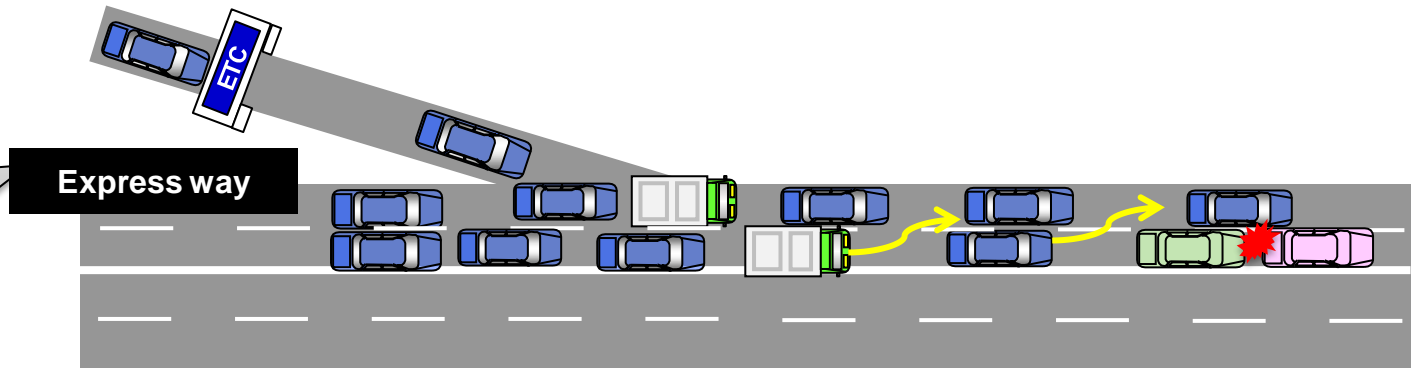
Due to road maintenance, turn-right prohibited at intersection.

Next intersection advisable.

Normal Road
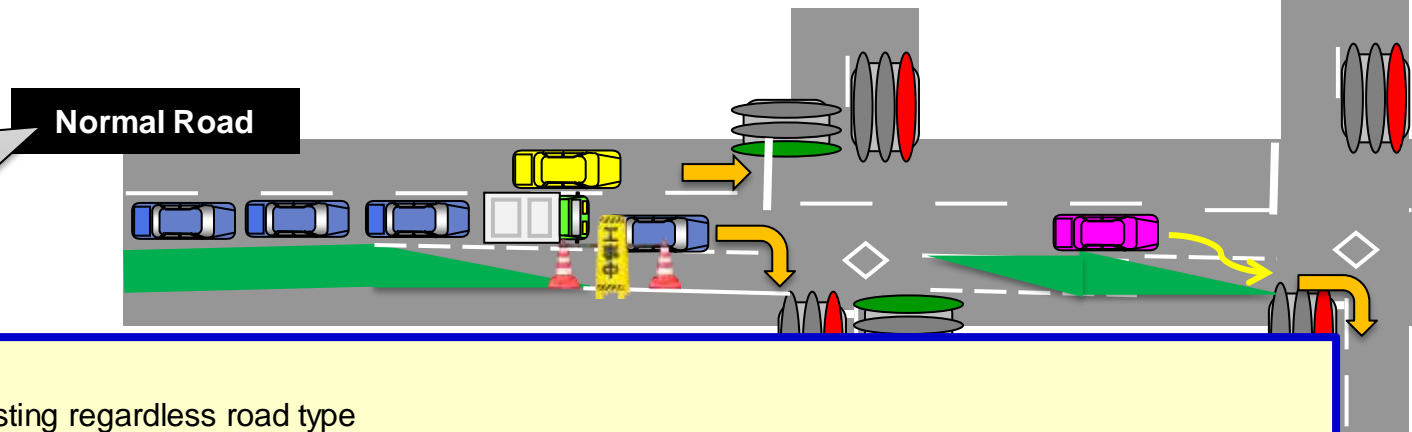
Case: V2N

Points: Wide-area broadcasting regardless road type

Issues: Co-existence with and/or differentiation from already deployed system, VICS.

Countermeasures upon commutation trouble.

Summary of Use case

- **On the basis of discussions in public & practical use cases, in this chapter, we focus on communication update interval.**

- **To find out and recognize unclear points, 5 use cases are discussed in next chapter.**

※Benefit of cellular V2X needs to be evaluated in order to realize those use cases.

Communication Architecture

Operation in Short-range Comm.

In case of terminal autonomous operation,
short-range communication has no relationship with wide-area communication(MNO).

Terminal Autonomous Operation

Comm. Parameters
Update by OTA, upon Delivery, Maintenance

Autonomous Comm. based on sensing

Short-range comm. control per MNO is mandatory for network management.

Network Management
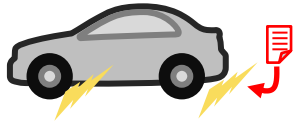
Parameter distribution from BS   Radio resource allocation

Autonomous operation: independent of network

Operation in Short-range Comm.
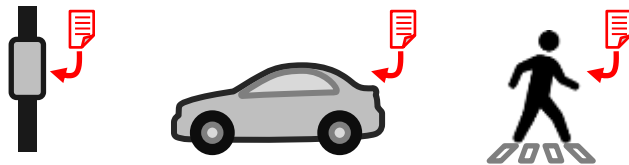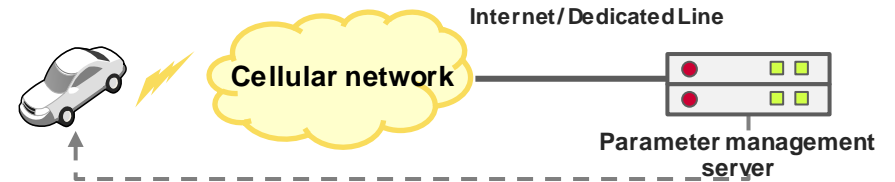
Type of parameters

use case

region

communication device

Parameter update

Parameter update: Capable through cellular network.

(Assuming new use cases & congestion control)

Internet / Dedicated Line

Cellular network

Parameter management server
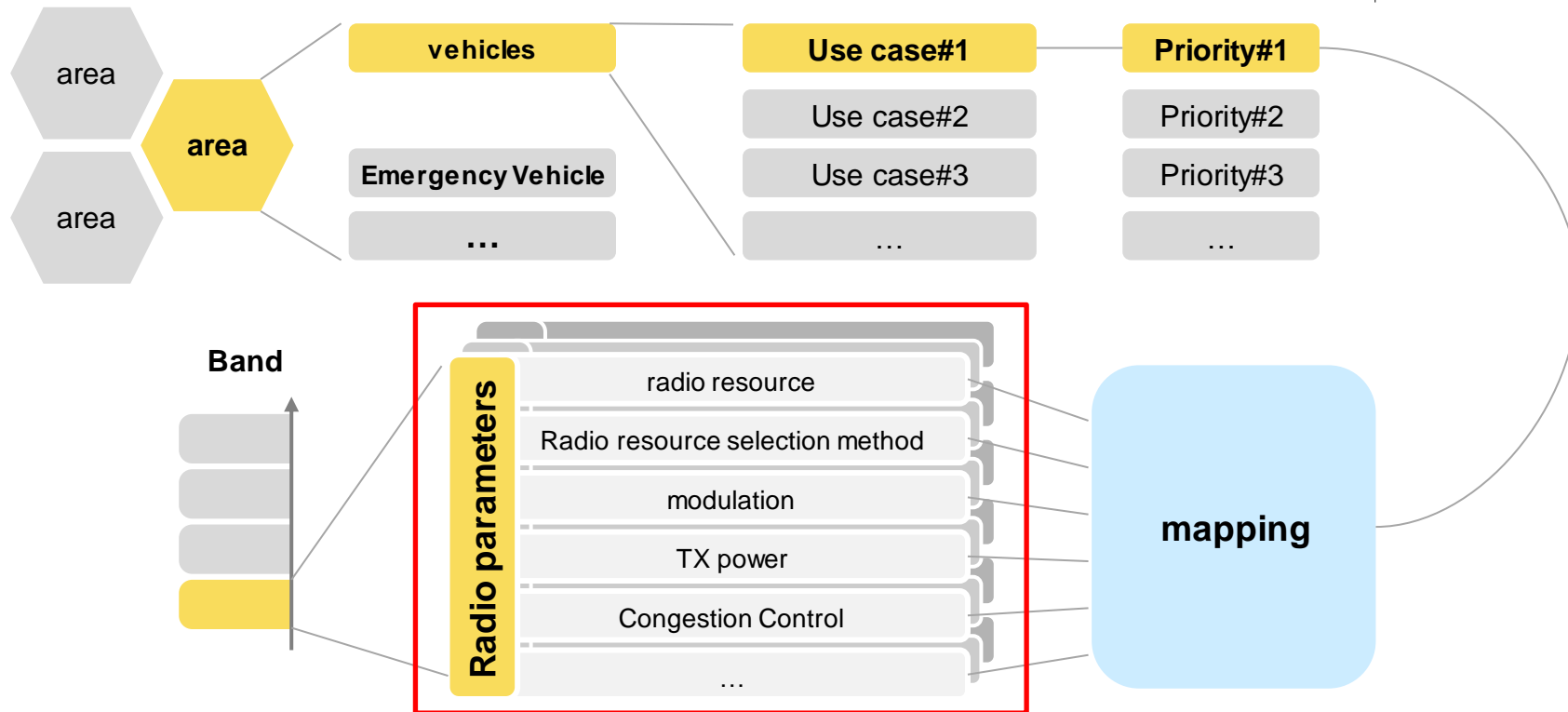
Cellular NW would be transparently used.
➔ Independent of MNO

Along with a particular use case, its parameter management needs to be considered.

Sample Parameters in Short-range Communication

Protocol Stack of Short-range Communication

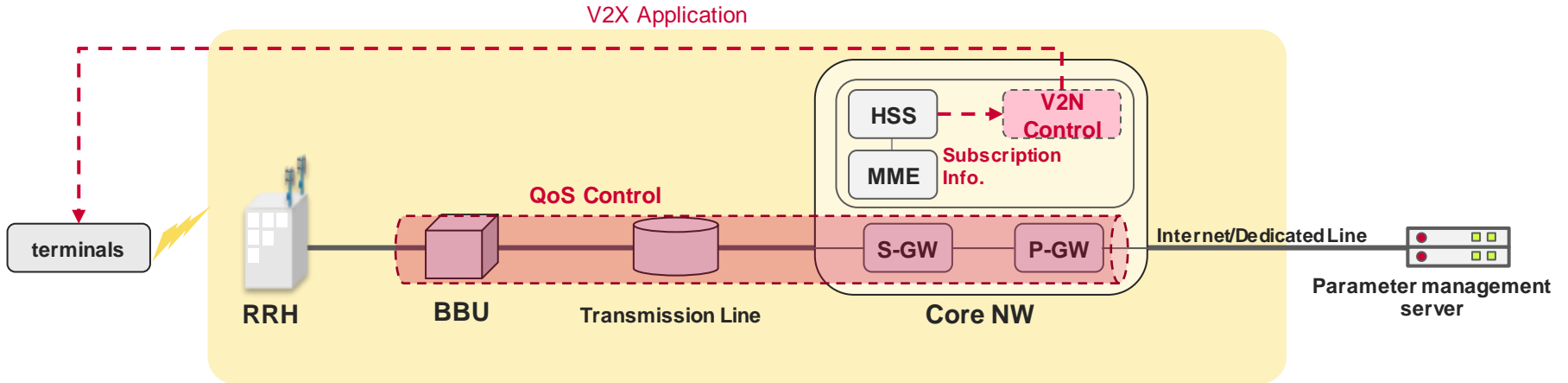| V2X Application		
Message/Facilities layer		**Security**
TCP/UDP	Non-IP	
IP	Transport/network (e.g., IEEE/ETSI)	
PDCP		
RLC		
MAC		
PHY		

- **Radio layer, lower layer, is defined by 3GPP.**

- **Upper layer specification, including security, needs to be defined for region in JAPAN.**

Upper layer specification in Japan : To be defined.

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Architecture in Wide-area Communication

V2X Application

V2N Control

HSS

MME

Subscription Info.

QoS Control

terminals

RRH

BBU

Transmission Line

S-GW

P-GW

Core NW

Internet/Dedicated Line

Parameter management server

- Cellular network ➔ Vast of maintenance cost
- Assuming MNO infrastructures (for unicast) realized shortly.
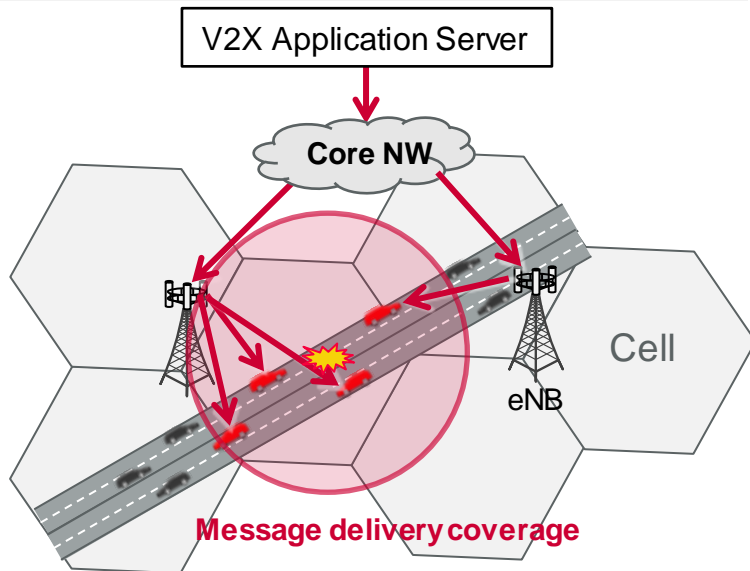- QoS would NOT be guaranteed even if it is implemented.

Existing MNO infrastructure needs to be evaluated for future architecture.

Wide-area Comm. (Geo-messaging)

(1) Unicast	**(2) Multicast**
Based on Vehicle location	**Based on BS coverage**

Message delivery coverage

Message delivery cell
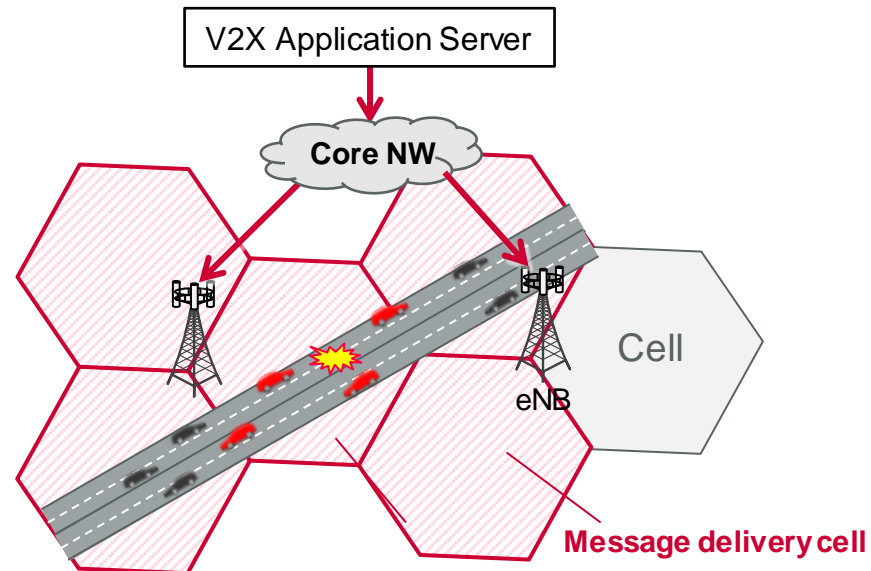
Further Discussion: Delivery method & Rule to the vehicles in a certain area.

Wide-area communication (message destination management)

(1) by V2X Application Server

V2X application server

IP packet

Core NW

unicast

Area

Vehicle ID mapping

(2) By LTE network

V2X application server

Delivery registration

API

Core NW

unicast

Area

Vehicle ID mapping

or

multicast

Area

BS mapping
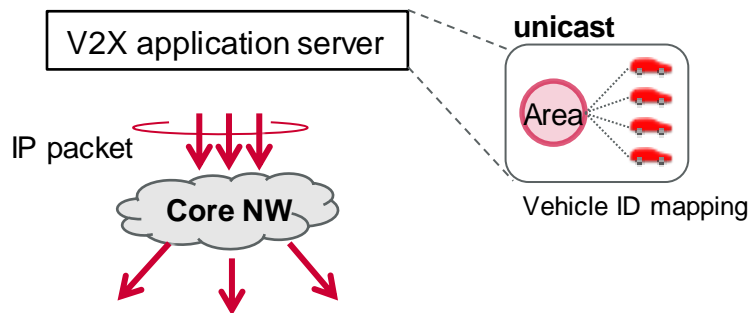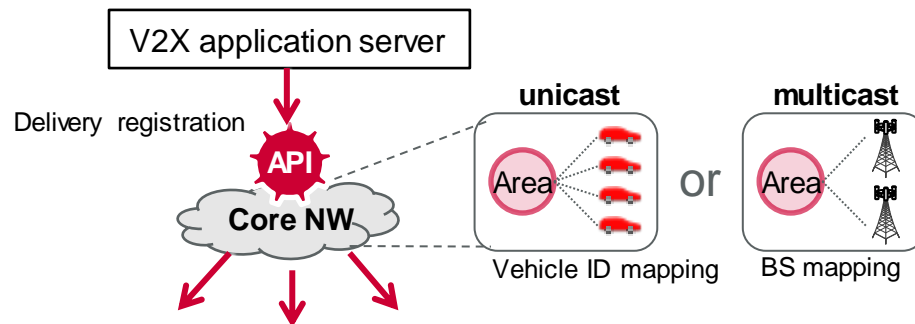
Considering scalability & efficiency...

Function-sharing for information delivery needs to be discussed and cleared.

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Wide-area Comm.(MEC & Multi-MNOs)

MNO_A

Terminal — RRH — BBU — Transmission Line — Core NW (S-GW — P-GW) — Interconnection Point — Internet — Cloud Server

MEC Server   MEC Server   MEC Server

-Latency
-NW load

Greater

-Number of server
-Difficulty of mobility control
-Difficulty of MNO inter-connection

Greater

MNO_B

Terminal — RRE — BBU — Transmission Line — Core NW (S-GW — P-GW) — Interconnection Point
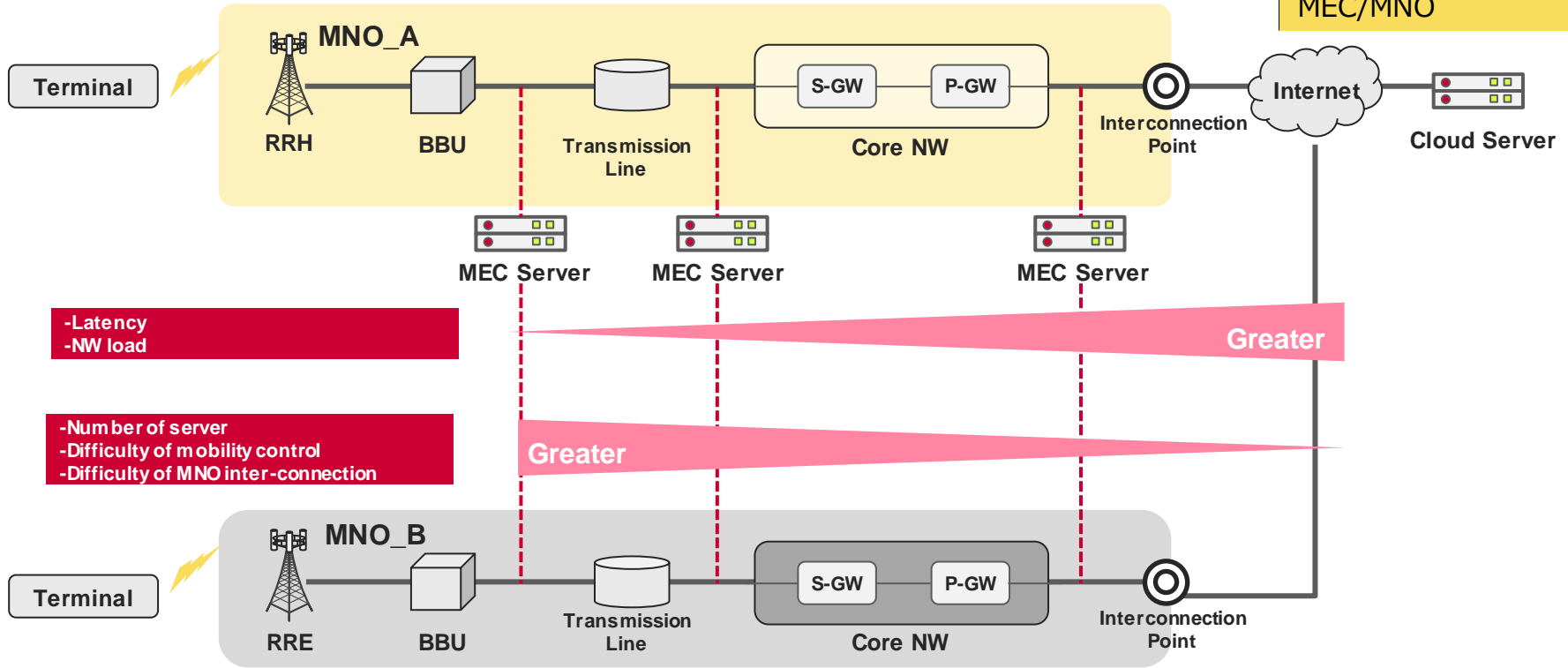
Considering its cost, effectiveness study on MEC is necessary.

Summary of Communication Architecture

● **Discussion Points for Short-range Communication**

Autonomous & independent communication
→Independent of MNO

Pre-configured parameters per area & management method to be discussed.
→Possible use case of wide-area communication, such as cloud management.

● **Discussion Points for Wide-area Communication**

Considering CAPEX & OPEX, existing infrastructure needs to be used.
→ Service design to be realized under multi-MNOs.

Information gathering & V2X information delivery server
→ Inter-connection among MNOs, Cloud and transmission line, Information delivery, System operation rule

MEC might be efficient at the point of latency or load
→ Much processing at edge shall be avoided, considering its cost performance?

Business Model

From the view of the report...

Based on the principle that beneficiaries should pay for a project,

Cost shall be compensated by the beneficiaries of the values, such as;
-accident decreasing
-expansion of autonomous driving industries.

Stakeholders are listed, then
Cost factors in V2V, V2I and V2N are evaluated, respectively.

Stakeholders of each use case

	Use case	Stakeholders		
		Information Provider	System Provider	Beneficiary
1	**Collision avoidance and emergency braking** due to falling objects, vehicles involved in accidents, etc.	Driver Vehicle Owner	Car OEMs, system operation managers, etc.	**Drivers, car owners, etc.**
2	**Intersection passage support/dilemma zone avoidance/red traffic signal warning** using traffic signal cycle information	Traffic signal managers, etc.	Traffic signal managers, MNOs, system operation managers, etc.	**Drivers, car owners, road administrators, etc.**
3	**Lane change support/route selection** using information on the presence of an obstacle, broken-down vehicle, etc.	Drivers, car owners, road managers, etc.	Road administrators, MNOs, system operation managers, etc.	**Drivers, car owners, etc.**
4	**Vehicle avoidance support** using information on nearby emergency vehicles	Emergency vehicle operators, etc.	Hospitals, MNOs, system operation managers, etc.	**Drivers, emergency vehicle operators, and users, etc.**
5	**Route reselection** using construction and regulatory information	Road administrators, constructors, etc.	Road administrators, MNOs, system operation managers, etc.	**Drivers, road administrators, constructors, etc.**

Cost factors in Cellular V2X business

V2N & V2I: Cost would be higher due to infrastructures, data communication.

Compensation of costs （V2V）

Assumption: V2V Terminal sales as mainstream

●Business Models
- Compared with initial & running fee of V2N, the fee of V2V is smaller.
- V2V terminal sales would be mainstream of its business, like existing ITS business model.

●Popularization requires:
- V2V communication by smartphone, with the limited features
- Low-cost in-vehicle devices
- Incentives for users

Popularization is expected by means of :
- Chargeable-sustainable business model.
- Mutual combination(V2N & V2I).

●**Business Model**
- Compared with V2V, initial & running fee of infrastructure is higher.
- Data fee is not negligible.

For recovery of infrastructure costs, chargeable-sustainable business model, like a cellular business, is expected.

Compensation of costs（V2I/V2N）

● **For popularization**

[1] V2I/V2N-common Service

V2N service would be launched together with cellular network, then;
   Step1: Service coverage expansion needs.
   Step2: V2I infrastructure development, for highly-demanded use cases, is necessary.

Compensation of costs （V2I/V2N）　　[3/3]
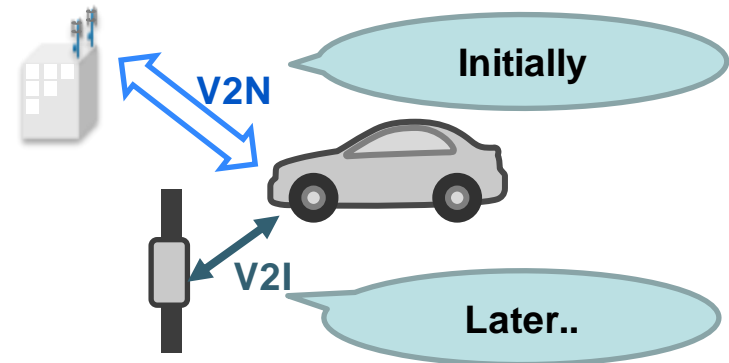
● **For popularization**

[2] Revenue improvement in B2B, B2B2C model
・ **Data acquired from V2N/I infrastructures would be shared to 3rd parties for a fee**
・ **V2N/I service providers would mediate information sharing among the multi-corporate users**
  & the drivers.

Traffic Information

Request to Information delivery

Information delivery

3rd parties,
Corporate users
(G or B)

V2N/I Service provider
(B)

Driver
(C)

Provision of gathered
Information
(ex. Probe data)
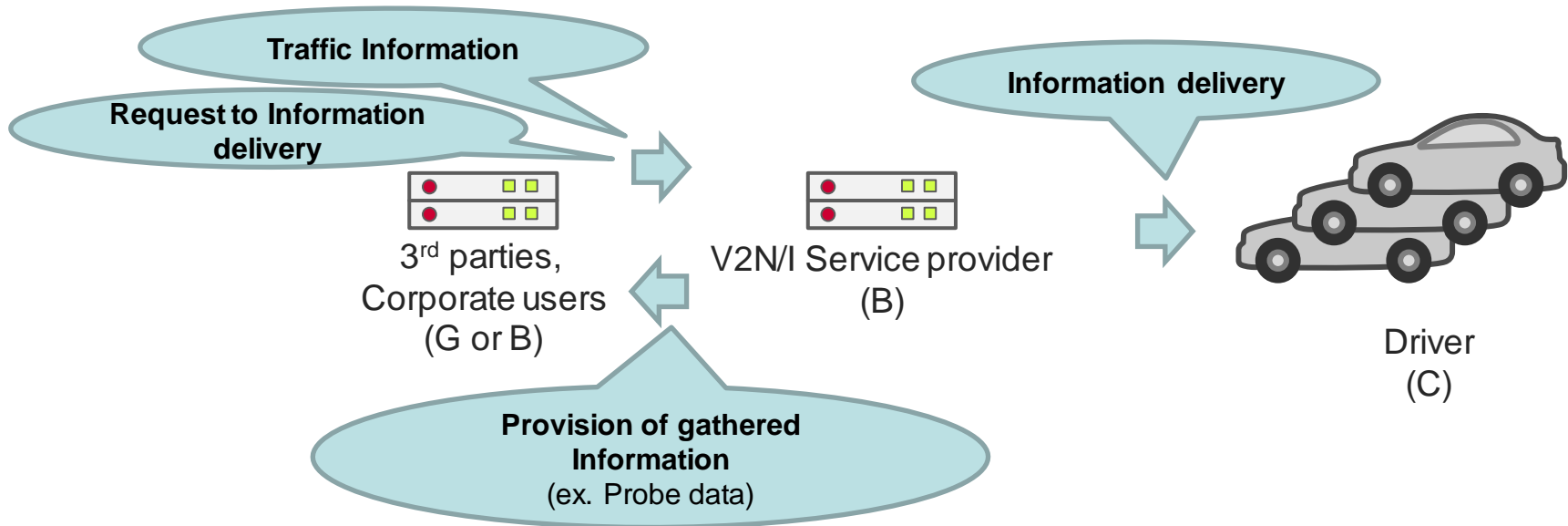
Summary

Categories by issues

- **Issues on Communication**
  - **Short-range communication**
  - **Wide-area communication**

- **Issues on Communication Sharing**
  - **Information acquisition**
  - **Information usage at Vehicles**

- **Issues on Services & Business models**

- **Issues on Service Responsibility**

Issues on Communication （Short-range Communication）

Currently, most issues are related to radio frequencies.
Further discussion in each use case needs for frequency standard & communication methods.

Current test is not sufficient.

Further discussion, especially on scalability & availability, is necessary.

Issues	Corresponding Use Case				
	#1	#2	#3	#4	#5
Acquisition of frequency allocation, standardization of communication methods	✓			✓	
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	✓			✓	

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection

Issues on Communication （Wide-area Communication）
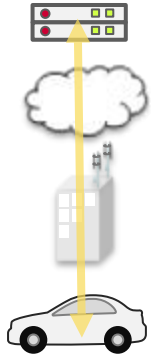
Performance test of existing cellular networks & countermeasures for irregular cases are to be considered.

Issues	Corresponding Use Case				
	#1	#2	#3	#4	#5
Verification of feasibility (latency and reliability) and availability		✓	✓	✓	✓
Investigation of communications quality improvement methods (if necessary)		✓	✓	✓	✓
Responses in cases where performance requirements are not met and countermeasure costs		✓	✓	✓	✓
Responses to differences in the service areas of each MNO		✓	✓	✓	✓

In case of priority control, investment & MNO arrangement are necessary to be discussed.

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection
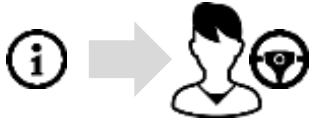
Issues on Communication Sharing(Information acquisition)

Interface definition & standardization for data acquisition are mandatory.
Feasibility test shall be required in view of security & privacy.

Further discussion on each use case is necessary to confirm the data source.

Perspective	Issues	Corresponding Use Case				
		#1	#2	#3	#4	#5
Acquisition from associations and organizations	Obtaining approval to acquire source 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 associations and organizations	Adoption of message format and protocol specifications	✓		✓	✓	
	Adoption of guidelines for controlling variations among vehicles generating information	✓			✓	
	Security and privacy countermeasures	✓		✓		
	Obtaining consent regarding the use of information from each vehicle owner	✓		✓		

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection

Issues on Communication Sharing（Information usage at Vehicles）

Standardization & Guideline are mandatory for assured information usage at receivers' side.

In wide-area communication, communication path becomes to be complexed, which is a matter.

Issues	Corresponding Use Case				
	#1	#2	#3	#4	#5
Adoption of message format and protocol specifications	✓	✓	✓	✓	✓
Ensuring the reliability of received information (communications route security)	✓	✓	✓	✓	✓
Formulation of guidelines on the use of received information (including consideration of latency)	✓	✓	✓	✓	✓

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection

Issues on services & business models

Continuous cost compensation & operation modeling-popularization are to be discussed and resolved.

Issues	Corresponding Use Case				
	#1	#2	#3	#4	#5
Formulation of service definitions and guidelines	✓	✓	✓	✓	✓
Development of systems from acquisition of source information to provision to vehicles		✓	✓	✓	✓
Securing service opportunities (promoting widespread adoption of terminals, developing infrastructure, etc.)	✓	✓	✓	✓	✓
Reducing the cost of PC5 onboard devices (to promote widespread adoption)	✓		✓	✓	
Burden of Uu communications costs		✓	✓	✓	✓
Investment relating to improvement of communications quality (if necessary)	✓	✓	✓	✓	✓
Development of servers for information acquisition, collection, and distribution and establishment of business taking into consideration costs for maintenance of distribution servers and other equipment (including acquisition of public funding and cooperation and collaboration with associations and organizations)		✓	✓	✓	✓

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection

Issues on service responsibility

The factors which do not exist in current ITS, such as wide-area communication & autonomous driving, is to be discussed.

Issues	Corresponding Use Case				
	#1	**#2**	**#3**	**#4**	**#5**
Clarification of the allocation of responsibility from acquisition of source 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.)	✓	✓			

Usecase#1= Collision avoidance and emergency braking, #2= Intersection passage support/dilemma zone avoidance/red traffic signal warning, #3= Lane change support/route selection, #4= Vehicle avoidance support, #5= Route reselection

Summary

- **Cellular V2X, wide-area(V2N) & short-range(V2V/I/P), is attractive for any types of services.**
  - Many items to be confirmed for commercial operation, thanks to its much flexibility.

- **Issues to be discussed for commercial phase:**
  - use cases, performance requirements, business models, frequencies, communication specifications, regulations, rules, infrastructure development, etc.

- **Expecting that:**
  -discussion on benefit / values,
  -discussion on impact in aspect of legal system & business, then
  -those activities move forward to better ITS services

Future Plan

Schedule

	Y2019			Y2020	
	2Q	3Q	4Q	1Q	2Q
3GPP	Rel.16				Rel.17
Cellular system TG	Report	Discussion for next edition			

▲ Workshop (Jul. 4th)

▲ ITS world congress in SIN

▲ Next edition

▲ JP-version issued

▲ EN-version issued