# SIP Use Cases for Cooperative Driving Automation — Activity Report of Task Force on V2X Communication for Cooperative Driving Automation in FY2019 —

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Innovation of Automated Driving for Universal Services (SIP-adus)

### Contents

1. Introduction ·····	· 2
2. Definition of terms·····	4
3. System definition and scope of study of the cooperative driving automation $\cdots$	6
4. Process of studying the SIP Use Cases······	8
4.1 Investigation of use cases	
4.2 Policy in selecting the SIP Use Cases	
5. SIP Use Cases ···································	10
5.1 Results of selecting the SIP Use Cases	
5.2 Use cases that were dropped	
6. Conclusion·····	39
7. References ······	39

### 1. Introduction

The Cross-Ministerial Strategic Innovation Promotion Program (SIP) Use Cases for Cooperative Driving Automation (hereinafter, "SIP Use Cases") were formulated by the Task Force on V2X Communication for Cooperative Driving Automation (hereinafter, "the TF"), which consists of stakeholders from industry, academia, and government, to study the communication protocols (including communication resources, such as frequencie and bandwidth) required for cooperative driving automation in the future. In formulating the use cases, we compiled those of projects related to cooperative driving automation and advanced driver assistance system in and outside Japan that were investigated under SIP Innovation of Automated Driving for Universal Services (hereinafter, "SIP-adus") (ministry in charge: Ministry of Internal Affairs and Communications) in FY2018 and those studied by the Japan Automobile Manufacturers Association, Inc. (hereinafter, "JAMA") to cover as many use cases as possible. While these cases have been studied with practical application in mind, some of them are less likely to be used in practice. If the communication resources required to achieve all of these cases are secured, resources that are unlikely to be used in the future would also be secured and may be wasted. For this reason, use cases that are likely to be used in the future were selected based on the views of the TF experts.

The SIP Use Cases were prepared to study communication protocols, but they are highly practical and are likely to be used in practice. We hope that they are widely used for R&D, standardization activities, etc. for cooperative driving automation beyond the scope of this project.

### **Background of formulating the SIP Use Cases**

An initiative is under way to achieve safe, smooth, and advanced automated driving by combining autonomous driving with the infrastructure cooperative system, and there are high expectations for its potential achievements. However, there are various questions related to the communication required for the achievements. For example, ITS communication for advanced driver assistance system has been used in practice in Japan, but there may be insufficient frequency and bandwidth, and new frequency may be required in the era of cooperative driving automation; if so, how much bandwidth will be required? In the U.S. and Europe, radio waves of the 5.9 GHz band are allocated for ITS communication. In Japan, radio waves of the 760 MHz band and 5.8 GHz band are used. Japan might be left out of the global standard. Discussions have been held from various aspects, but no clear conclusion is in sight. This is because the assumptions for discussing

communication protocols for the cooperative driving automation (i.e., objective of the system, functionality required to achieve the objective) have not been defined. To study Japan's initiative for communication protocols and required frequency and bandwidth while taking into account the future developments and the current status in Japan, the TF was organized under the System Implementation Working Group of SIP-adus.

The TF aims to "envision the ideal situation of cooperative driving automation, create a road map toward achievement, and establish the policy on optimal communication protocols at the national level while taking into account the international standard." The goal of the activity is to propose optimal communication protocols for cooperative driving automation and create a road map for communication protocols. The TF's study process consists of three phases. Phase 1 aims to clarify the system definition and scope of cooperative driving automation and to study and select use cases based on the system definition and scope. Phase 2 aims to investigate and study the technology requirements and communication technology requirements for achieving the use cases defined in Phase 1 and to clarify issues related to the application to the current ITS communication. Phase 3 aims to study new communication protocols for solving the issues and evaluate the validity of such protocols, propose optimal communication protocols for cooperative driving automation, and formulate a road map for communication protocols into the future.

The SIP Use Cases were formulated in the process of study described above.

### 2. Definition of terms

The terms used in this report are defined as follows.

Term	Meaning and explanation
Autonomous driving system	A system that enables automated driving using only the on-
	board sensors of each vehicle.
Cooperative automated	A system developed from the autonomous driving system to
driving system	enable more advanced automated driving by using traffic
	environment information, etc. obtained through communication.
Infrastructure	Roadside devices for dedicated short range communications
	(DSRC) and base stations for long range communications.
Roadside infrastructure	Roadside devices for DSRC.
Merging assistance	Enables smooth merging by providing necessary information
	through communication to automated driving vehicles merging
	from the merging lane to the main lane or automated driving
	vehicles driving on the main lane.
Lane change assistance	Enables smooth lane change by vehicle-to-vehicle (V2V)
	communication when lane change.
Preliminary acceleration	To attain the target speed by acceleration or deceleration in
and deceleration	advance for smooth driving (control) by the autonomous driving
	system.
Provision of traffic signal	To provide information about present signal color and signal
information	phase and timing, etc. when vehicles pass signalized
	intersections so that they can pass through such intersections
	smoothly.
Lookahead information:	To avoid collision by obtaining information about obstacles
collision avoidance	ahead of an automated driving vehicle.
Lookahead information:	To change the initial trajectory by obtaining information about
trajectory change	obstacles ahead of an automated driving vehicle.
Lookahead information:	To avoid obstruction of emergency vehicles by obtaining
emergency vehicle	information about approaching emergency vehicles.
notification	
Information collection by	The infrastructure collects the location information and feature
infrastructure	information detected by on-board sensors, etc. to use such
	information for updating maps, etc. by estimating changes in
	road structures, etc.

Platooning/adaptive cruise	A system for platooning by multiple trucks and an adaptive
control	cruise control system equipped with a gap distance control
	function.
Teleoperation	Manual operation from a remote location in a traffic environment
	that is difficult to drive with an autonomous driving system to
	avoid.
Terms used in the diagrams	of the SIP Use Cases in Section 5
Term	Meaning and explanation
V2V: vehicle-to-vehicle	Communication between vehicles.
communication	
V2I: vehicle-to-	Communication between vehicles and roadside infrastructure.
infrastructure	
communication	
V2P: vehicle-to-pedestrian	Communication between vehicles and pedestrians.
communication	
V2N: vehicle-to-network	Communication between vehicles and the cloud network.
communication	
One-to-one	Information is transmitted to a specified recipient.
One-to-many	Information is transmitted to unspecified recipients.
Message	Information that is transmitted and received for automated
	driving control (warning, intention, request, instruction, traffic
	signal information, speed limit) or forecast information, etc. that
	is generated based on the sensor data (time to arrive at a
	merging section, status of congestion).
Sensor data	Information that is transmitted to vehicles around one's own
	vehicle and to the infrastructure by detecting the status of one's
	own vehicle and the surrounding environment using on-board
	sensors (e.g., speed, location, driving operation).
Rich contents	Information of photos, images, etc. (e.g., images captured by on-
	board cameras, locations of features).

### 3. System definition and scope of study of the cooperative driving automation

### 1) System definition of the cooperative driving automation

The cooperative driving automation was defined as follows to build a consensus on cooperative driving automation and facilitate discussions in the TF.

The cooperative automated driving system achieves safer and <u>smoother</u> automated driving control\*1 based on the autonomous driving system by obtaining <u>information outside the detection range of on-board sensors,\*2 providing information of one's own vehicle,\*3 and <u>mutual communication by using V2I and V2V.</u> \*4</u>

### **Explanation**

The autonomous driving system achieves automated driving control by using information obtained from on-board sensors of one's own vehicle. Meanwhile, the cooperative automated driving system achieves advanced automated driving by adding information obtained through communication to the autonomous driving system. The cooperative automated driving system was defined based on the above concept.

### \*1 Smoother automated driving control

This refers to enabling driving control with enough time margin by adding information obtained through communication to the autonomous driving system (which makes the final judgment on driving control) based on the information obtained through on-board sensors of one's own vehicle. Specific examples include the following:

- a) Preliminary acceleration and deceleration/speed adjustment toward lane change and merging
- b) Mutual concessions and mediation with other traffic participants
- c) Selection of an optimal route
- d) Response to control instructions

### \*2 Information outside the detection range of on-board sensors

Information outside the detection range of on-board sensors refers to the following:

- a) Information beyond the detection range of on-board sensors of the autonomous driving system
- b) Definite information in the future (e.g., traffic signal phase and timing information)
- c) Statistical prediction information (e.g., traffic congestion prediction information)

### \*3 Providing information of one's own vehicle

Providing information of one's own vehicle refers to providing information about the status of one's own vehicle and the surrounding traffic environment obtained from GNSS, on-board sensors, etc. to the infrastructure.

### \*4 Mutual communication by using V2I and V2V

Mutual communication by using V2I and V2V refers to communication between an automated driving vehicle and vehicles around it and between an automated driving vehicle and infrastructure, respectively. Specifically, it refers to the following:

- a) Transmission of intention of an automated driving vehicle to vehicles around it (unspecified)
- b) Mutual communication between an automated driving vehicle and vehicles around it (specified or unspecified)
- c) Provision of information from external stakeholders related to a vehicle's driving (e.g., road administrators, traffic managers) to the vehicle or vice versa
- d) Driving behavior instructions from external stakeholders related to a vehicle's driving (e.g., road administrators, traffic managers) to the vehicle, or requests for mediation from the vehicle to external stakeholders

### 2) Scope of study of the cooperative driving automation

In the SIP Use Cases, the scope of study of the cooperative driving automation is as follows.

### (1) Privately owned vehicles

- Expressways
- · General roads

### (2) Logistics/mobility service cars

- Platooning (expressways)
- Shuttle services/buses (fixed route on general roads/teleoperation)
- · Taxis/logistics vehicles (variable route on general roads/teleoperation)

### 4. Process of studying the SIP Use Cases

### 4.1 Investigation of use cases

In the "Study of utilization of new communication technologies including V2X technology for automated driving system"<sup>(1)</sup> under SIP-adus (ministry in charge: Ministry of Internal Affairs and Communications) conducted in FY2018, use cases used in cooperative driving automation and advanced safety driver assistance projects in Europe, the U.S., and Asia (including Japan) were investigated and collected. In Japan, use cases on expressways and general roads have been studied by JAMA; they were used as references in examining the SIP Use Cases.

### 4.2 Policy in selecting the SIP Use Cases

The TF aims to propose future communication protocols and communication resources. The use cases collected as described in the previous section include those that are less likely to be used in practice. If communication resources are secured to achieve all the use cases, such resources are likely to be wasted. For this reason, the TF selected use cases that are likely to be used in practice in the future. The selection criteria were as indicated in 1) and 2) below.

- 1) Meets the preconditions for examining the cooperative driving automation

  The following preconditions are established for examining the cooperative driving
  automation. Use cases that meet the preconditions are selected as the SIP Use Cases.
  - (1) All traffic participants comply with the laws and regulations in principle.

Reason: Achievement of functionality to avoid accidents attributed to intentional violations of traffic laws and regulations by surrounding traffic participants would require excessive performance and cost to the cooperative automated driving system.

(2) Use cases that are achieved by the autonomous driving system alone are excluded.

Reason: The cooperative automated driving system will be achieved based on the autonomous driving system. Thus, the functionality that can be achieved by the autonomous driving system alone is redundant, and practical application as the cooperative automated driving system is considered to be less likely.

2) Meets the system definition of the cooperative driving automation

The following three items were established as the requirements for selecting the SIP Use Cases based on the system definition of the cooperative driving automation by the TF:

a) It is necessary to obtain information outside the detection range of on-board

### sensors.

- b) It is necessary to provide information of one's own vehicle.
- c) It is necessary to ensure **V2V and V2I interaction**.

### 5. SIP Use Cases

### 5.1 Results of selecting the SIP Use Cases

The use cases collected in 4.1 were compiled. Then, use cases that fall under the preconditions of 4.2 1) were extracted, and were sorted based on the three requirements in 4.2 2). To clarify the overall picture, the use cases were classified into eight functions (a. merging/lane change assistance, b. traffic signal information, c. lookahead information: collision avoidance, d. lookahead information: trajectory change, e. lookahead information: emergency vehicle notification, f. information collection/distribution by infrastructure, g. platooning/adaptive cruise control, h. teleoperation).

## **5.1.1 Classification by function of the SIP Use Cases** (The number in parentheses indicates the number of use cases.)

- (1) Use cases in which information outside the detection range of on-board sensors must be obtained (14)
  - a. Merging/lane change assistance (2)
  - b. Traffic signal information (2)
  - c. Lookahead information: collision avoidance (4)
  - d. Lookahead information: trajectory change (5)
  - e. Lookahead information: emergency vehicle notification (1)
- (2) Use cases in which information of one's own vehicle must be provided (4)
  - f. Information collection/distribution by infrastructure (4)
- (3) Use cases in which V2V and V2I interaction must be ensured (7)
  - a. Merging/lane change assistance (4)
  - g. Platooning/adaptive cruise control (2)
  - h. Teleoperation (1)

### **5.1.2 Overview of the SIP Use Cases**

### 1) SIP Use Cases

The SIP Use Cases compiled based on classification by function are listed below.

## (1) Use cases in which information outside the detection range of on-board sensors must be obtained

Classification	Name of the use	O
by function	case	Overview
a. Merging/lane	a-1-1. Merging	Information, such as the speed of vehicles driving on the main
change	assistance by	lane at the measurement location on the main lane and
assistance	preliminary	predicted time to arrive at a merging section, is provided by the
	acceleration and	infrastructure to merging vehicles to assist preliminary
	deceleration	acceleration and deceleration.
	a-1-2. Merging	Continuous measurement information (e.g., location and speed
	assistance by	of vehicles driving on the main lane) is continuously provided
	targeting the gap on	by the infrastructure to merging vehicles to assist merging by
	the main lane	targeting the gap between vehicles driving on the main lane.
b. Traffic signal	b-1-1. Driving	Current traffic signal color and traffic signal phase and timing
information	assistance by using	information (the next traffic signal color and the time until
	traffic signal	change), etc. at intersections are provided by the roadside
	information (V2I)	infrastructure to vehicles that enter intersections to assist
		deceleration and stopping, and thereby avoid a dilemma.
	b-1-2. Driving	Traffic signal phase and timing information (the next traffic
	assistance by using	signal color and the time until change), etc. at intersections is
	traffic signal	provided through the network to vehicles that enter
	information (V2N)	intersections to assist deceleration and stopping, and thereby
		avoid a dilemma.
c. Lookahead	c-1. Collision	Sudden braking information as well as location and speed
information:	avoidance	information are provided by the vehicle that suddenly
collision	assistance when a	decelerates to the following vehicles to prompt them to stop or
avoidance	vehicle ahead stops	decelerate in advance and prevent multiple-vehicle collision
	or decelerates	accidents.
	suddenly	
	c-2-1. Driving	Location and speed information of vehicles that approach
	assistance based	intersections is provided by the approaching vehicles to other
	on intersection	vehicles that approach or pass through intersections to assist
	information (V2V)	them to pass through or make a right turn at intersections with

Classification	Name of the use	
by function	case	Overview
		many blind spots.
	c-2-2. Driving	Location and speed information of vehicles that approach
	assistance based	intersections, which is obtained from roadside sensors or
	on intersection	vehicles, is provided by the infrastructure to other vehicles that
	information (V2I)	approach or pass through intersections to assist them to pass
		through or make a right turn at intersections with many blind
		spots.
	c-3. Collision	When an automated driving vehicle performs emergency
	avoidance	deceleration or emergency lane change, emergency hazard
	assistance by using	information is transmitted to the following vehicles to assist
	hazard information	smooth avoidance control.
d. Lookahead	d-1. Driving	Event information of abnormal vehicles that are stopped on
information:	assistance by	roads (e.g., malfunctioning vehicles, vehicles involved in
trajectory	notification of	accidents) and location information (sections and lanes where
change	abnormal vehicles	such vehicles are located) are provided by the infrastructure to
		the surrounding vehicles or by abnormal vehicles to the
		surrounding vehicles to assist lane change and trajectory
		change at an early stage.
	d-2. Driving	Location and speed information of wrong-way vehicles and
	assistance by	information about the presence of wrong-way vehicles are
	notification of	provided by the infrastructure to the surrounding vehicles to
	wrong-way vehicles	prompt lane change, etc. in advance and assist collision
		avoidance.
	d-3. Driving	Traffic congestion status information obtained from vehicles
	assistance based	that are caught in traffic congestion is provided by the
	on traffic congestion	infrastructure to the surrounding vehicles to assist driving.
	information	
	d-4. Traffic	Information about traffic congestion on shoulders (location,
	congestion	speed) is provided by the infrastructure to vehicles on the main
	assistance at	lane to assist entry to branches.
	branches and exits	

Classification	Name of the use	Overview			
by function	case	Overview			
	d-5. Driving	Information about obstacles, construction work, traffic			
	assistance based	congestion, etc. is provided by the infrastructure to the			
	on hazard	surrounding vehicles to assist driving.			
	information				
e. Lookahead	e-1. Driving	Information about the driving direction, speed, and planned			
information:	assistance based	driving route (planned driving lane) of emergency vehicles is			
emergency	on emergency	provided by the emergency vehicles to the surrounding			
vehicle	vehicle information	vehicles to prompt the surrounding vehicles to drive at reduced			
notification		speed or to stop, etc. and thereby assist the emergency			
		vehicles to pass smoothly.			

### (2) Use cases in which information of one's own vehicle must be provided

Classification	Name of the use	Overview				
by function	case	Overview				
f. Information	f-1. Request for	Rescue information is transmitted from abnormal vehicles				
collection/	rescue (e-Call)	(e.g., vehicles involved in accidents) to the infrastructure to				
distribution by		request rescue.				
infrastructure	f-2. Collection of	Information about the location and speed of driving vehicles is				
	information to optimize	collected via the infrastructure to analyze and optimize the				
	the traffic flow	traffic flow.				
	f-3. Update and	Vehicles' information is collected by the infrastructure to				
	automatic generation	update and automatically generate the map data.				
	of maps					
	f-4. Distribution of	Dynamic map information is provided by the infrastructure to				
	dynamic map	vehicles.				
	information					

### (3) Use cases in which V2V and V2I interaction must be ensured

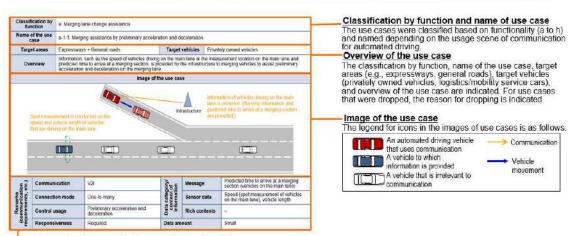
Classification	Name of the use	Overview
by function	case	Overview
a. Merging/lane	a-1-3. Cooperative	Measurement information (e.g., location, speed) of vehicles
change	merging assistance	driving on certain range of main lane is provided by the
assistance	with vehicles on the	infrastructure to merging vehicles. Meanwhile, instructions
	main lane by	(e.g., adjustment of the gap between vehicles) are given by the
	roadside control	infrastructure to vehicles on the main lane to assist merging.

Classification	Name of the use	Out and all and
by function	case	Overview
	a-1-4. Merging	During merging to a main lane with heavy traffic, vehicles on
	assistance based on	the main lane communicate with merging vehicles (e.g.,
	negotiations between	location and speed information, gap adjustment requests) to
	vehicles	conduct negotiations between vehicles for merging assistance.
	a-2. Lane change	During lane change to a lane with heavy traffic, the location
	assistance when the	and speed information and the intention of lane change, etc.
	traffic is heavy	are communicated between vehicles for lane change
		assistance.
	a-3. Entry assistance	At unsignalized intersections, location and speed information
	from non-priority	and the intention of entry are communicated between vehicles
	roads to priority roads	near intersections for driving assistance to enter priority roads
	during traffic	from non-priority roads.
	congestion	
g. Platooning/	g-1. Unmanned	Operation information, etc. of platooning vehicles is
adaptive cruise	platooning of	communicated between trucks that form a platoon to assist
control	following vehicles by	platooning (electronic towbar).
	electronic towbar	
	g-2. Adaptive cruise	Location and speed information and driving operation
	control and manned	information of vehicles at the front, etc. are communicated with
	platooning of	the following vehicles to assist adaptive cruise control.
	following vehicles	
	using adaptive cruise	
	control	
h. Teleoperation	h-1. Operation and	In a traffic environment that is difficult for an autonomous
	management of	driving system, an operation manager in a remote location
	mobility service cars	communicates a remote control instruction to the mobile
		service car based on video information from the mobile service
		car.

### 2) Use case diagrams

To present the use cases in an easy-to-understand manner, images and additional information were compiled as diagrams.

### How to read the diagrams



Remarks (communication requirements, etc.)

Remarks (overall information including communication requirements) are indicated as shown below for future analysis of technology requirements for use cases.

- Communication: V2V, V2I, etc.
- Connection mode: one-to-one, one-to-many
- Control usage: vehicle control or provision of information, etc.
- Responsiveness: vehicle response after obtaining information
- Data category/content of information: typical information that is exchanged through communication in respective categories (message, sensor data, rich contents)
- Data amount: large (data size that cannot be transmitted by DSRC)
   : small (data size that can be transmitted by DSRC)

## (1) Use cases in which information outside the detection range of on-board sensors must be obtained

## a. Merging/lane change assistance a-1-1. Merging assistance by preliminary acceleration and deceleration

Classifi fun	cation by ction	a. Merging/lane change assistance								
	of the use ase	a-1-1. Merging assistance by preliminary acceleration and deceleration								
Targe	et areas	Expressways + General roads Target vehicles Privately owned vehicles								
Ove	rview	Information, such as the speed of vehicles driving on the main lane at the measurement location on the main lane and predicted time to arrive at a merging section, is provided by the infrastructure to merging vehicles to assist preliminary acceleration and deceleration on the merging lane.								
			Image of	the use cas	ie .					
Spot measurement is conducted on the speed and vehicle length of vehicles that are driving on the main lane.  Information of vehicles driving on the main lane is provided. (Sensing information and predicted time to arrive at a merging section are provided.)  Information of vehicles driving on the main lane is provided. (Sensing information and predicted time to arrive at a merging section are provided.)										
S	peed and ve	ehicle length on ng on the mai	of vehicles	Inf	rastructure	predict	ted time to arrive at a merging section			
S	peed and ve	ehicle length on ng on the mai	of vehicles	Inf	rastructure	predict	ted time to arrive at a merging section			
s th	peed and ve	chicle length on the main	of vehicles		Message	predict are pro	ted time to arrive at a merging section			
s th	peed and venat are drivir	cation	f vehicles n lane.	category/ ntent of rmation		predict are pro	Predicted time to arrive at a merging section ovided.)			
S	peed and venat are drivir	cation	vehicles n lane.	Data category/ content of information	Message	predict are pro	Predicted time to arrive at a merging section section (vehicles on the main lane)  Speed (spot measurement of vehicles			

### a-1-2. Merging assistance by targeting the gap on the main lane

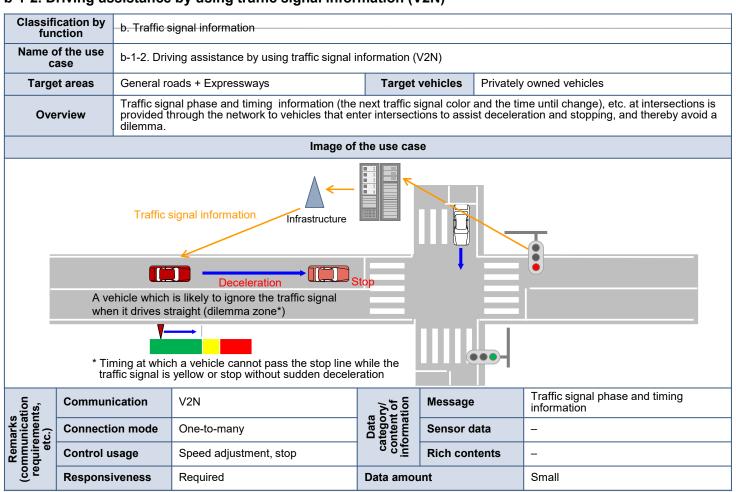
Classificat function	ition by a. Mer	a. Merging/lane change assistance								
Name of the case	1 2-1-/	a-1-2. Merging assistance by targeting the gap on the main lane								
Target a	areas Expres	Expressways + General roads Target vehicles Privately owned vehicles								
Overvi	iew provid	Continuous measurement information (e.g., location and speed of vehicles driving on the main lane) is continuously provided by the infrastructure to merging vehicles to assist merging by targeting the gap between vehicles driving on the main lane.								
		Image	of the us	se case						
		vehicles that are	Speed	Infrastructure						
driving or monitored	n the main lane a		adjustm							
driving or monitored	n the main lane a	re continuously	adjustm		Predicted time to arrive at a merging section (vehicles on the main lane)					
driving or monitored	n the main lane and by sensing (se	vection measurement).	category/ ntent of rmation	rent	(vehicles on the main lane)					
driving or monitored would be considered with the considered with	n the main lane and by sensing (se	vection measurement).		Message	(vehicles on the main lane)  Speed, location (continuous measurement of					

### b. Traffic signal information

### b-1-1. Driving assistance by using traffic signal information (V2I)

Classifi fun	Classification by function b. Traffic signal information									
	of the use ase	b-1-1. Driving assistance by using traffic signal information (V2I)								
Targe	et areas	General roads + Expressways Target vehicles Privately owned vehicles								
Overview  Current traffic signal color and traffic signal phase and timing information (the next traffic signal color and the time until change), etc. at intersections are provided by the roadside infrastructure to vehicles that enter intersections to assist deceleration and stopping, and thereby avoid a dilemma.										
			Image of	the use ca	se					
*	when it of	drives str	Deceleration Sto s likely to ignore the traffic signal aight (dilemma zone*)  a vehicle cannot pass the stop line while and cannot stop without sudden decele	e the	Inf	rastructure				
tion its,	Communica	ation	V2I	Data category/ content of information	Message		Current traffic signal color, traffic signal phase and timing information			
Remarks (communication requirements, etc.)	Connection	mode	One-to-many	ta	-					
Ren	Control usa	age	Speed adjustment, stop	in S S	Rich cont	ents	-			
00) er	Responsive	eness	Required	Data amo	unt		Small			

### b-1-2. Driving assistance by using traffic signal information (V2N)

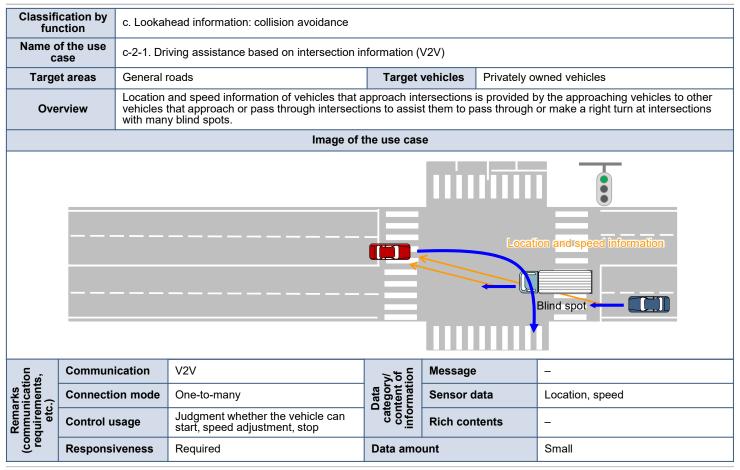


### c. Lookahead information: collision avoidance

### c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly

fun	cation by ction	c. Lookahead information: collision avoidance							
	of the use ase	c-1. Collis	ion avoidance assistance whe	en a vehic	cle ahead s	tops or dece	lerates su	uddenly	
Targe	t areas	Expressw	ays + General roads		Target	vehicles	Privately	y owned vehicles	
Ove	rview	Sudden braking information as well as location and speed information are provided by the vehicle that suddenly decelerates to the following vehicles to prompt them to stop or decelerate in advance and prevent multiple-vehicle collision accidents.							
			li	mage of t	the use ca	se			
			riving ahead of an automated ly decelerates cannot be dete	_		te blind spots	Su	udden stop, idden deceleration	
and	d a vehicle th	at sudden	Deceleration	_	ensing		Su	adden deceleration	
and		at sudden	ly decelerates cannot be dete	cted by se	ensing	te blind spots  Message	Su	1 / Land	
and	d a vehicle th	at sudden	Deceleration	cted by se	ensing		Susu	adden deceleration	
	d a vehicle th	eation mode	Deceleration  Deceleration	cted by se	ensing Jo uoi	Message	Su su	Sudden braking information	

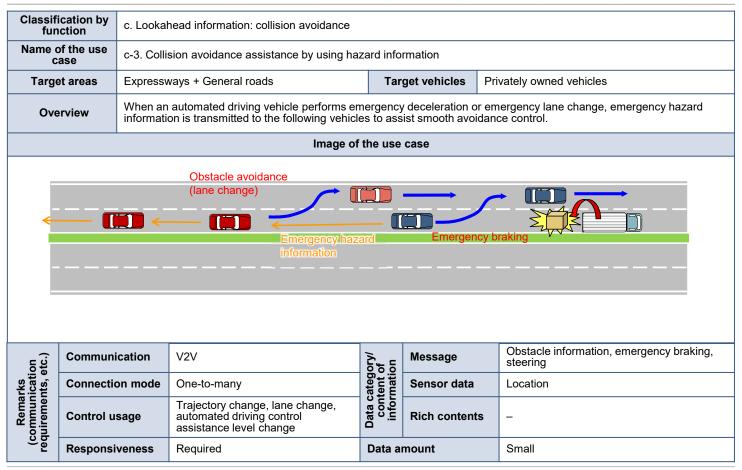
### c-2-1. Driving assistance based on intersection information (V2V)



### c-2-2. Driving assistance based on intersection information (V2I)

Classifi fun	cation by c. Le	c. Lookahead information: collision avoidance							
	of the use c-2-	c-2-2. Driving assistance based on intersection information (V2I)							
Targe	t areas Ger	ral roads	Targe	t vehicles	Privately of	owned vehicles			
Ove	rview vehi	Location and speed information of vehicles that approach intersections, which is obtained from roadside sensors or vehicles, is provided by the infrastructure to other vehicles that approach or pass through intersections to assist them to pass through or make a right turn at intersections with many blind spots.							
		Image o	f the use ca	ıse					
				Locatic	on and information	astructure and spot			
_	Communication	V2I	o o €	Message		_			
ion ts,		1. 0 1	Data tegor rent	Sensor data		Location, speed			
arks nication ments,	Connection m	de One-to-many							
Remarks (communication requirements, etc.)	Control usage	Judgment whether the vehicle can start, speed adjustment, stop	Data category/ content of information	Rich conte	ents	-			

### c-3. Collision avoidance assistance by using hazard information

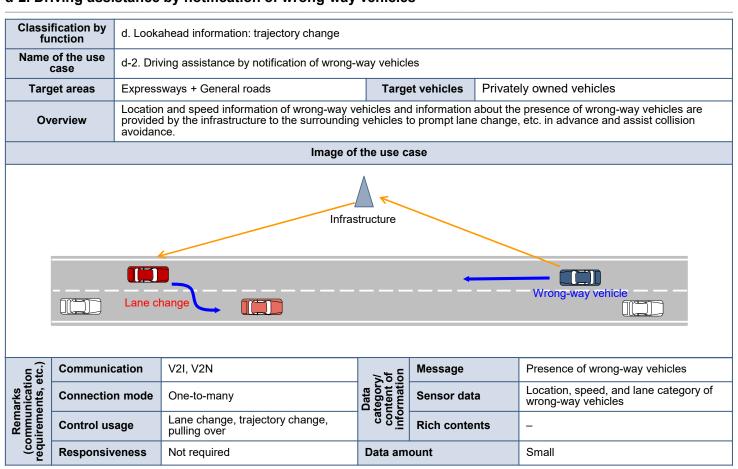


### d. Lookahead information: trajectory change

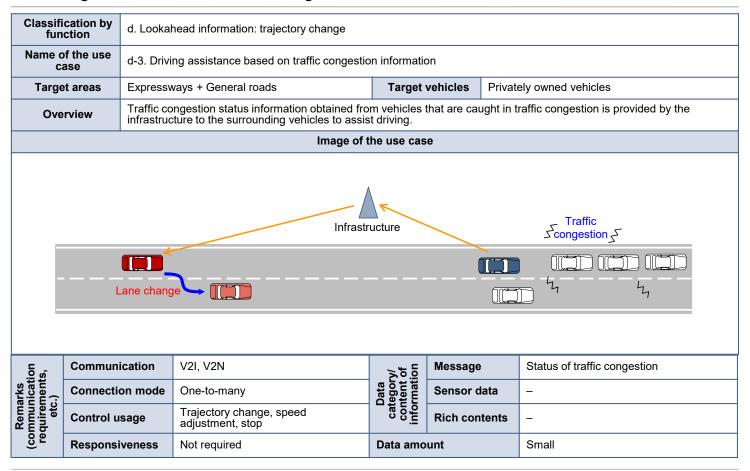
### d-1. Driving assistance by notification of abnormal vehicles

Classifica funct	ation by tion	d. Lookahead information: trajectory change								
Name of cas		d-1. Driving assistance by notification of abnormal vehicles								
Target	areas	Expresswa	ys + General roads	Privately	owned vehicles					
Overv	Overview  Event information of abnormal vehicles that are stopped on roads (e.g., malfunctioning vehicles, vehicles in accidents) and location information (sections and lanes where such vehicles are located) are provided by the infrastructure to the surrounding vehicles or by abnormal vehicles to the surrounding vehicles to assist lane change and trajectory change at an early stage.									
			Image of	the use ca	se					
			Lane char	frastructure		Abnormal	vehicle			
				(m	nalfunctionin		vehicle in an accident)			
Remarks (communication requirements, etc.)	Communi	ication	V2I, V2N	t of tion	Message		Event information of abnormal vehicles			
marks nunica iremen etc.)	Connection	on mode	One-to-many	Data category/ content of information	Sensor da	ata	Location			
Ren mmu quire	Control u	sage	Lane change, trajectory change	2 8 3 <u>F</u>	Rich cont	ents	-			
(So o	Responsi	veness	Not required	Data amo	unt		Small			

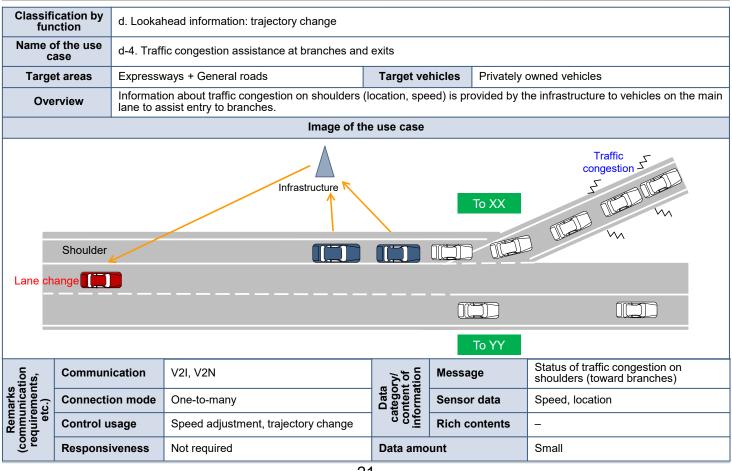
### d-2. Driving assistance by notification of wrong-way vehicles



### d-3. Driving assistance based on traffic congestion information



### d-4. Traffic congestion assistance at branches and exits



### d-5. Driving assistance based on hazard information

Classifica funct	d. Lookahead information: trajectory change									
	d-5. Driving assistance based on hazard information									
Target a	areas Expre	Expressways + General roads Target vehicles Privately owned vehicles								
Overv	Information about obstacles, construction work, traffic congestion, etc. is provided by the infrastructure to the surrounding vehicles to assist driving.									
	Image of the use case									
		Emergency hazard information Infrastr Obstacle avoidance (lane chan	<b>→</b> [							
رن (ز:	Communicatio	V2I, V2N	ار م <sup>و</sup> در	Message	Obstacle information					
ks catic its, e	Connection mo	de One-to-many	atego ent o natio	Sensor da	ta Location					
Remarks (communication requirements, etc.)	Control usage	Trajectory change, lane change, automated driving control assistance level change	Data category/ content of information	Rich conto	ents –					
R E 를		assistance level change								

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## e. Lookahead information: emergency vehicle notification e-1. Driving assistance based on emergency vehicle information

	ification by inction	e. Lookahead information: emergency vehicle notification								
	of the use case	e-1. Dri	ving assistance based on emergency ve	hicle inforn	nation					
Tarç	get areas	Expres	sways + General roads	Targe	et vehicles	Private	ely owned vehicles			
Ov	Overview Information about the driving direction, speed, and planned driving route (planned driving lane) of emergency vehicles in provided by the emergency vehicles to the surrounding vehicles to prompt the surrounding vehicles to drive at reduced speed or to stop, etc. and thereby assist the emergency vehicles to pass smoothly.									
	•		Image of	the use c	ase					
		Drivi	Emergency vehicle (e.g., ambulance)  **The state of the s		Lane char	Infrastru	ucture			
tion etc.)	Communica	ition	V2V, V2I, V2N	ry/ ∶of tion	Message		Information about approaching emergency vehicles			
arks nicat ents,	Connection	mode	One-to-many	Data category/ content of information	Sensor dat	а	Location, speed			
Remarks (communication requirements, etc.)	Control usa	ge	Speed adjustment, lane change, stop (shoulder)	ca cor info	Rich conte	nts	-			
c (cc	Responsive	ness	Not required	Data am	ount		Small			

## Intentionally blank

## (2) Use cases in which information of one's own vehicle must be provided f. Information collection/distribution by infrastructure

### f-1. Request for rescue (e-Call)

Classific func	ation by	f. Information collection/distribution by infrastructure							
Name of cas		f-1. Reque	st for rescue (e-Call)						
Target	areas	Expresswa	ys + General roads	Target	vehicles	Privately of	owned vehicles		
Over		Rescue inf rescue.	ormation is transmitted from abnorma	l vehicles (e	.g., vehicles	in accider	nts) to the infrastructure to request		
Image of the use case									
				Infras	structure				
				· £					
					Vehicle in an	accident			
tion ts,	Communi	ication	V2N	ry/ iof iion	Message		Request for rescue		
Remarks (communication requirements, etc.)	Connection	on mode	One-to-one	Data category/ content of information	Sensor d	ata	Location		
Rem mmu quire	Control us	sage	Notification	ca info	Rich con	tents	-		
CO re	Responsi	veness	_	Data amou	unt		Small		

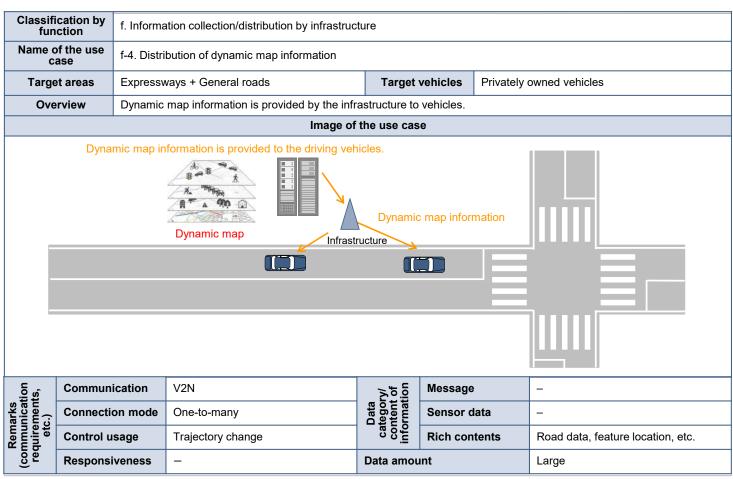
### f-2. Collection of information to optimize the traffic flow

Classificati functio	<b>on by</b> <b>n</b> f. Inform	f. Information collection/distribution by infrastructure							
Name of the case	e use f-2. Coll	ection of information to optimize the traff	ic flow						
Target ar	eas Express	ways + General roads	Target	vehicles	Privately o	wned vehicles			
Overvie		Information about the location and speed of driving vehicles is collected via the infrastructure to analyze and optimize the traffic flow.							
		Image of	the use ca	se					
The traffic flow is analyzed and optimized by using the probe information and traffic information of the driving vehicles obtained by roadside devices.									
			Intras	tructure					
u (s	ommunication	V2I, V2N		Message		_			
ments,	ommunication onnection mode	, , , , , , , , , , , , , , , , , , ,			ıta	- Location, speed			
unicatic ements tc.)		, , , , , , , , , , , , , , , , , , ,	Data category/ content of information	Message					

### f-3. Update and automatic generation of maps

Classifi fun	cation by ction	f. Informa	tion collection/distribution by infrastruc	ture						
	of the use ase	f-3. Update and automatic generation of maps								
Targe	et areas	Expressw	/ays + General roads	Target	vehicles	Privately or	wned vehicles			
Ove	Vehicles' information is collected by the infrastructure to update and automatically generate the map data.									
	Image of the use case									
const updat	nap data (e.g ructed roads ted and autor rated by usin nation from thes.	) is matically	Map update	nev	ormation abo	ted I	Newly constructed roads, features			
ion S,	Communic	cation	V2N	o of	Message		-			
arks nicati ment	Connectio	n mode	One-to-one	Data category/ content of information	Sensor da	ta	Location			
Remarks (communication requirements, etc.)	Control us	sage	_	cat con info	Rich conto	ents	Image captured by on-board cameras			
oo) Pe	Responsiv	/eness	-	Data amo	unt		Large			

### f-4. Distribution of dynamic map information



### (3) Use cases in which V2V and V2I interaction must be ensured

### a. Merging/lane change assistance

### a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control

Classifi fun	Classification by function a. Merging/lane change assistance										
	ame of the use case a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control										
Targe	et areas Exp	essways + General roads	-	Target vehicles	Privately owned vehicles						
Ove	Overview  Measurement information (e.g., location, speed) of vehicles driving on certain range of main lane is provided by the infrastructure to merging vehicles. Meanwhile, instructions (e.g., adjustment of the gap between vehicles) are given by the infrastructure to vehicles on the main lane to assist merging.										
		lma	age of the ι	ise case							
on the roadsid Merging	The driving status of vehicles that are driving on the main lane is continuously provided.  Speed adjustment Infrastructure on the main lane is continuously monitored by roadside sensor.  Merging assistance instructions are also given by the infrastructure to vehicles on the main lane.  Requests to maintain/ increase the gap or requests for lane change										
				e I							
tion etc.)	Communicatio	or requests for	lane chang	e Message	Time to arrive at a merging section (vehicles on the main lane), requests for gap adjustment						
narks inication ents, etc.)	Communicatio	or requests for V2I	lane chang		Time to arrive at a merging section (vehicles on the main lane), requests for gap adjustment  Speed, location						
Remarks (communication requirements, etc.)		or requests for V2I	lane chang	Message	the main lane), requests for gap adjustment						

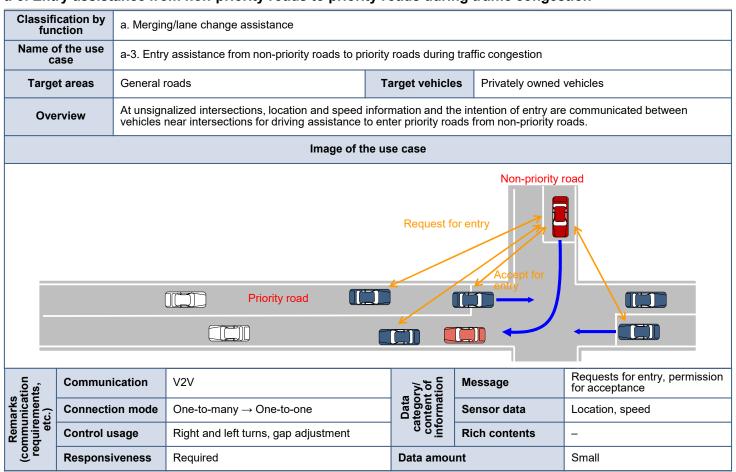
### a-1-4. Merging assistance based on negotiations between vehicles

Classificat function	tion by on a. Mer	a. Merging/lane change assistance							
Name of the	a-1-4	a-1-4. Merging assistance based on negotiations between vehicles							
Target a	reas Expres	sways + General roads	Target vehicle	es Privately own	ned vehicles				
Overvi	iew locatio	During merging to a main lane with heavy traffic, vehicles on the main lane communicate with merging vehicles (e.g., location and speed information, gap adjustment requests) to conduct negotiations between vehicles for merging assistance.							
		Image of t	ne use case						
		Negotiations be	ween vehicles						
į		Negotiations be							
ation nts,	Communication	Negotiations be		Message	Requests for gap adjustment, permission for acceptance				
minimum minimu	Communication	V2V		Message Sensor data	Requests for gap adjustment, permission for acceptance  Speed, location				
nunicatio rements stc.)		V2V	V/v noi		permission for acceptance				

### a-2. Lane change assistance when the traffic is heavy

Classifi fun	cation by ction	a. Merging/lane change assistance								
	of the use ase	a-2. Lane	change assistance when the traffic is he	avy						
Targe	et areas	Expressw	ays + General roads	Target veh	icles	Privately owned	vehicles			
Ove	Overview  During lane change to a lane with heavy traffic, the location and speed information and the intention of lane change, etc. are communicated between vehicles for lane change assistance.									
			Image of th	e use case						
			Lane change							
							Degreets for our adjustment			
s ation nts,	Communic	cation	V2V	a ory/ it of	Messa	age	Requests for gap adjustment, permission for acceptance			
narks unication ements, tc.)	Connectio		V2V One-to-many → One-to-one	Data ategory/ ontent of ormation		age or data	Requests for gap adjustment, permission for acceptance  Speed, location			
Remarks (communication requirements, etc.)		n mode		Data category/ content of information	Senso					

### a-3. Entry assistance from non-priority roads to priority roads during traffic congestion

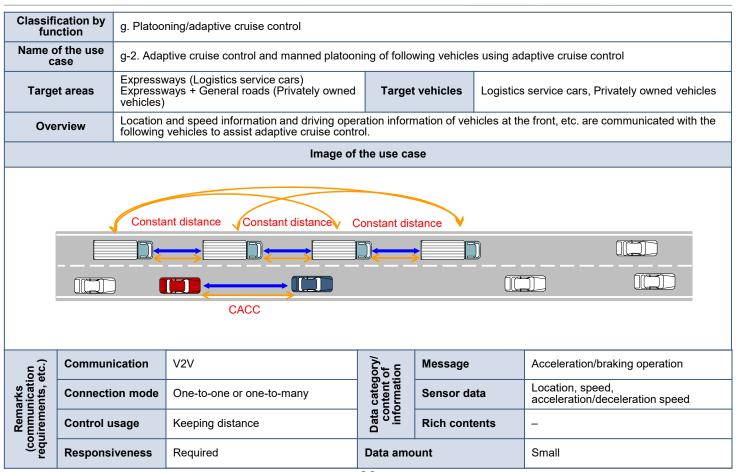


### g. Platooning/adaptive cruise control

### g-1. Unmanned platooning of following vehicles by electronic towbar

Classific fund	cation by ction	g. Platooning/adaptive cruise control								
	of the use ase	g-1. Unmanned platooning of following vehicles by electronic towbar								
Targe	et areas	Expressw	ays ays	Target	vehicles	Logistics	s service cars			
Ove	Overview Operation information, etc. of platooning vehicles is communicated between trucks that form a platoon to assist platooning (electronic towbar).									
	·		Image of	the use ca	se					
			Constant distance	Constant dis	stance					
ion etc.)	Communic	cation	V2V	Jory/ of ion	Message		Acceleration, braking, steering operation, information about following vehicles			
narks inicati ents,	Connectio	n mode	One-to-many	Data category/ content of information	Sensor da	ta	Location, speed, gap, acceleration/deceleration speed			
Remarks (communication requirements, etc.)	Control us	age	Keeping distance, platoon maintenance	Data co infe	Rich conto	ents	Transmission of image from the second truck to the first truck by using an electronic mirror			
_	Responsiv	eness	Required	Data amo	unt		Large			

### g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control



## h. Teleoperation h-1. Operation and management of mobility service cars

Classifi fun	ication by	h. Teleoperation						
	of the use ase	h-1. Operation and management of mobility service cars						
Targe	et areas Expressways + General roads Target vehicles Mobility service cars							
Ove	In a traffic environment that is difficult for an autonomous driving system, an operation manager in a remote location communicates a remote control instruction to the mobile service car based on video information from the mobile service car.							
			Image of	the use ca	se			
			Infrastructure	of image in		•• <b>•</b> •••••••••••••••••••••••••••••••••		
ion Is,	Communic	ation	V2N	o o €	Message		Teleoperation instructions	
arks nicat men	Connectio	n mode	One-to-one	Data category/ content of information	Sensor da	ta	Location, speed	
Remarks (communication requirements, etc.)	Control us	age	Teleoperation	cat cor info	Rich conte	ents	Image captured by on-board cameras	
(co	Responsiv	eness	Required	Data amo	ount		Large	

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### 5.2 Use cases that were dropped

Use cases that do not meet the preconditions for examining the cooperative driving automation in 4.2 1) and those that were integrated with other use cases were dropped from the SIP Use Cases. However, we decided to retain these use cases as a record of our study and as a reference when needed to review the SIP Use Cases due to changes in the system definition of the cooperative driving automation in the future, etc.

### 1) Overview of use cases that were dropped

Name of the use case	Overview
x-1. Driving assistance based on traffic	Current traffic signal color information, etc. transmitted by a
signal information before a tunnel	traffic signal before a tunnel is provided by the infrastructure
	to vehicles to assist deceleration and stopping.
x-2. Collision avoidance assistance when	Sudden braking information and location and speed
a vehicle ahead (suddenly) stops or	information are provided by a vehicle that suddenly
decelerates	decelerates to the following vehicles to assist collision
	avoidance by stopping or deceleration.
x-3. Collision avoidance assistance when	Location and speed information is provided by a vehicle that
a vehicle ahead changes lanes	will change lanes to enter the same lane to vehicles on either
	side to assist collision avoidance.
x-4. Lane change assistance	Location and speed information transmitted by the
	surrounding vehicles is communicated between vehicles to
	assist lane change.
x-5. Provision of blind spot information	The road situation ahead captured by a camera is provided
ahead (see-through)	by a vehicle that recorded the image to the following vehicles
	to assist collision avoidance.
x-6. Driving assistance based on	Speed limit information (including variable information) is
lookahead information (notification of	provided by the infrastructure to the surrounding vehicles to
speed limit)	assist driving.
x-7. Collision avoidance assistance at	Location and speed information is exchanged between
intersections	vehicles that approach intersections to assist collision
	avoidance.
x-8. Assistance of entry from non-priority	At unsignalized intersections, location and speed information
roads to priority roads at unsignalized	is provided by vehicles on the priority roads to vehicles on
intersections	the non-priority roads to assist driving to enter the priority
	roads.

Name of the use case	Overview
x-9. Warning when a bus starts	Location and speed information and the intention of lane
	change are provided by vehicles that are going to make a left
	turn ahead of a bus that has stopped, to assist the bus to
	start safely.
x-10. Driving assistance at an alternating	In a section that switches from two-way traffic to alternating
traffic section	traffic or in a waiting section for alternating traffic, the location
	and speed information is communicated between vehicles of
	both directions to assist driving, such as passing through the
	alternating traffic section or waiting until oncoming vehicles
	pass.
x-11. Driving assistance based on	Location and speed information is provided by pedestrians
pedestrian information	and bicycles to vehicles to assist driving and stopping of
	vehicles, etc.
x-12. Driving assistance based on	Location and speed information is provided by streetcars to
streetcar information	the surrounding vehicles to assist driving of the surrounding
	vehicles.
x-13. Driving assistance based on traffic	Traffic congestion status information is provided by vehicles
congestion information (V2V)	caught in traffic congestion to the following vehicles to assist
	the trajectory change.
x-14. Traffic congestion assistance at	Location and speed information and information about traffic
branches and exits (V2V)	congestion on shoulders are provided by vehicles caught in
	traffic congestion to the following vehicles on the main lane
	to assist entry to branches.

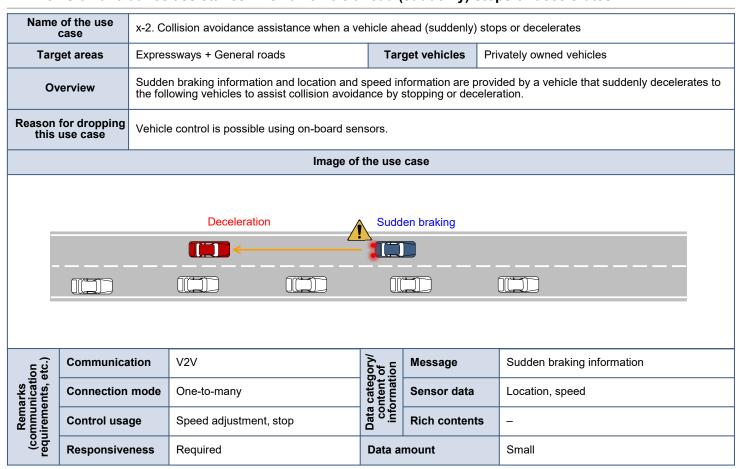
### 2) Use case diagrams

The use case diagrams are shown in the following pages.

### x-1. Driving assistance based on traffic signal information before a tunnel

Nam	e of the use case	x-1. Driving assistance based on traffic signal information before a tunnel							
Tai	Target areas   Expressways     Target vehicles   Privately owned vehicles								
С	Overview	nal before a tunnel is provided by the infrastructure							
Reasor this	Reason for dropping this use case is similar to driving assistance by using traffic signal information on general roads. Thus, it was integrated into b-1-1.								
	Image of the use case								
an ex transi	rations signal to the transition of the surritopping.	pefore a tunnel is red on the main lane of affic signal display information is ounding vehicles to assist deceleration  Traffic signal color Infras  Stop  Deceleration	tructure						
on etc.)	Communication	on V2I	of of ion	Message	Traffic signal color				
Remarks (communication equirements, etc.)	Connection m	ode One-to-many	Data category/ content of information	Sensor data	-				
Rem ommu uireme	Control usage	Speed adjustment, stop	Data cor info	Rich conten	es –				
(co	Responsivene	Required	Data a	mount	Small				

### x-2. Collision avoidance assistance when a vehicle ahead (suddenly) stops or decelerates



### x-3. Collision avoidance assistance when a vehicle ahead changes lanes

Nam	ame of the use case x-3. Collision avoidance assistance when a vehicle ahead changes lanes								
Та	rget areas	Expressways + General roads	Tai	get vehicles	rivately owned vehicles				
(	Overview  Location and speed information is provided by a vehicle that will change lanes to enter the same lane to vehicles either side to assist collision avoidance.								
Reaso thi	Reason for dropping this use case  Vehicle control is possible using on-board sensors.								
	Image of the use case								
	[	Deceleration Lane char	ige						
-		Start of lane	<b>→</b> []						
	change operation								
on etc.)	Communication	on V2V	of of ion	Message	-				
arks nicati ents, e	Connection m	ode One-to-many	Data category/ content of information	Sensor data	Location, speed				
Remarks (communication requirements, etc.)	Control usage	Speed adjustment, stop	Data co infc	Rich content	<b>5</b> –				
co) redu	Responsivene	ss Required	Data a	mount	Small				

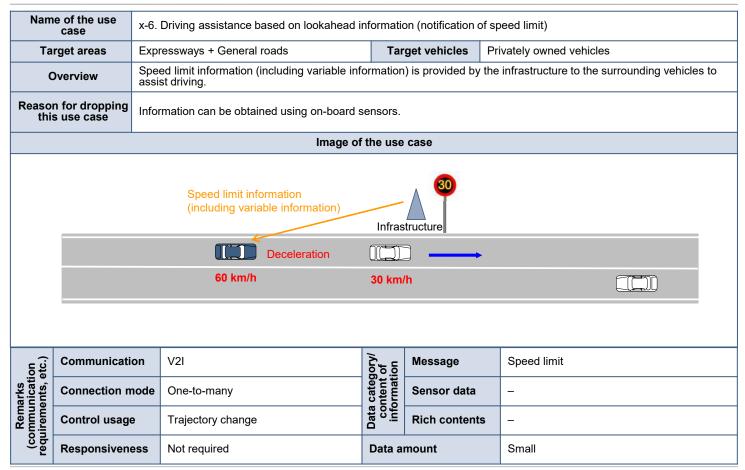
### x-4. Lane change assistance

Name (	of the use case	x-4. Lane change assistance					
Та	arget areas	Expressways + General roads Target vehicles Privately owned vehicles					
(	Overview	Location and speed information transmitted by the surrounding vehicles is communicated between vehicles to assist lane change.					
Reaso thi	this use case  Vehicle control is possible using on-board sensors.						
		Image of t	the use case				
		Lane keep (					
ion etc.)	Communication		Messa	age			
arks nication ents, etc.)	Communication Connection mo		ontent of Messa Senso	age or data	- Speed, location		
Remarks (communication requirements, etc.)			ro catego formatio		Speed, location		

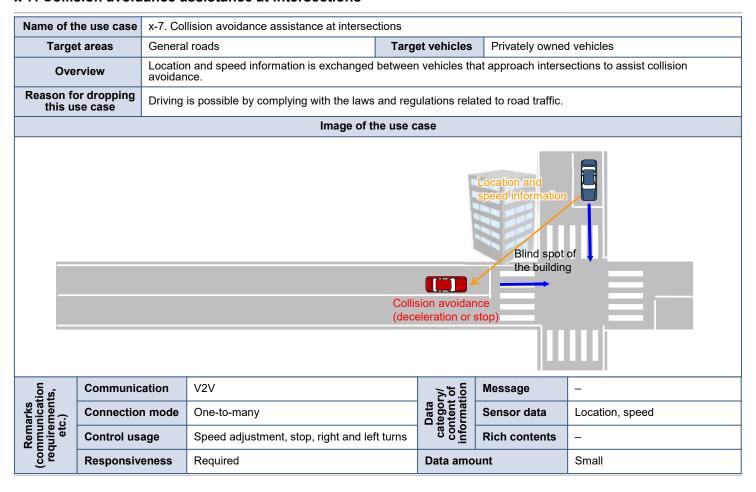
### x-5. Provision of blind spot information ahead (see-through)

Name	of the use case x-5. Provision of blind spot information ahead (see-through)							
Та	arget areas	Expressways + General roads	Tarç	get vehicles	Privately owned vehicles			
	Overview	The road situation ahead captured by a camera is provided by a vehicle that recorded the image to the following vehicles to assist collision avoidance.						
	this use case  Collision avoidance is possible if the movement of vehicles ahead is detected using on-board sensors.							
		Image of	the use	case				
	following vehicle) is shared with a following vehicle.  Traffic  Congestion  Deceleration							
	I							
ion etc.)	Communication	V2V	gory/ of ion	Message	Status of traffic congestion			
iarks inication ents, etc.)	Communication		category/ intent of ormation	Message Sensor data	Status of traffic congestion			
Remarks (communication equirements, etc.)			Data category/ content of information		_			

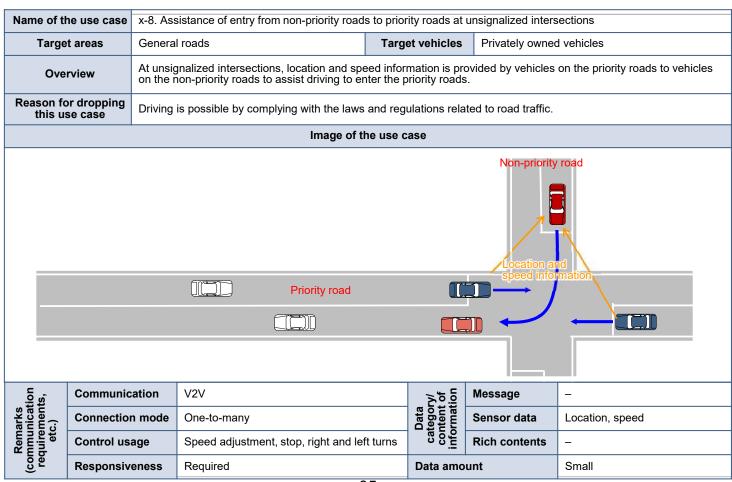
### x-6. Driving assistance based on lookahead information (notification of speed limit)



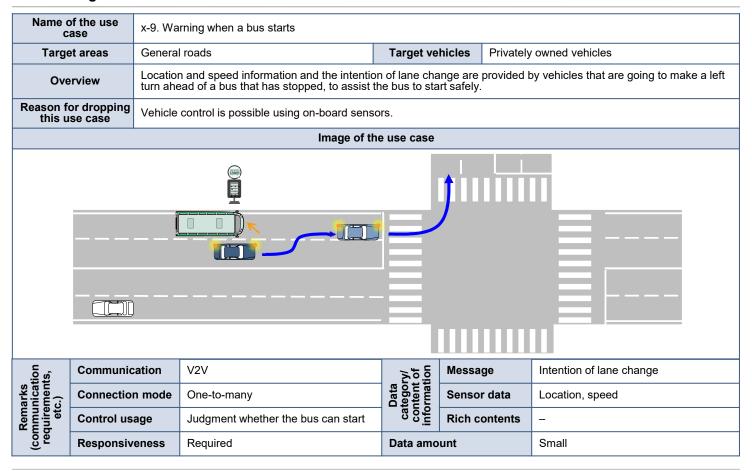
### x-7. Collision avoidance assistance at intersections



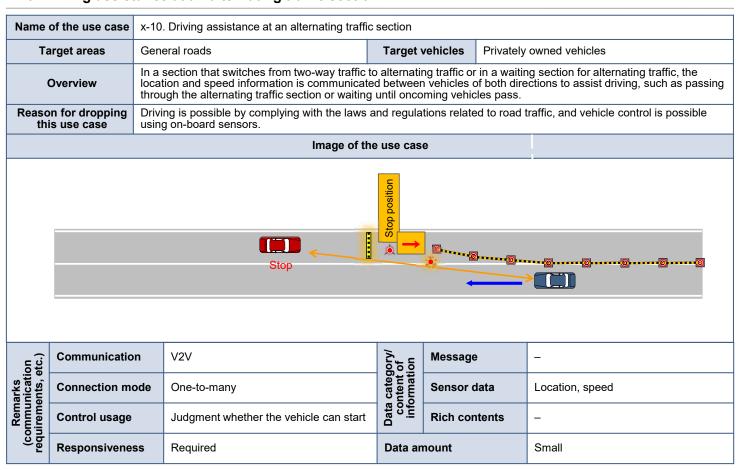
### x-8. Assistance of entry from non-priority roads to priority roads at unsignalized intersections



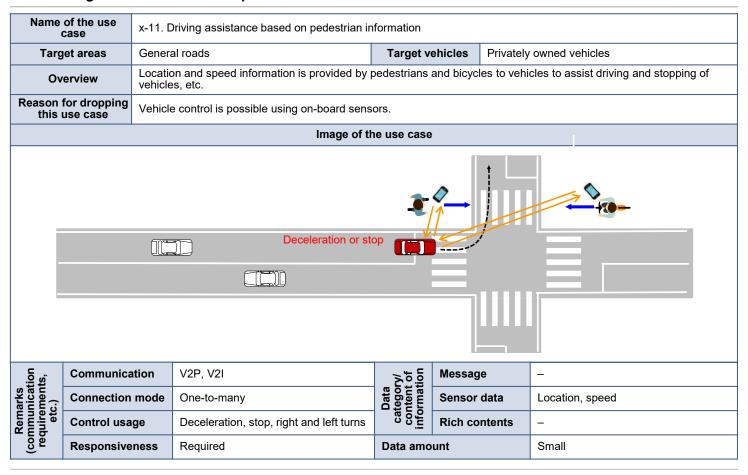
### x-9. Warning when a bus starts



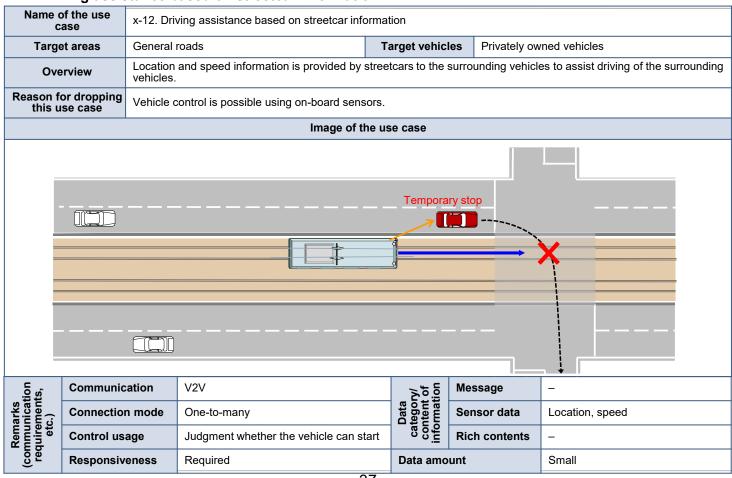
### x-10. Driving assistance at an alternating traffic section



### x-11. Driving assistance based on pedestrian information



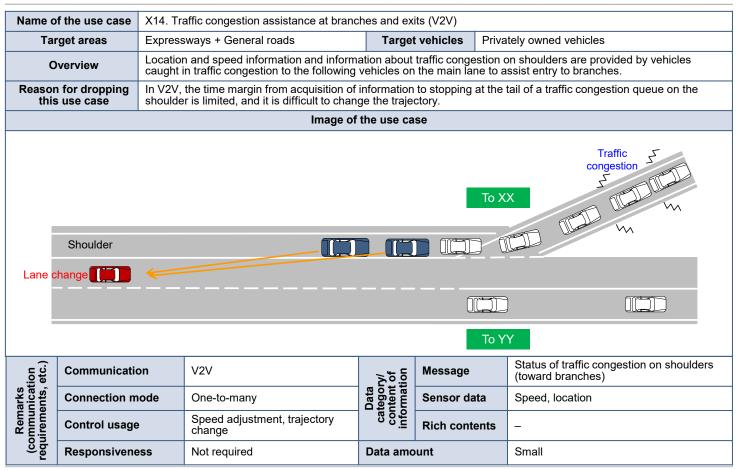
### x-12. Driving assistance based on streetcar information



### x-13. Driving assistance based on traffic congestion information (V2V)

Name of the use case X13. Driving assistance based on traffic congestion information (V2V)							
Tar	get areas	Expressways + General roads	Target	vehicles	Privatel	y owned vehicles	
O	Overview Traffic congestion status information is provided by vehicles caught in traffic congestion to the follo assist the trajectory change.						
	The time margin for avoidance is limited due to short range when information is provided from the tail of a traffic congestion. Thus, this use case was dropped from those of trajectory change. (It may be regarded as a use case of collision avoidance will be enabled by the functionality of autonomous driving. Thus, it was also dropped as a use case of collision avoidance.)						
		Image of	the use ca	se			
						Traffic  Scongestion	
		<u> </u>					
		Lane change				4 4	
		Larie Glange -				7	
ion s,	Communication	on V2V	y/ of	Message		Status of traffic congestion	
arks nication ments, :.)	Communication m	1 - 1	Data egory/ itent of rmation	Message Sensor da	ta	Status of traffic congestion	
(communication requirements, etc.)		ode One-to-many  Trajectory change speed	Data category/ content of information				

### x-14. Traffic congestion assistance at branches and exits (V2V)



### 6. Conclusion

The SIP Use Cases were compiled to study communication protocols under SIP. They were selected from use cases studied in projects, etc. for the cooperative automated driving system and advanced driver assistance system in and outside Japan as of 2020. They are not intended to rule out use cases that improve the marketability of the cooperative driving automation or that are derived from new business ideas. We hope that they will be used as the basis for examining the cooperative driving automation in the future.

Finally, we sincerely thank Mitsubishi Research Institute, Inc., which provided the investigation report of FY2018<sup>(1)</sup> and prepared the draft SIP use cases for cooperative driving automation, and JAMA, which provided its use cases, in compiling the SIP Use Cases.

### 7. References

 Study of utilization of new communication technologies including V2X technology for automated driving system

(February 28, 2019)

https://www.sip-adus.go.jp/rd/rddata/rd02/204 s.pdf (in Japanese)