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

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 driving system	A system developed from the autonomous driving system to 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 and deceleration	To attain the target speed by acceleration or deceleration in advance for smooth driving (control) by the autonomous driving system.
Provision of traffic signal information	To provide information about present signal color and signal phase and timing, etc. when vehicles pass signalized intersections so that they can pass through such intersections smoothly.
Lookahead information: collision avoidance	To avoid collision by obtaining information about obstacles ahead of an automated driving vehicle.
Lookahead information: trajectory change	To change the initial trajectory by obtaining information about obstacles ahead of an automated driving vehicle.
Lookahead information: emergency vehicle notification	To avoid obstruction of emergency vehicles by obtaining information about approaching emergency vehicles.
Information collection by infrastructure	The infrastructure collects the location information and feature 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 control	A system for platooning by multiple trucks and an adaptive 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	Communication between vehicles.
V2I: vehicle-to-infrastructure communication	Communication between vehicles and roadside infrastructure.
V2P: vehicle-to-pedestrian communication	Communication between vehicles and pedestrians.
V2N: vehicle-to-network communication	Communication between vehicles and the cloud network.
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 smoother automated driving control[*1] based on the autonomous driving system by obtaining information outside the detection range of on-board sensors,[*2] providing information of one's own vehicle,[*3] and mutual communication by using V2I and V2V. [*4]

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”[1] 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 by function	Name of the use case	Overview
a. Merging/lane change assistance	a-1-1. Merging assistance by preliminary acceleration and deceleration	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.
	a-1-2. Merging assistance by targeting the gap on the main lane	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.
b. Traffic signal information	b-1-1. Driving assistance by using traffic signal information (V2I)	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.
	b-1-2. Driving assistance by using traffic signal information (V2N)	Traffic signal phase and timing information (the next traffic signal color and the time until change), etc. at intersections is provided through the network to vehicles that enter intersections to assist deceleration and stopping, and thereby avoid a dilemma.
c. Lookahead information: collision avoidance	c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly	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.
	c-2-1. Driving assistance based on intersection information (V2V)	Location and speed information of vehicles that approach intersections is provided by the approaching vehicles to other vehicles that approach or pass through intersections to assist them to pass through or make a right turn at intersections with

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

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

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

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

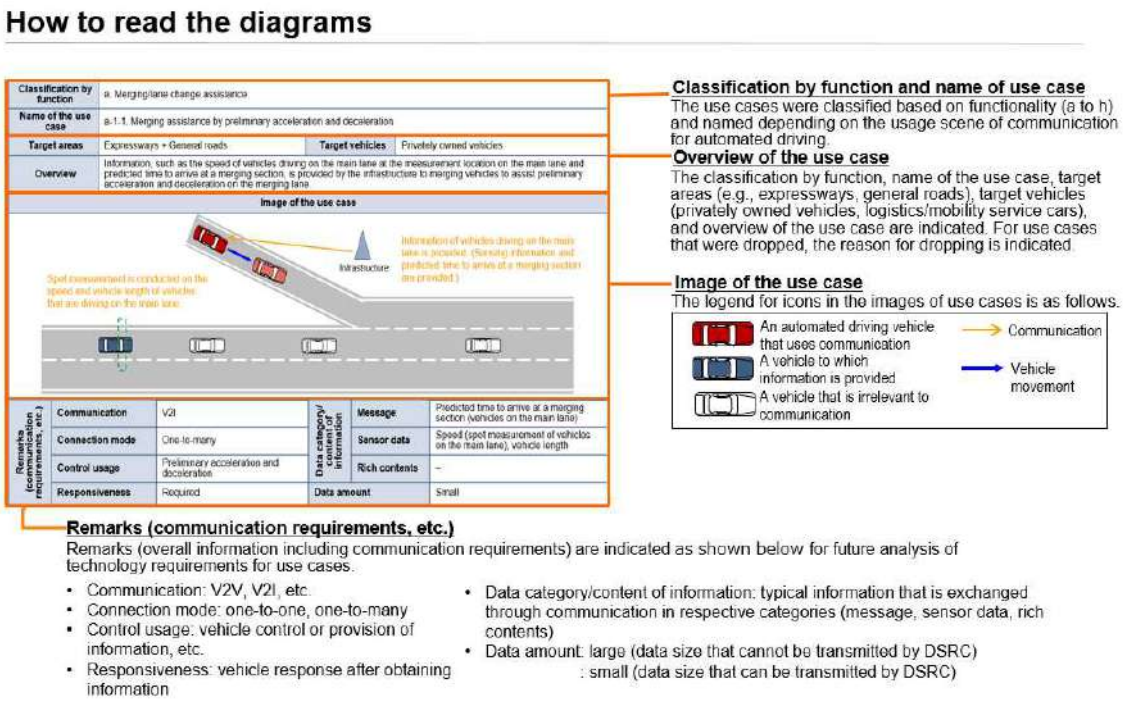
(3) Use cases in which V2V and V2I interaction must be ensured

Classification by function	Name of the use case	Overview
a. Merging/lane change assistance	a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control	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.

Classification by function	Name of the use case	Overview
	a-1-4. Merging assistance based on negotiations between vehicles	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.
	a-2. Lane change assistance when the traffic is heavy	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.
	a-3. Entry assistance from non-priority roads to priority roads during traffic congestion	At unsignalized intersections, location and speed information and the intention of entry are communicated between vehicles near intersections for driving assistance to enter priority roads from non-priority roads.
g. Platooning/ adaptive cruise control	g-1. Unmanned platooning of following vehicles by electronic towbar	Operation information, etc. of platooning vehicles is communicated between trucks that form a platoon to assist platooning (electronic towbar).
	g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control	Location and speed information and driving operation information of vehicles at the front, etc. are communicated with the following vehicles to assist adaptive cruise control.
h. Teleoperation	h-1. Operation and management of mobility service cars	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.

2) Use case diagrams

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



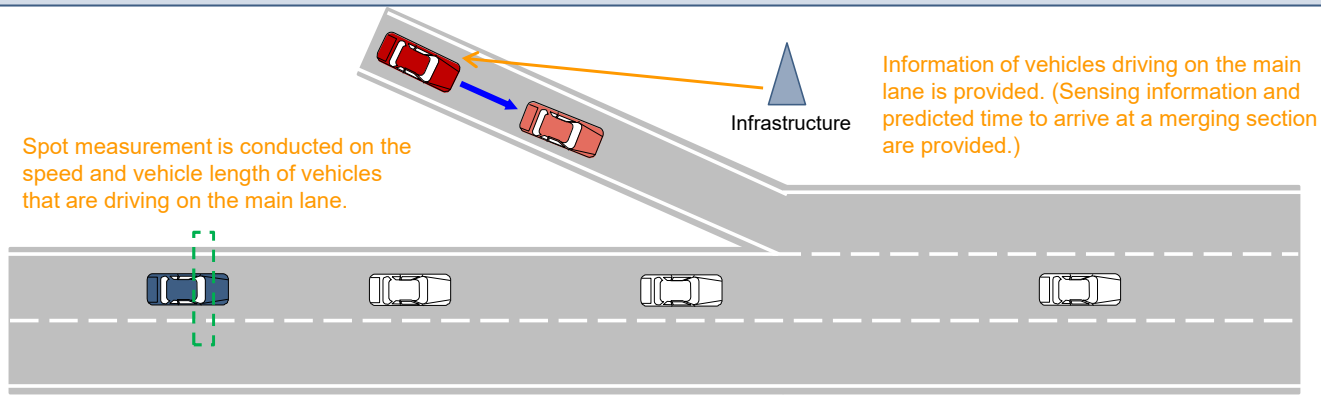
(1) Use cases in which information outside the detection range of on-board sensors must be obtained

a. Merging/lane change assistance

a-1-1. Merging assistance by preliminary acceleration and deceleration

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-1-1. Merging assistance by preliminary acceleration and deceleration		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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 case

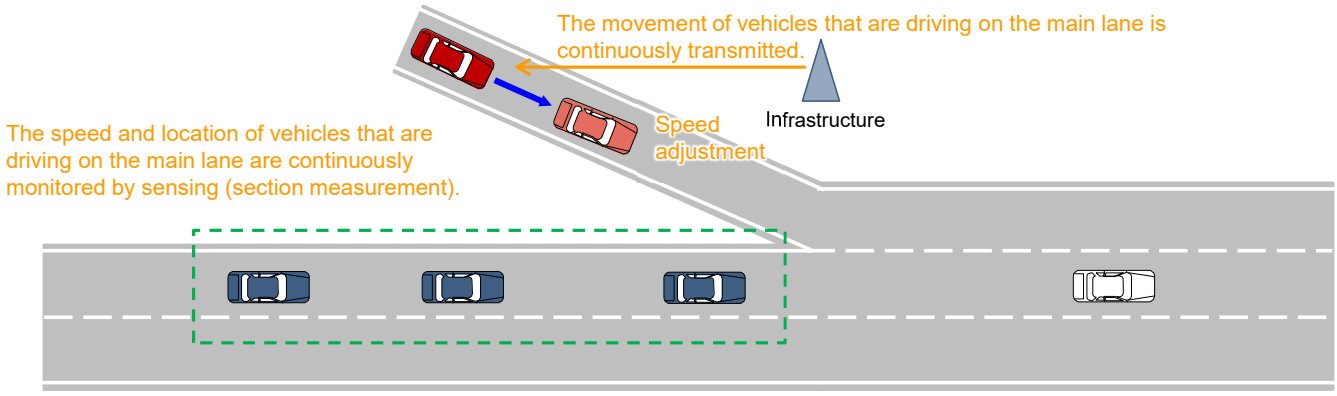


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Predicted time to arrive at a merging section (vehicles on the main lane)
	Connection mode	One-to-many		**Sensor data**	Speed (spot measurement of vehicles on the main lane), vehicle length
	Control usage	Preliminary acceleration and deceleration		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-1-2. Merging assistance by targeting the gap on the main lane		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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 use case



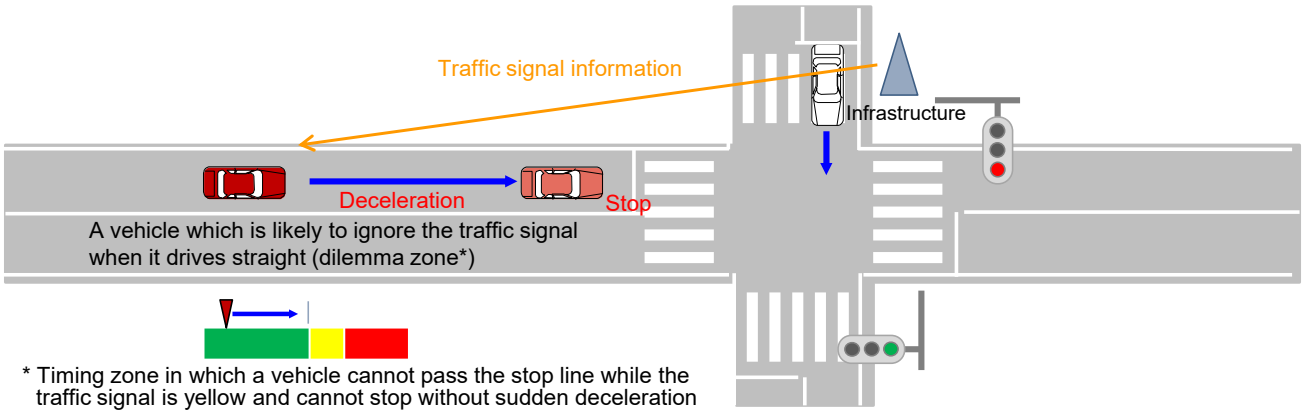
Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Predicted time to arrive at a merging section (vehicles on the main lane)
	Connection mode	One-to-many		**Sensor data**	Speed, location (continuous measurement of vehicles on the main lane), vehicle length
	Control usage	Speed adjustment		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

b. Traffic signal information

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

Classification by function	b. Traffic signal information		
Name of the use case	b-1-1. Driving assistance by using traffic signal information (V2I)		
Target 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 case

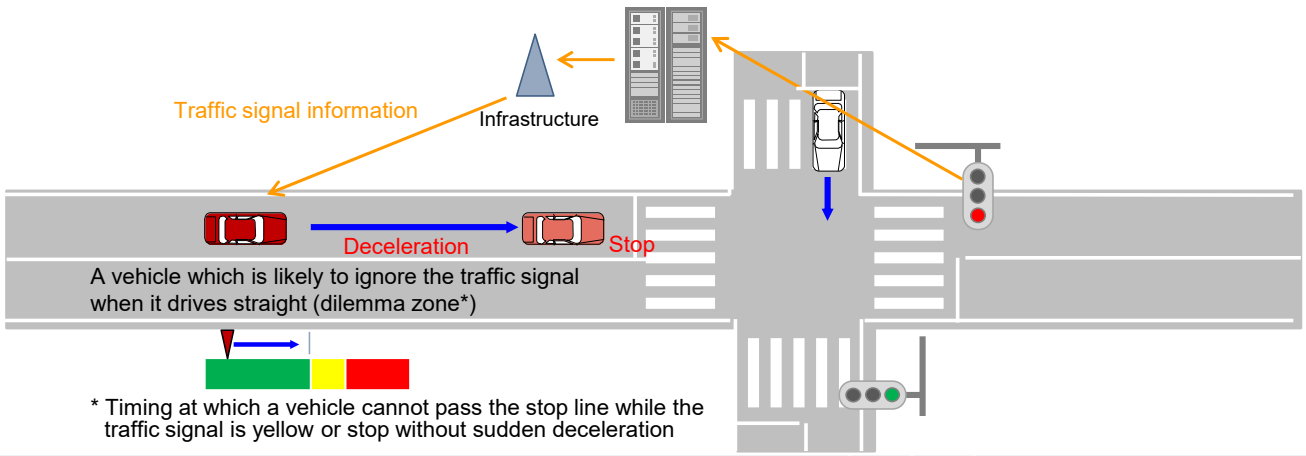


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Current traffic signal color, traffic signal phase and timing information
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	b. Traffic signal information		
Name of the use case	b-1-2. Driving assistance by using traffic signal information (V2N)		
Target areas	General roads + Expressways	**Target vehicles**	Privately owned vehicles
Overview	Traffic signal phase and timing information (the next traffic signal color and the time until change), etc. at intersections is provided through the network to vehicles that enter intersections to assist deceleration and stopping, and thereby avoid a dilemma.		

Image of the use case



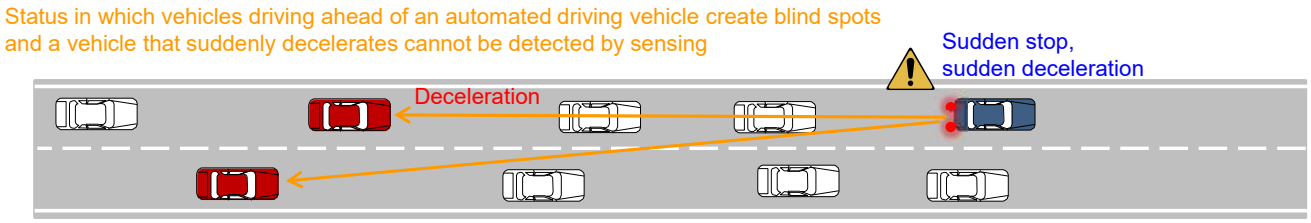
Remarks (communication requirements, etc.)	**Communication**	V2N	**Data category/ content of information**	**Message**	Traffic signal phase and timing information
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

c. Lookahead information: collision avoidance

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

Classification by function	c. Lookahead information: collision avoidance		
Name of the use case	c-1. Collision avoidance assistance when a vehicle ahead stops or decelerates suddenly		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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.		

Image of the use case

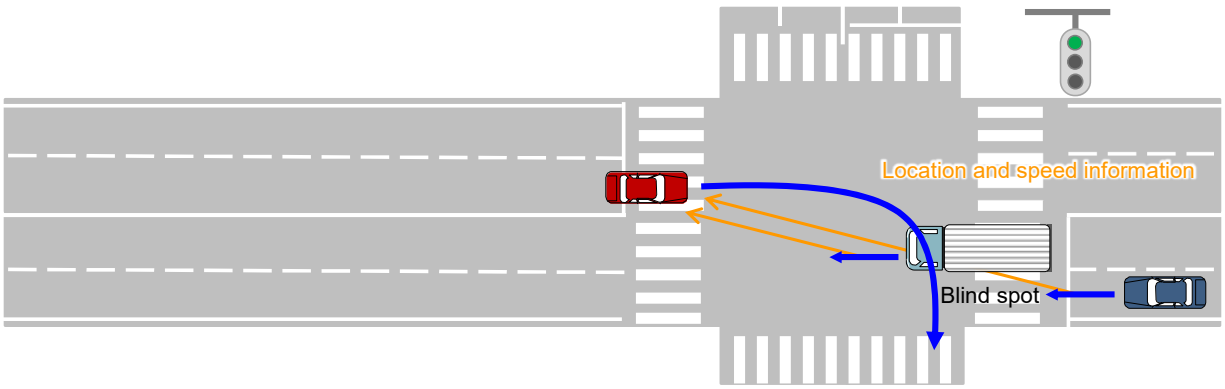


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Sudden braking information
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	c. Lookahead information: collision avoidance		
Name of the use case	c-2-1. Driving assistance based on intersection information (V2V)		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information of vehicles that approach intersections is provided by the approaching vehicles 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 of the use case

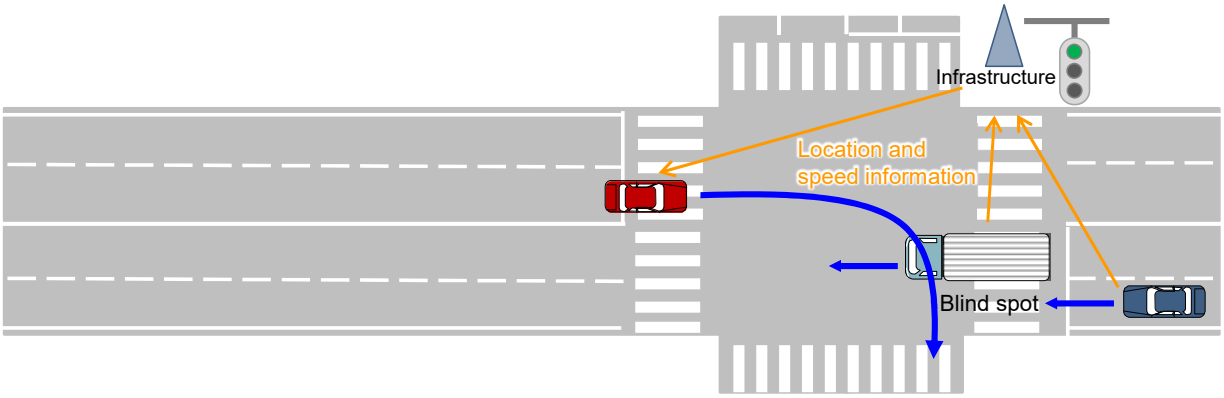


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Judgment whether the vehicle can start, speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	c. Lookahead information: collision avoidance		
Name of the use case	c-2-2. Driving assistance based on intersection information (V2I)		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	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 of the use case

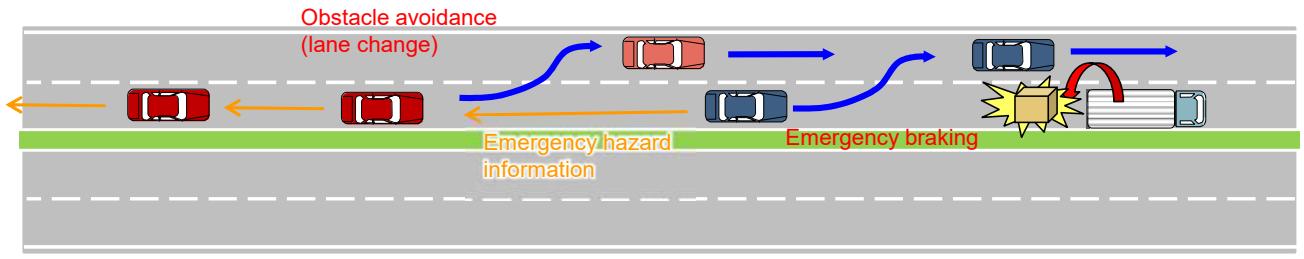


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Judgment whether the vehicle can start, speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

c-3. Collision avoidance assistance by using hazard information

Classification by function	c. Lookahead information: collision avoidance		
Name of the use case	c-3. Collision avoidance assistance by using hazard information		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	When an automated driving vehicle performs emergency deceleration or emergency lane change, emergency hazard information is transmitted to the following vehicles to assist smooth avoidance control.		

Image of the use case



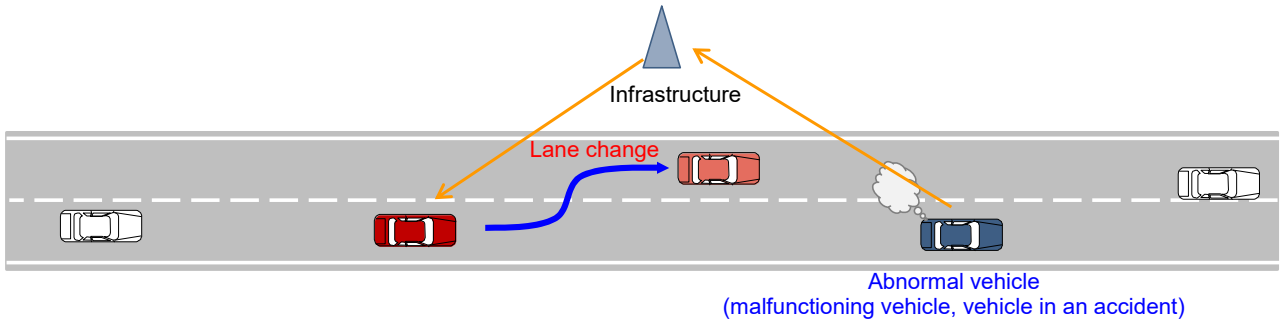
Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Obstacle information, emergency braking, steering
	Connection mode	One-to-many		**Sensor data**	Location
	Control usage	Trajectory change, lane change, automated driving control assistance level change		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

d. Lookahead information: trajectory change

d-1. Driving assistance by notification of abnormal vehicles

Classification by function	d. Lookahead information: trajectory change		
Name of the use case	d-1. Driving assistance by notification of abnormal vehicles		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
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 case

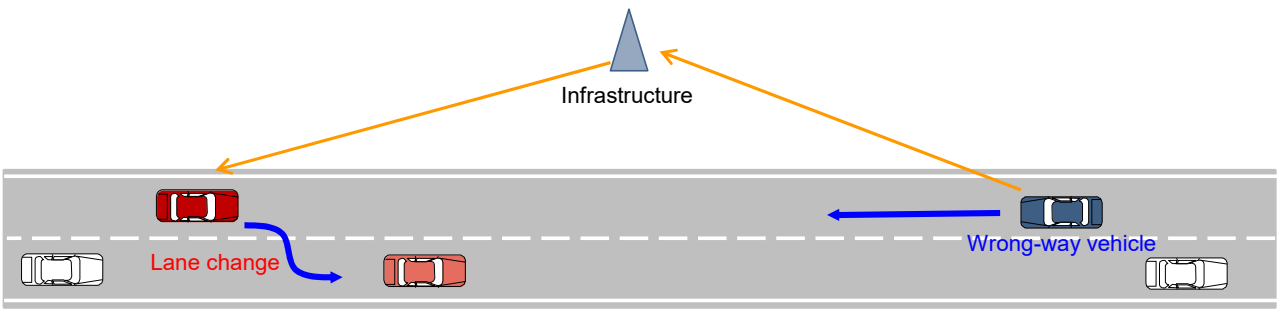


Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	Event information of abnormal vehicles
	Connection mode	One-to-many		**Sensor data**	Location
	Control usage	Lane change, trajectory change		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

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

Classification by function	d. Lookahead information: trajectory change		
Name of the use case	d-2. Driving assistance by notification of wrong-way vehicles		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information of wrong-way vehicles and information about the presence of wrong-way vehicles are provided by the infrastructure to the surrounding vehicles to prompt lane change, etc. in advance and assist collision avoidance.		

Image of the use case

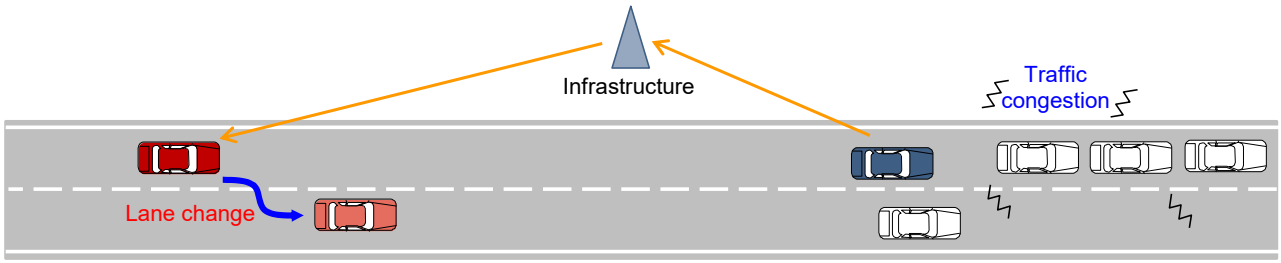


Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	Presence of wrong-way vehicles
	Connection mode	One-to-many		**Sensor data**	Location, speed, and lane category of wrong-way vehicles
	Control usage	Lane change, trajectory change, pulling over		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

d-3. Driving assistance based on traffic congestion information

Classification by function	d. Lookahead information: trajectory change		
Name of the use case	d-3. Driving assistance based on traffic congestion information		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Traffic congestion status information obtained from vehicles that are caught in traffic congestion is provided by the infrastructure to the surrounding vehicles to assist driving.		

Image of the use case

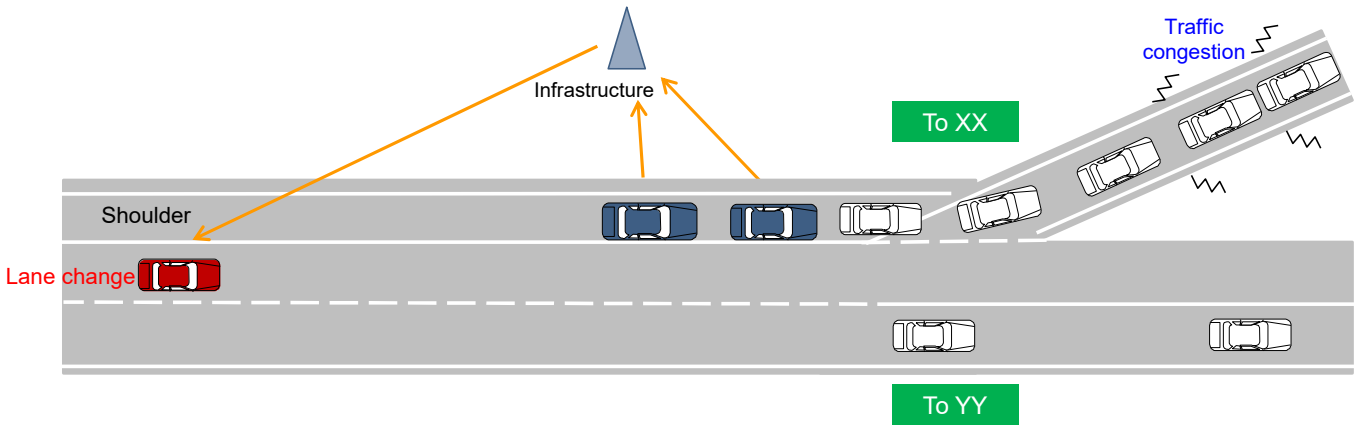


Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	Status of traffic congestion
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Trajectory change, speed adjustment, stop		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

d-4. Traffic congestion assistance at branches and exits

Classification by function	d. Lookahead information: trajectory change		
Name of the use case	d-4. Traffic congestion assistance at branches and exits		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Information about traffic congestion on shoulders (location, speed) is provided by the infrastructure to vehicles on the main lane to assist entry to branches.		

Image of the use case

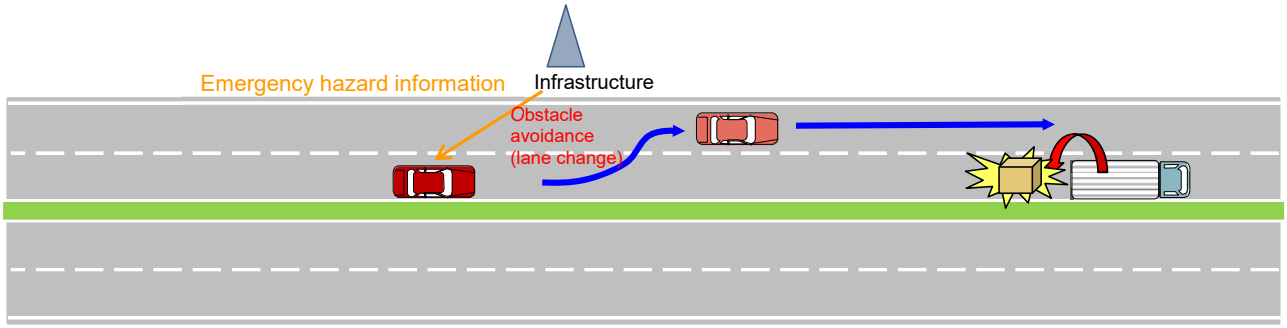


Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	Status of traffic congestion on shoulders (toward branches)
	Connection mode	One-to-many		**Sensor data**	Speed, location
	Control usage	Speed adjustment, trajectory change		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

d-5. Driving assistance based on hazard information

Classification by function	d. Lookahead information: trajectory change		
Name of the use case	d-5. Driving assistance based on hazard information		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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



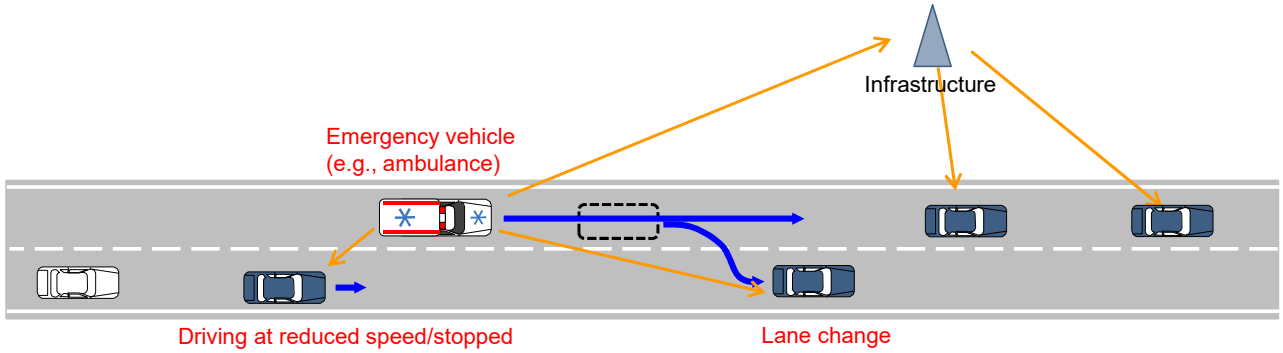
Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	Obstacle information
	Connection mode	One-to-many		**Sensor data**	Location
	Control usage	Trajectory change, lane change, automated driving control assistance level change		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

Intentionally blank

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

Classification by function	e. Lookahead information: emergency vehicle notification		
Name of the use case	e-1. Driving assistance based on emergency vehicle information		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Information about the driving direction, speed, and planned driving route (planned driving lane) of emergency vehicles is 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 case



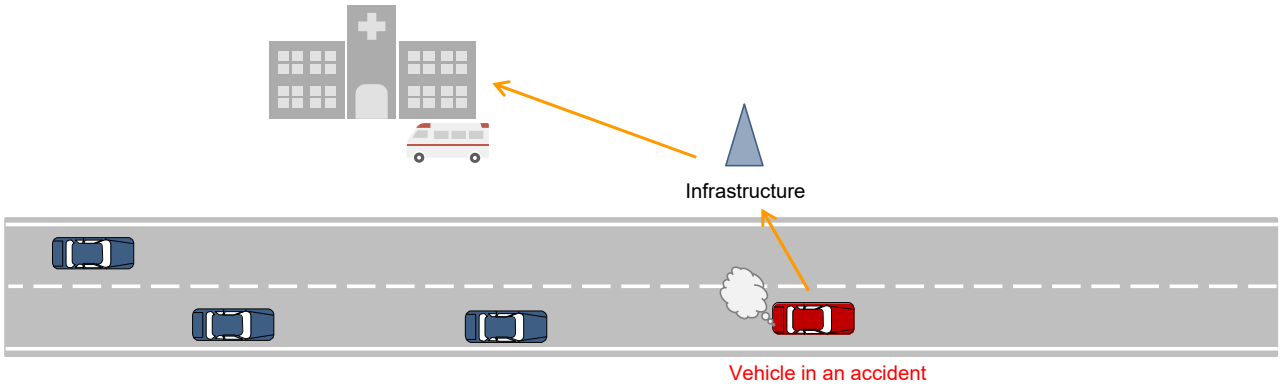
Remarks (communication requirements, etc.)	**Communication**	V2V, V2I, V2N	**Data category/ content of information**	**Message**	Information about approaching emergency vehicles
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, lane change, stop (shoulder)		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		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)

Classification by function	f. Information collection/distribution by infrastructure		
Name of the use case	f-1. Request for rescue (e-Call)		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Rescue information is transmitted from abnormal vehicles (e.g., vehicles in accidents) to the infrastructure to request rescue.		

Image of the use case

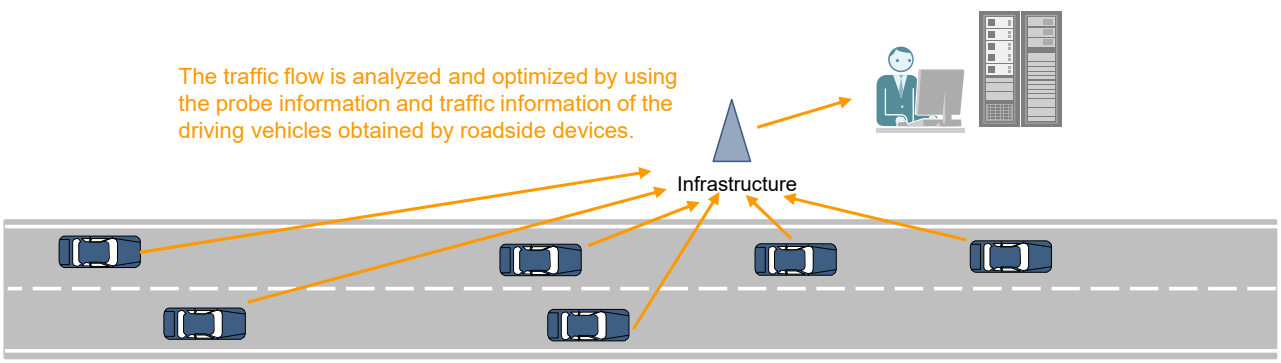


Remarks (communication requirements, etc.)	**Communication**	V2N	**Data category/ content of information**	**Message**	Request for rescue
	Connection mode	One-to-one		**Sensor data**	Location
	Control usage	Notification		**Rich contents**	–
	Responsiveness	–	**Data amount**		Small

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

Classification by function	f. Information collection/distribution by infrastructure		
Name of the use case	f-2. Collection of information to optimize the traffic flow		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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 case

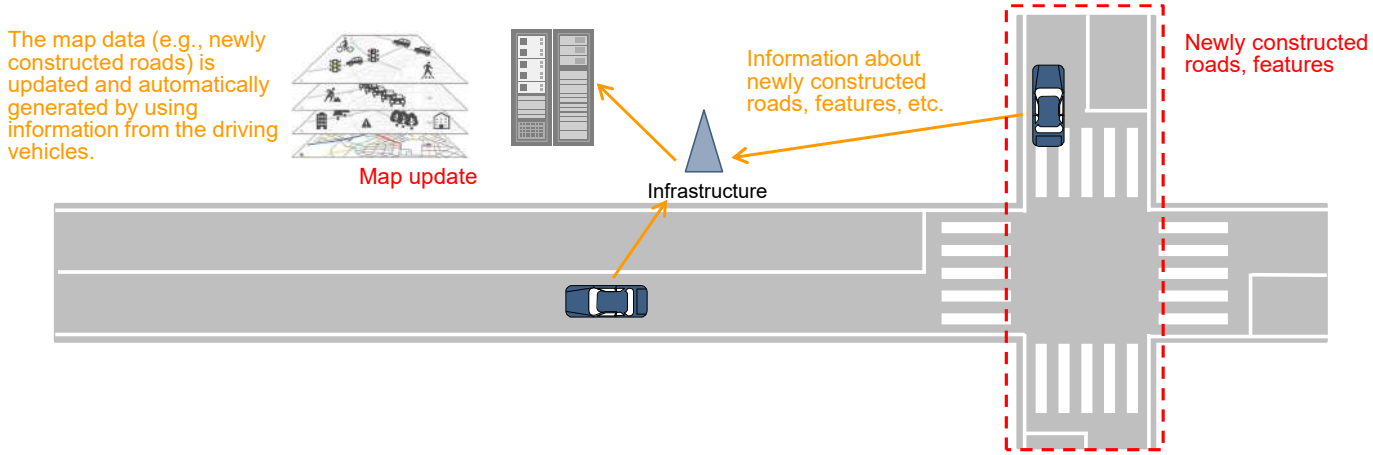


Remarks (communication requirements, etc.)	**Communication**	V2I, V2N	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-one		**Sensor data**	Location, speed
	Control usage	–		**Rich contents**	–
	Responsiveness	–	**Data amount**		Small

f-3. Update and automatic generation of maps

Classification by function	f. Information collection/distribution by infrastructure		
Name of the use case	f-3. Update and automatic generation of maps		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Vehicles' information is collected by the infrastructure to update and automatically generate the map data.		

Image of the use case

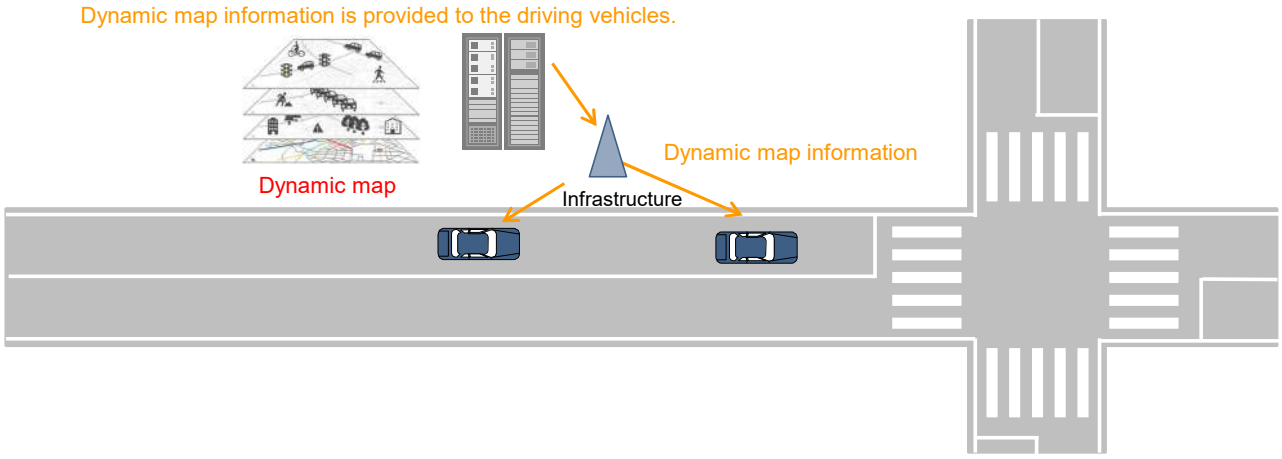


Remarks (communication requirements, etc.)	**Communication**	V2N	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-one		**Sensor data**	Location
	Control usage	–		**Rich contents**	Image captured by on-board cameras
	Responsiveness	–	**Data amount**		Large

f-4. Distribution of dynamic map information

Classification by function	f. Information collection/distribution by infrastructure		
Name of the use case	f-4. Distribution of dynamic map information		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Dynamic map information is provided by the infrastructure to vehicles.		

Image of the use case



Remarks (communication requirements, etc.)	**Communication**	V2N	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Trajectory change		**Rich contents**	Road data, feature location, etc.
	Responsiveness	–	**Data amount**		Large

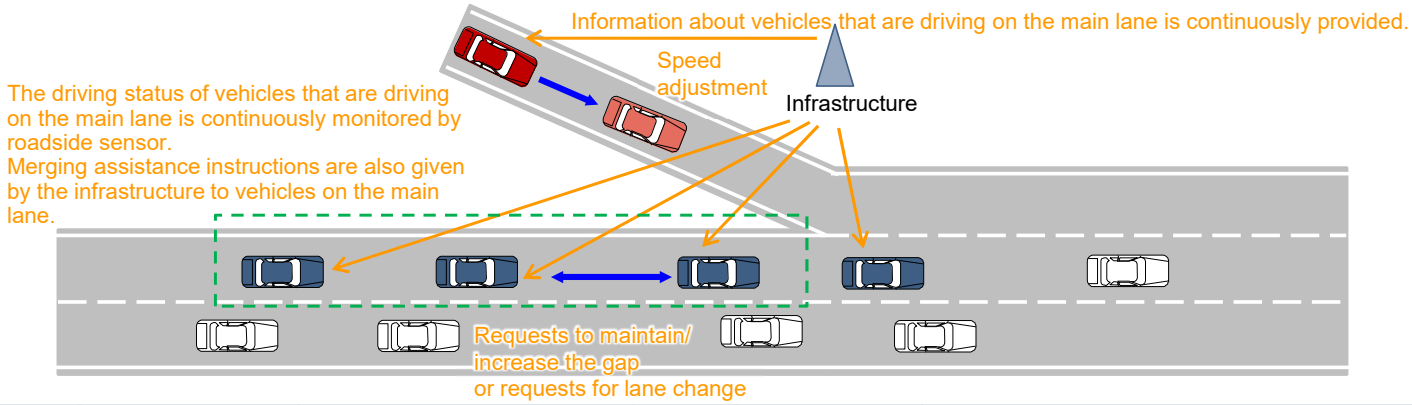
(3) Use cases in which V2V and V2I interaction must be ensured

a. Merging/lane change assistance

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

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-1-3. Cooperative merging assistance with vehicles on the main lane by roadside control		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
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.		

Image of the use case

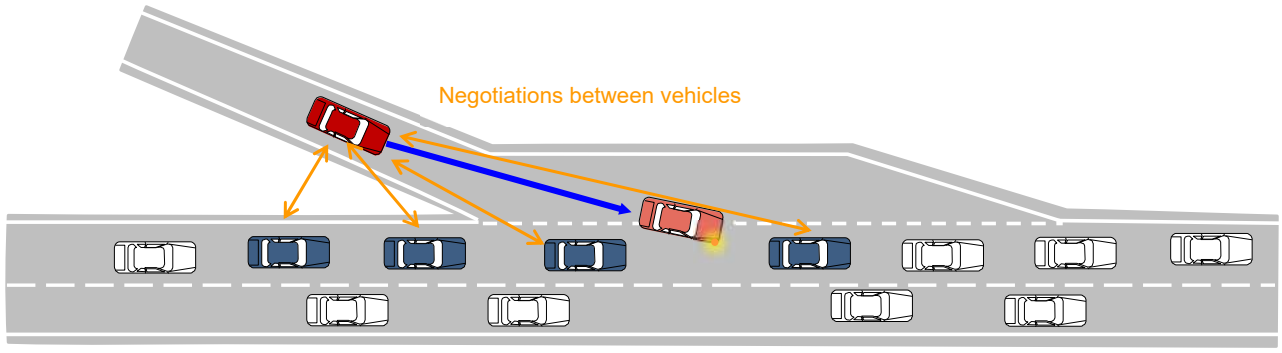


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Time to arrive at a merging section (vehicles on the main lane), requests for gap adjustment
	Connection mode	One-to-many		**Sensor data**	Speed, location
	Control usage	Speed adjustment, gap adjustment		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-1-4. Merging assistance based on negotiations between vehicles		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	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 the use case

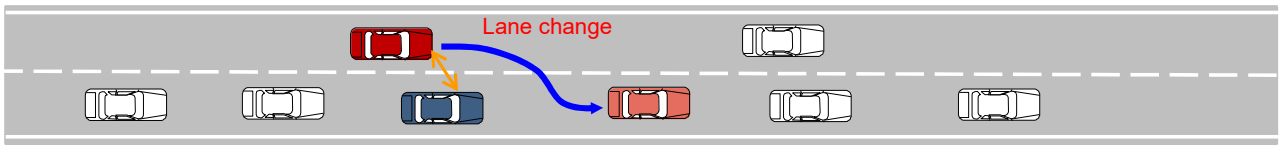


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Requests for gap adjustment, permission for acceptance
	Connection mode	One-to-many → One-to-one		**Sensor data**	Speed, location
	Control usage	Speed adjustment, gap adjustment		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-2. Lane change assistance when the traffic is heavy		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
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 the use case

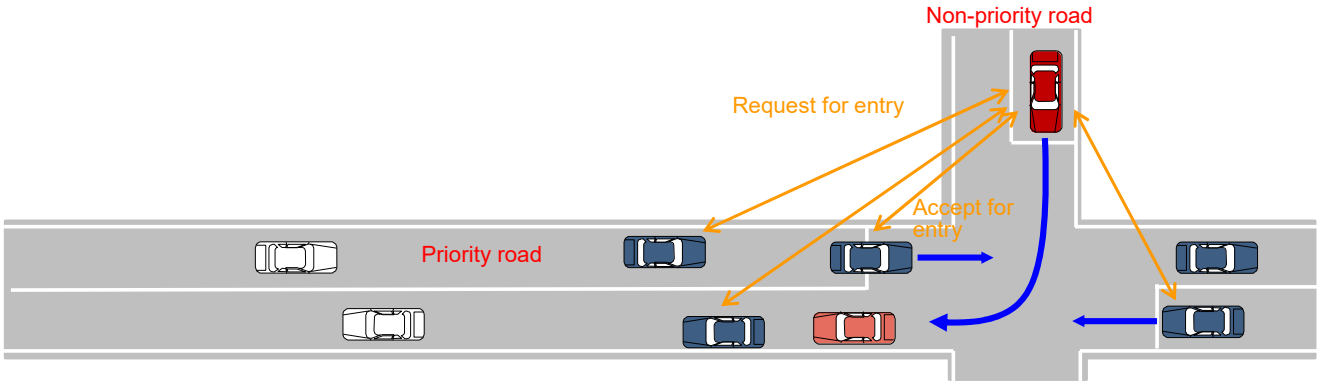


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Requests for gap adjustment, permission for acceptance
	Connection mode	One-to-many → One-to-one		**Sensor data**	Speed, location
	Control usage	Gap adjustment, lane change		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	a. Merging/lane change assistance		
Name of the use case	a-3. Entry assistance from non-priority roads to priority roads during traffic congestion		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	At unsignalized intersections, location and speed information and the intention of entry are communicated between vehicles near intersections for driving assistance to enter priority roads from non-priority roads.		

Image of the use case

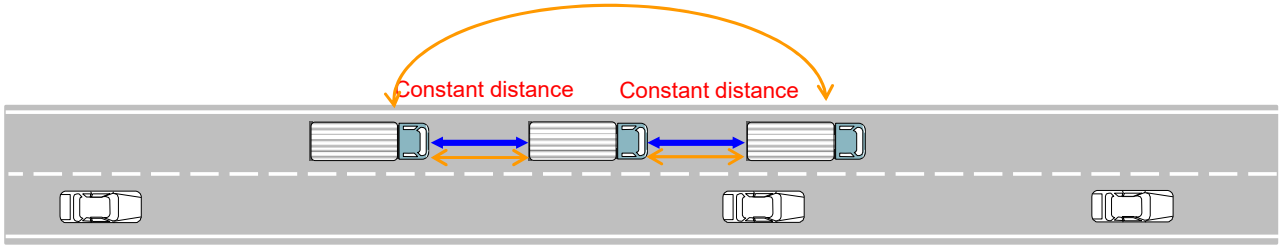


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Requests for entry, permission for acceptance
	Connection mode	One-to-many → One-to-one		**Sensor data**	Location, speed
	Control usage	Right and left turns, gap adjustment		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

g. Platooning/adaptive cruise control
g-1. Unmanned platooning of following vehicles by electronic towbar

Classification by function	g. Platooning/adaptive cruise control		
Name of the use case	g-1. Unmanned platooning of following vehicles by electronic towbar		
Target areas	Expressways	**Target vehicles**	Logistics service cars
Overview	Operation information, etc. of platooning vehicles is communicated between trucks that form a platoon to assist platooning (electronic towbar).		

Image of the use case

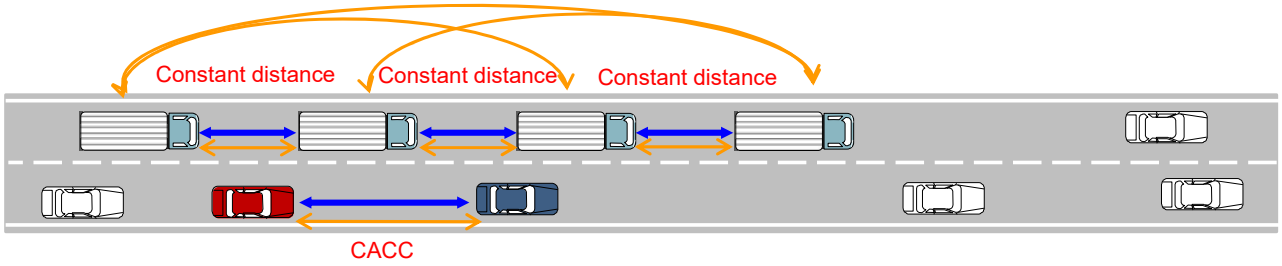


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Acceleration, braking, steering operation, information about following vehicles
	Connection mode	One-to-many		**Sensor data**	Location, speed, gap, acceleration/deceleration speed
	Control usage	Keeping distance, platoon maintenance		**Rich contents**	Transmission of image from the second truck to the first truck by using an electronic mirror
	Responsiveness	Required	**Data amount**		Large

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

Classification by function	g. Platooning/adaptive cruise control		
Name of the use case	g-2. Adaptive cruise control and manned platooning of following vehicles using adaptive cruise control		
Target areas	Expressways (Logistics service cars) Expressways + General roads (Privately owned vehicles)	**Target vehicles**	Logistics service cars, Privately owned vehicles
Overview	Location and speed information and driving operation information of vehicles at the front, etc. are communicated with the following vehicles to assist adaptive cruise control.		

Image of the use case

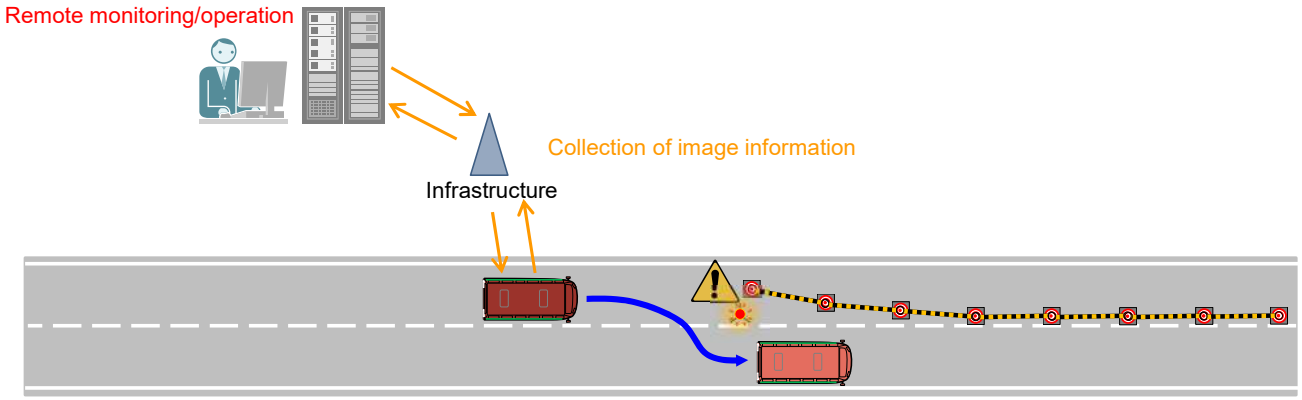


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Acceleration/braking operation
	Connection mode	One-to-one or one-to-many		**Sensor data**	Location, speed, acceleration/deceleration speed
	Control usage	Keeping distance		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Classification by function	h. Teleoperation		
Name of the use case	h-1. Operation and management of mobility service cars		
Target areas	Expressways + General roads	**Target vehicles**	Mobility service cars
Overview	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 case



Remarks (communication requirements, etc.)	**Communication**	V2N	**Data category/ content of information**	**Message**	Teleoperation instructions
	Connection mode	One-to-one		**Sensor data**	Location, speed
	Control usage	Teleoperation		**Rich contents**	Image captured by on-board cameras
	Responsiveness	Required	**Data amount**		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 signal information before a tunnel	Current traffic signal color information, etc. transmitted by a traffic signal before a tunnel is provided by the infrastructure to vehicles to assist deceleration and stopping.
x-2. Collision avoidance assistance when a vehicle ahead (suddenly) stops or decelerates	Sudden braking information and location and speed information are provided by a vehicle that suddenly decelerates to the following vehicles to assist collision avoidance by stopping or deceleration.
x-3. Collision avoidance assistance when a vehicle ahead changes lanes	Location and speed information is provided by a vehicle that 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 ahead (see-through)	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.
x-6. Driving assistance based on lookahead information (notification of speed limit)	Speed limit information (including variable information) is provided by the infrastructure to the surrounding vehicles to assist driving.
x-7. Collision avoidance assistance at intersections	Location and speed information is exchanged between vehicles that approach intersections to assist collision avoidance.
x-8. Assistance of entry from non-priority roads to priority roads at unsignalized intersections	At unsignalized intersections, location and speed information is provided by vehicles on the priority roads to vehicles on 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 traffic section	In a section that switches from two-way traffic to alternating 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 pedestrian information	Location and speed information is provided by pedestrians and bicycles to vehicles to assist driving and stopping of vehicles, etc.
x-12. Driving assistance based on streetcar information	Location and speed information is provided by streetcars to the surrounding vehicles to assist driving of the surrounding vehicles.
x-13. Driving assistance based on traffic congestion information (V2V)	Traffic congestion status information is provided by vehicles caught in traffic congestion to the following vehicles to assist the trajectory change.
x-14. Traffic congestion assistance at branches and exits (V2V)	Location and speed information and information about traffic congestion on shoulders are provided by vehicles caught in traffic congestion to the following vehicles on the main lane to assist entry to branches.

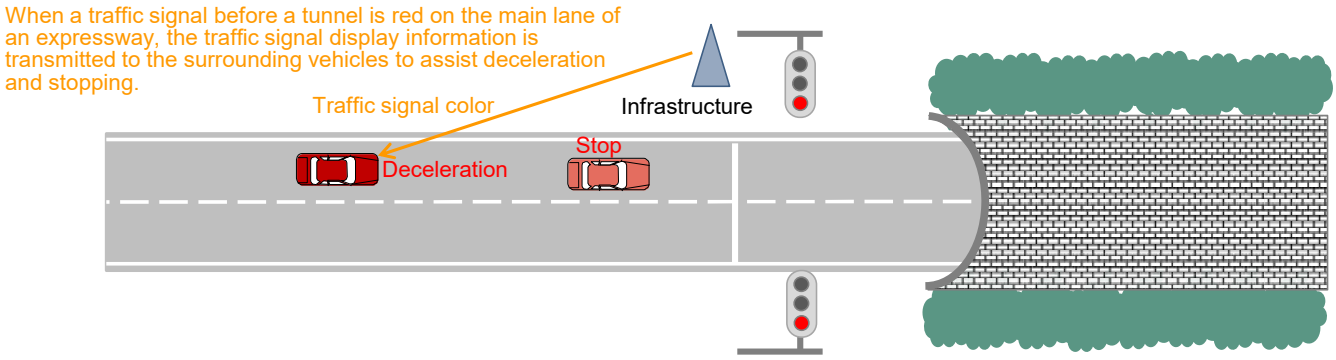
2) Use case diagrams

The use case diagrams are shown in the following pages.

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

Name of the use case	x-1. Driving assistance based on traffic signal information before a tunnel		
Target areas	Expressways	**Target vehicles**	Privately owned vehicles
Overview	Current traffic signal color information, etc. transmitted by a traffic signal before a tunnel is provided by the infrastructure to vehicles to assist deceleration and stopping.		
Reason for dropping this use case	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

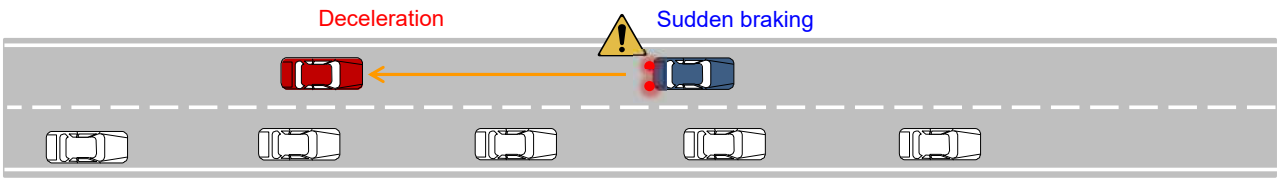


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Traffic signal color
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Name of the use case	x-2. Collision avoidance assistance when a vehicle ahead (suddenly) stops or decelerates		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Sudden braking information and location and speed information are provided by a vehicle that suddenly decelerates to the following vehicles to assist collision avoidance by stopping or deceleration.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

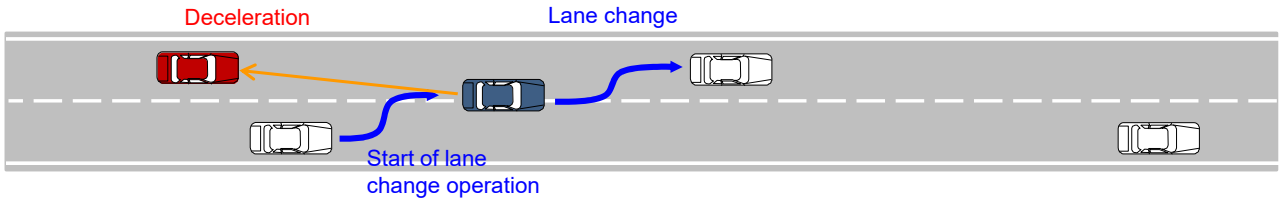


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Sudden braking information
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Name of the use case	x-3. Collision avoidance assistance when a vehicle ahead changes lanes		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information is provided by a vehicle that will change lanes to enter the same lane to vehicles on either side to assist collision avoidance.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

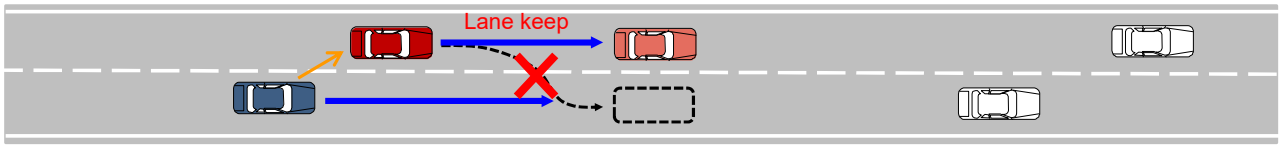


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, stop		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

x-4. Lane change assistance

Name of the use case	x-4. Lane change assistance		
Target 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.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

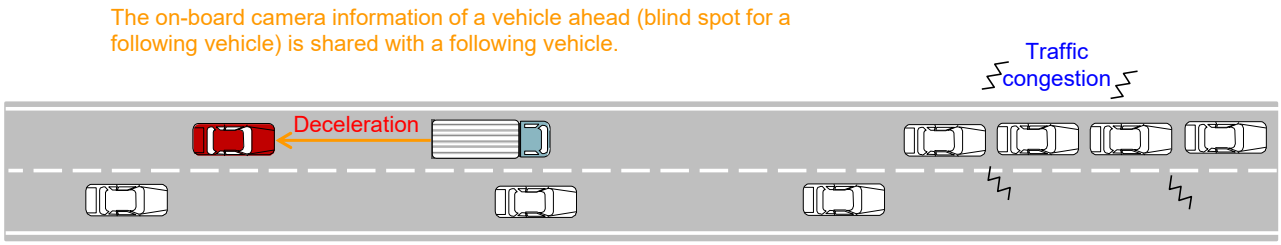


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Speed, location
	Control usage	Lane change		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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)		
Target areas	Expressways + General roads	**Target 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.		
Reason for dropping this use case	Collision avoidance is possible if the movement of vehicles ahead is detected using on-board sensors.		

Image of the use case

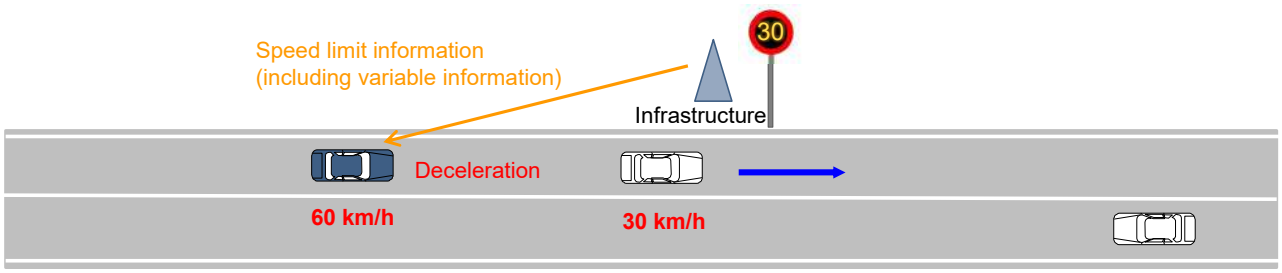


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Status of traffic congestion
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Speed adjustment, stop		**Rich contents**	Image captured by on-board cameras
	Responsiveness	Required	**Data amount**		Large

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

Name of the use case	x-6. Driving assistance based on lookahead information (notification of speed limit)		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Speed limit information (including variable information) is provided by the infrastructure to the surrounding vehicles to assist driving.		
Reason for dropping this use case	Information can be obtained using on-board sensors.		

Image of the use case

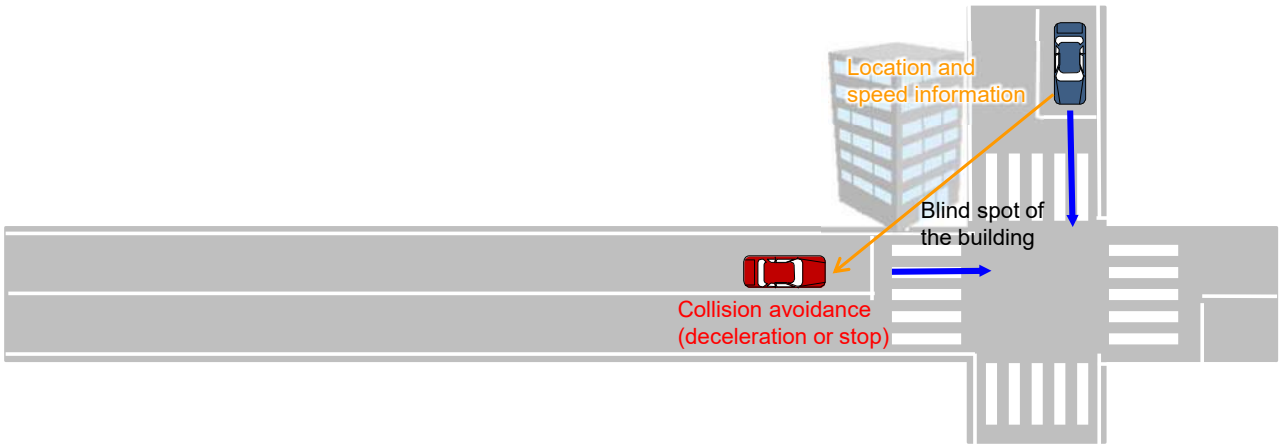


Remarks (communication requirements, etc.)	**Communication**	V2I	**Data category/ content of information**	**Message**	Speed limit
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Trajectory change		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

x-7. Collision avoidance assistance at intersections

Name of the use case	x-7. Collision avoidance assistance at intersections		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information is exchanged between vehicles that approach intersections to assist collision avoidance.		
Reason for dropping this use case	Driving is possible by complying with the laws and regulations related to road traffic.		

Image of the use case

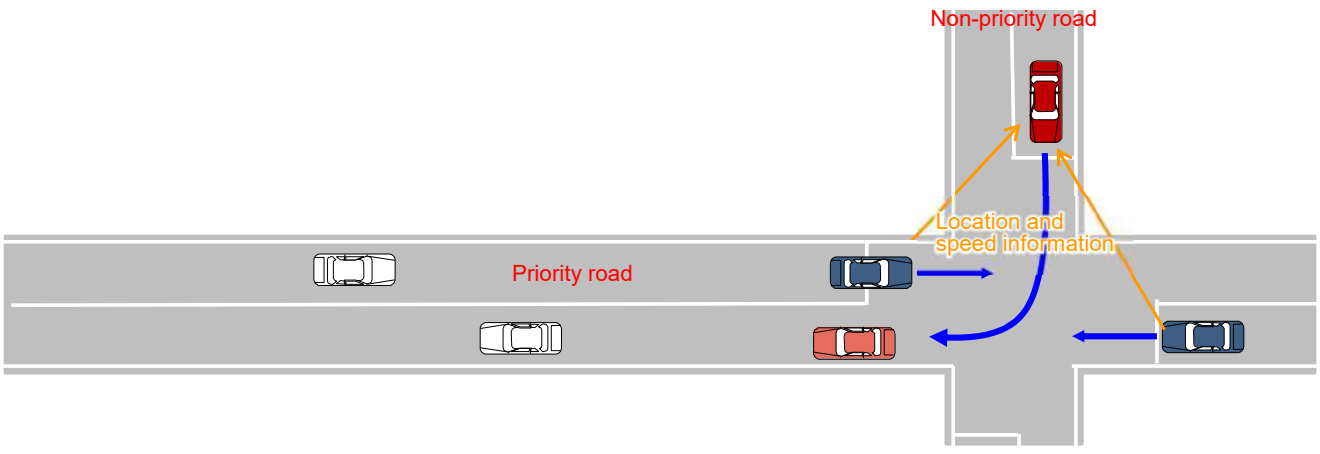


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, stop, right and left turns		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Name of the use case	x-8. Assistance of entry from non-priority roads to priority roads at unsignalized intersections		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	At unsignalized intersections, location and speed information is provided by vehicles on the priority roads to vehicles on the non-priority roads to assist driving to enter the priority roads.		
Reason for dropping this use case	Driving is possible by complying with the laws and regulations related to road traffic.		

Image of the use case

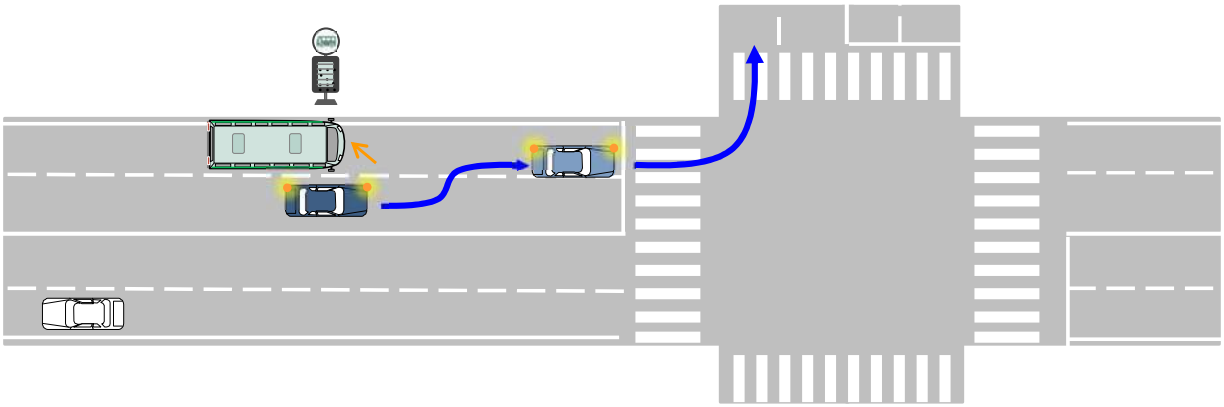


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Speed adjustment, stop, right and left turns		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

x-9. Warning when a bus starts

Name of the use case	x-9. Warning when a bus starts		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	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.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

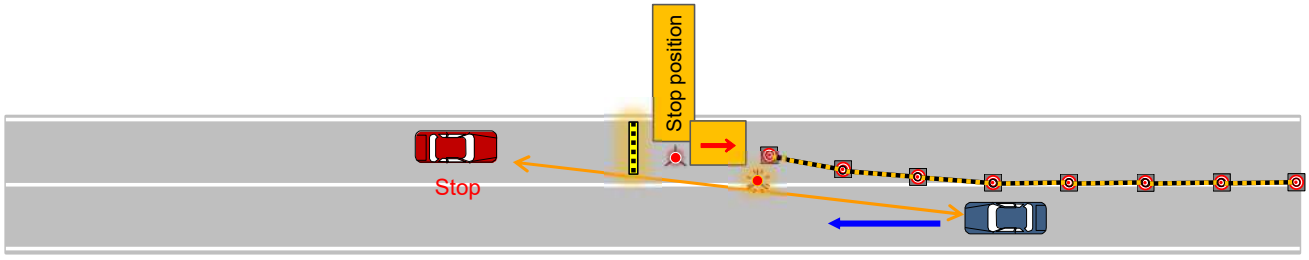


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Intention of lane change
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Judgment whether the bus can start		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

x-10. Driving assistance at an alternating traffic section

Name of the use case	x-10. Driving assistance at an alternating traffic section		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	In a section that switches from two-way traffic to alternating 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.		
Reason for dropping this use case	Driving is possible by complying with the laws and regulations related to road traffic, and vehicle control is possible using on-board sensors.		

Image of the use case

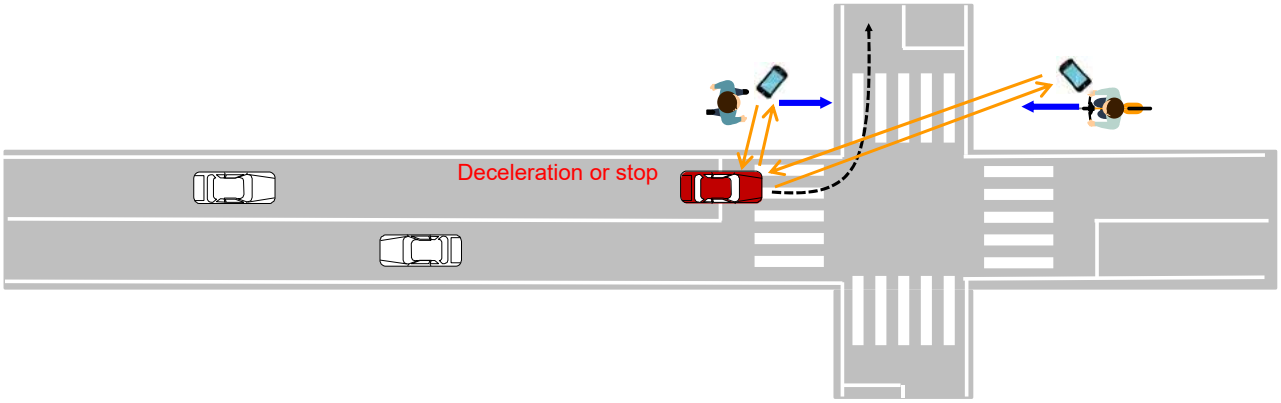


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Judgment whether the vehicle can start		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

x-11. Driving assistance based on pedestrian information

Name of the use case	x-11. Driving assistance based on pedestrian information		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information is provided by pedestrians and bicycles to vehicles to assist driving and stopping of vehicles, etc.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

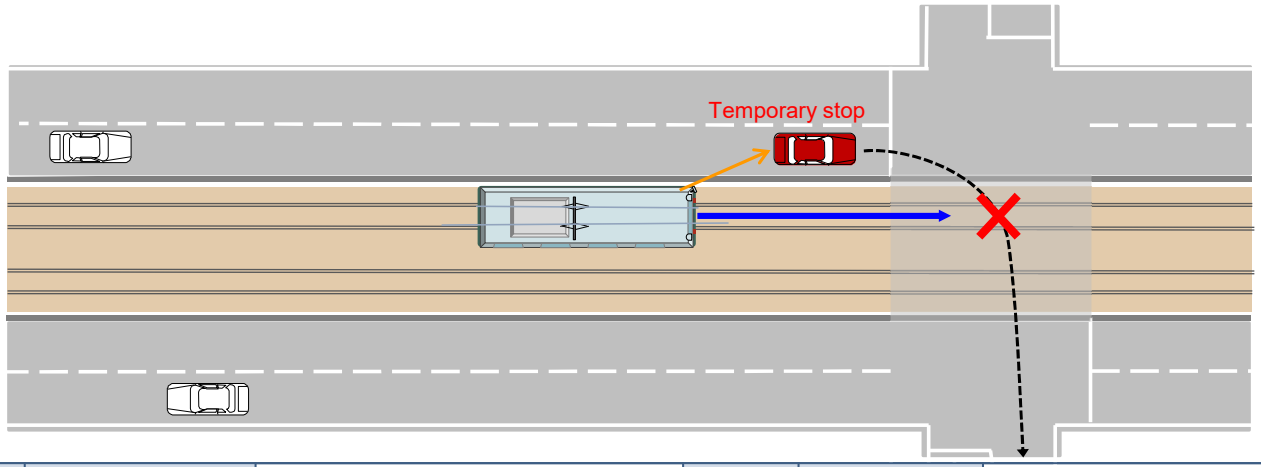


Remarks (communication requirements, etc.)	**Communication**	V2P, V2I	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Deceleration, stop, right and left turns		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

x-12. Driving assistance based on streetcar information

Name of the use case	x-12. Driving assistance based on streetcar information		
Target areas	General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information is provided by streetcars to the surrounding vehicles to assist driving of the surrounding vehicles.		
Reason for dropping this use case	Vehicle control is possible using on-board sensors.		

Image of the use case

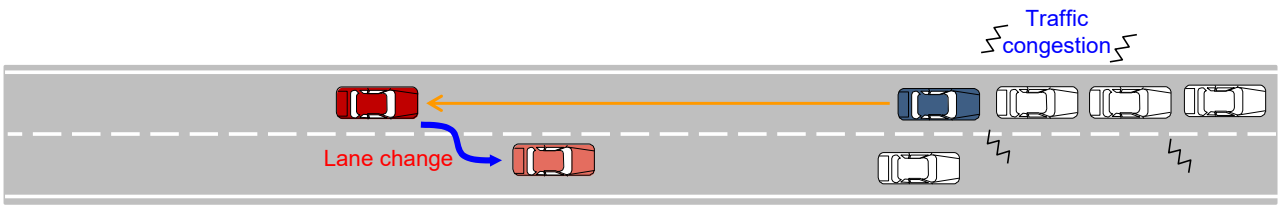


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	–
	Connection mode	One-to-many		**Sensor data**	Location, speed
	Control usage	Judgment whether the vehicle can start		**Rich contents**	–
	Responsiveness	Required	**Data amount**		Small

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

Name of the use case	X13. Driving assistance based on traffic congestion information (V2V)		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Traffic congestion status information is provided by vehicles caught in traffic congestion to the following vehicles to assist the trajectory change.		
Reason for dropping this use case	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, but 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 case

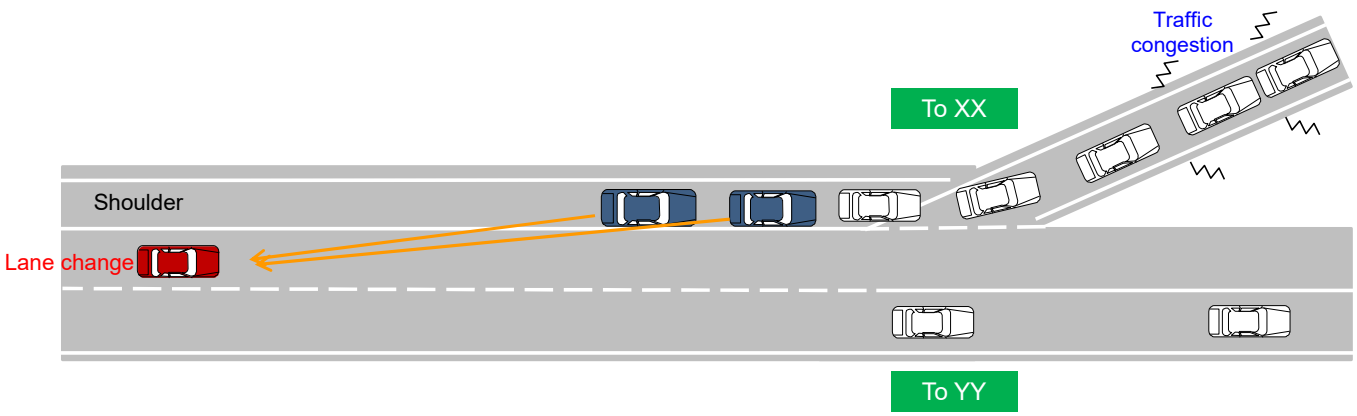


Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Status of traffic congestion
	Connection mode	One-to-many		**Sensor data**	–
	Control usage	Trajectory change, speed adjustment, stop		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

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

Name of the use case	X14. Traffic congestion assistance at branches and exits (V2V)		
Target areas	Expressways + General roads	**Target vehicles**	Privately owned vehicles
Overview	Location and speed information and information about traffic congestion on shoulders are provided by vehicles caught in traffic congestion to the following vehicles on the main lane to assist entry to branches.		
Reason for dropping this use case	In V2V, the time margin from acquisition of information to stopping at the tail of a traffic congestion queue on the shoulder is limited, and it is difficult to change the trajectory.		

Image of the use case



Remarks (communication requirements, etc.)	**Communication**	V2V	**Data category/ content of information**	**Message**	Status of traffic congestion on shoulders (toward branches)
	Connection mode	One-to-many		**Sensor data**	Speed, location
	Control usage	Speed adjustment, trajectory change		**Rich contents**	–
	Responsiveness	Not required	**Data amount**		Small

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[(1)] 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

(1) 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)