The second phase of SIP-Automated Driving for Universal Services

Research on assessment of the impact of automated driving on society and the economy and on measures to promote deployment

Report summary version　March 2022

The University of Tokyo / Doshisha University

Purpose

Purpose of the second phase of SIP-adus project

Practical development and widespread diffusion of automated vehicles will help to resolve a variety of issues facing society, such as reducing traffic accidents, alleviating traffic congestion, ensuring mobility for vulnerable road users, resolving the shortage of drivers for logistics and transport services, and reducing costs, with the aim of achieving a society in which everyone is able to enjoy a high quality of life.

Purpose of this study

I **Basic consensus of public and private entities regarding the premises for quantification.**

II **Quantification of socioeconomic impact of automated driving.**

III **Study of measures to promote automated driving and provision of information to support decision-making.**

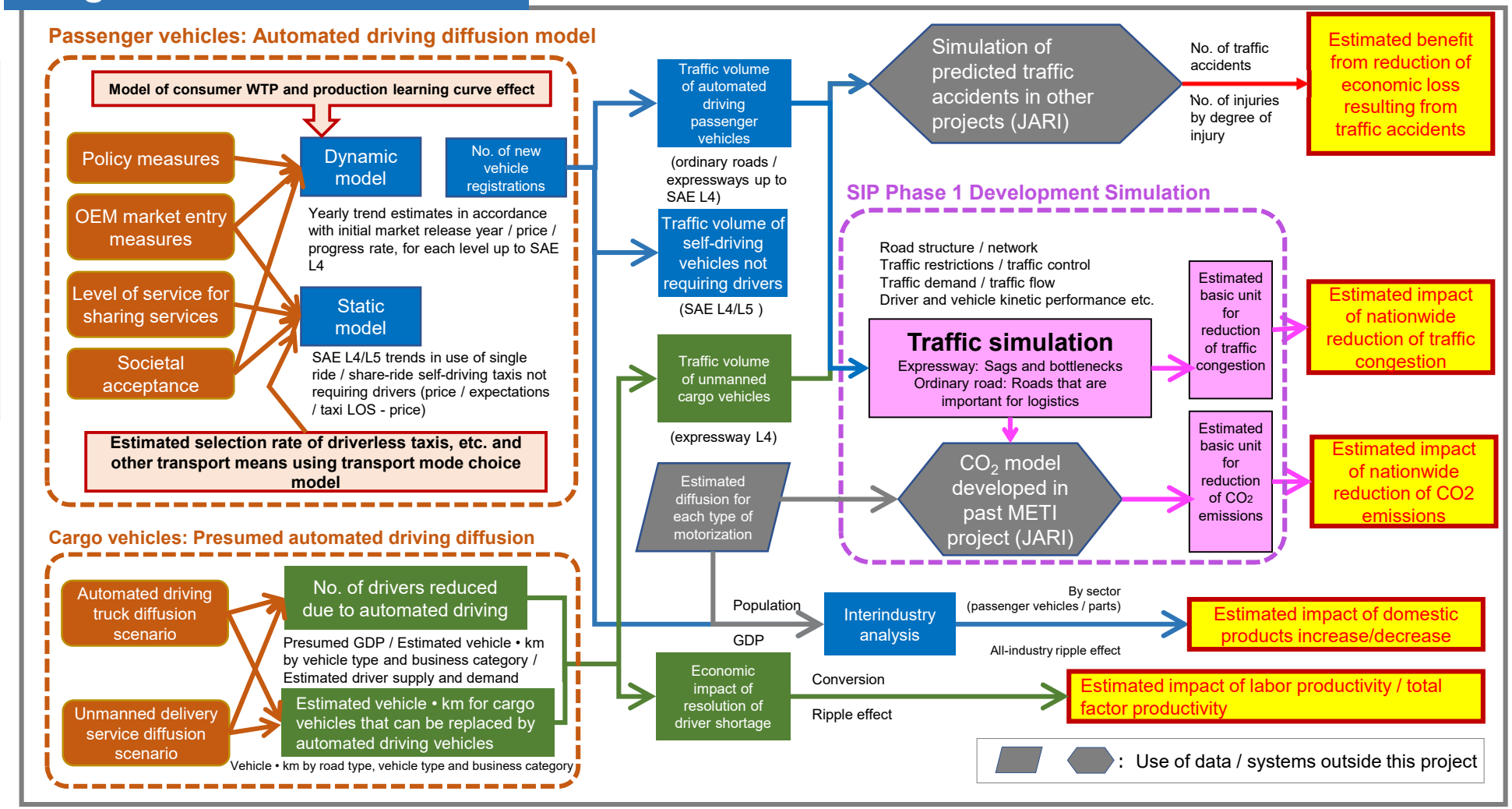
Approach

Past achievements

SIP-Automated Driving Systems
Analysis of social and industrial aspects in preparation for advancement and deployment of automated driving systems
(FY 2016 - 2017)

The second phase of SIP-Automated Driving for Universal Services
Study of the Impact of Automated Driving on Reducing Traffic Accidents and on Others
(FY 2018 - 2021)

Integrated model framework



Use of models constructed in
“Study of the Impact of Automated Driving on Reducing Traffic Accidents and on Others"
conducted in previous years (FY 2018-2021)

Overview of Research Study

I Basic consensus
of public and private entities regarding the premises for quantification

II Quantification
of socioeconomic impact of automated driving

III Provision of information

A. Relating to assessment of socioeconomic impact
Qualitative organization of overall approach

B. Organization of preconditions
for diffusion and impact assessment simulation models

C. Organization of promotion measures (scenario formulation)

D. Estimation of diffusion rate corresponding to promotion measures in multiple scenarios

E. Estimation of no. of traffic accidents, traffic congestion and CO_2 emissions

i . Estimation of impact on traffic accidents
ii . Estimation of impact on traffic congestion and CO_2 emissions

F. Assessment of impact on domestic economy overall

i . Quantitative assessment from the perspective of resolving the driver shortage in logistics and transport services
ii . Quantitative assessment from the perspective of the productivity of Japanese economy and the ripple effects of automated driving on production, etc.

G. Research output

Completed by FY 2021

Starting in FY 2021

For execution in FY 2022

Holding of Discussions

In order to achieve "A. Qualitative organization of overall approach" "B. Organization of preconditions for diffusion and impact prediction simulation models" and "C. Organization of promotion measures (scenario formulation)," discussions were held using the monthly meeting of the Business Promotion Working Group (WG) of SIP-adus. An overview of the discussions is presented below.

Date	Issues	
August 19, 2021	**Report at time of commissioning**	Project objective, content and methods, schedule and organization
September 16	**Discussion of method and scope of discussions**	Premises and approach to discussions, discussion of scope, discussion of outcomes
October 21	**Shared image of success** **Discussion of premises for calculation (1)**	Image of success, discussion of privately owned vehicles x accidents, discussion of privately owned vehicles x congestion
November 18	**Discussion of premises for calculation (2)**	Discussion of privately owned vehicles x CO_2 emissions, discussion of main road transport x driver shortage, discussion of intraregional transport x driver shortage
December 16	**Discussion of premises for calculation (3)**	Premises for diffusion models, premises for calculation of accidents, premises for main road transport, premises for intraregional transport
January 20, 2022	**Discussion of premises for calculation (4)**	Premises for diffusion models, premises for calculation of congestion
February 17	**Discussion of premises for calculation (5)**	Premises for diffusion models, discussion of CO_2 emissions, economic impact, lifestyle changes
March 17	**Summary of discussions held during fiscal year** **Sharing of plans for next fiscal year**	Reflecting back on discussions held up to now, shared image of research output, future plans

Note: Discussions through the WG were not sufficiently in-depth with regard to some aspects of the organization of preconditions. Accordingly, more in-depth discussions and exchanges of views were held separately on an individual basis with key figures and relevant entities. The individual discussions were held with OEM automobile companies, automotive journalists, persons in the logistics field, the contractors of other SIP-adus projects, the U. S. Department of Transportation research institute and so on. Separate exchanges of views were also held with German specialists by means of workshops with specialists on Japan-German collaboration.

Objectives and Overview

Objectives

To **prepare a rough draft of the overall qualitative objectives** for the items to be included in the assessment of the socioeconomic impact of automated driving, as well as the preconditions for the quantitative calculations to be conducted for these items and the highly feasible promotion measures, etc. for which sensitivity analysis will be conducted. The rough draft will be based on the achievements of the previous project and the suggestions expressed by the committee of experts in the previous project.

Overview

- **The framework for discussions, including the scope of the discussions, the approach to discussions, the main points to be discussed, was discussed and decided in the WG**.
  - The discussions needed for the series of projects will be conducted primarily using the WG. However, it was necessary to consider the framework for discussions before detailed discussions regarding each item.
  - It was decided to include lifestyle changes produced by automated driving in the scope of the discussion, along with the diffusion of privately owned vehicles, reduction of traffic accidents, alleviation of traffic congestion and resulting reduction of CO_2 emissions, resolution of the shortage of logistics drivers, and economic impact.
  - Moreover, it was also decided to use the approach of holding discussions from the standpoint of both inputs and outcomes, and to focus on the essential points for analysis rather than the premises for detailed calculation and computational constraints.
- **The approach to final research output was also discussed**. In addition, it was decided to share achievements produced through student education in addition to the initially anticipated communication and content provision at academic events and SIP-related events.

Discussion Scopes for the Project

Analysis method		Input		Outcome Area
Quantitative / Qualitative Analysis (Quantification using the models up through the previous phase and organization of issues and necessary innovation)	1	Privately owned vehicles	×	Accidents
	2		×	Congestion
	3		×	CO_2 emissions produced by congestion
	4	Main road logistics	×	Driver shortage
	5	Intraregional delivery	×	
Qualitative Analysis (Organization of issues and necessary innovation)	6	Privately owned vehicles	×	Lifestyle changes
	7	Mobility services	×	
	α	Economic impact		

On the WG discussions, the flame of 7 + α areas combining input and outcomes was established.

(For the area relating to lifestyle changes, discussions were held in the Mobility Business Innovation Contest (M-BIC) sponsored by the contractors.)

External Communication Strategy

Target		Overview of communication methods

Specialists / industry personnel	● Persons involved in projects, administration or research relating to mobility, transport, logistics, movement, urban planning etc.
	● Persons taking some types of action in individual areas that relates to automated driving.
		● **Reporting at academic events or SIP-related events**
		  ● e.g. Reporting of achievements at academic meetings or international conferences.
		  ● e.g. Reporting of achievements at SIP-adus WS or other SIP-related events
		● **Provision of content at academic events or SIP-related events**
		  ● e.g. Provision of content at SIP-adus WS or other SIP-related events
		● **Provision of information to serve as the basis of policy discussions**

General	● Persons not directly involved in the development, introduction and use of automated driving vehicles.
	● Persons with no detailed knowledge of, or interest in, automated driving.
		● **Sharing of achievements through student education**
		  ● e.g. Explanation of project achievements to students through student education by means of the Mobility Business Innovation Contest (M-BIC)
		  ● e.g. Use of achievements in other research and educational activities
		● **Provision of information to SIP-sponsored events designed for the general public (tie-ups with the Societal Acceptance team)**
		  ● e.g. Provision of information to serve as the basis for SIP-cafe content creation
		  ● e.g. Provision of information to serve as the basis for citizen dialogue content creation

External Communication Strategy of research output will also be organized.
Content and information will be provided, primarily to specialists and industry personnel.

Objectives and Overview

Objectives

To achieve a general consensus on the preconditions to be used when estimating various impacts and to also study changes to the preconditions and models as needed, using the models developed in the previous project, in accordance with the overall objectives organized in "A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact.'

Overview

- The following points were agreed upon as a result of discussions at the WG and separate detailed discussions with WG members.
  - It was decided to adopt a policy of calculating **traffic accidents** by linking automated driving functions that have been organized into detailed categories and accidents that can be prevented as a result, and multiplication by both the diffusion rate and the use rate of automated driving.
  - In calculating the reduction of traffic congestion, in general it was decided to follow the content of discussions up to now and prior research, but also to reflect the latest developments and add updates in places. Participants also agreed to use a longer setting for the vehicle interval of automated vehicles than that of existing manually operated vehicles.
  - Participants agreed that data relating to the **use rate for functions** needed for calculating traffic accidents and traffic congestion will be shared in coordination with the second phase of SIP-adus "Study of strategy formulation and assessment to foster societal acceptance.“
  - With regard to calculating the **reduction of CO_2 emissions**, a shared understanding was reached with regard to the policy of calculating the effect of the reduction of CO_2 emissions resulting from reduced traffic congestion due to changes in driving behavior as a result of automated driving. And that the effect of electrification will be considered only if electrification affects the aforementioned reduction of CO_2 emissions.
  - With regard to calculations relating to resolution of the shortage of **logistics** drivers, a shared understanding was reached regarding the policy of limiting the scope of calculation for this project to main road logistics on expressways. Furthermore, through interviews with key figures, the specific operations envisioned in these calculations were organized.
  - It was decided that the methods in the previous project will be followed with regard to **economic impact**, but the input data will be updated with the most up-to-date data.
  - With regard to "**lifestyle changes**" which was added as an area of discussion in “A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact," the policy of pursuing separated discussions using the Mobility Business Innovation Contest (M-BIC) sponsored by the contractors was confirmed.

The timing of marketization, price, driving control characteristics and so on for each self-driving vehicle category also constitute one category for “B. Organization of the premises of simulation models for diffusion.” However, as the details are noted in "D. Estimated diffusion rate for promotion measures in multiple scenarios," they are omitted in this chapter.

Traffic Accidents

Linkage of functions that can reduce traffic accidents with accident categories

- Safe driving assist function
- Driving assist function

Accidents resulting from driver inattention and operational errors

Function 1	Accident Pattern A
Function 2	Accident Pattern B
Function 3	Accident Pattern C

- System driving function

Level 3	Accidents resulting from intentional legal violations by driver (Ignore signals, overtaking in the overtaking-prohibited places, etc.)
Level 4	

Changes in the diffusion rate of each function

Accident number changes in the 'Accident Pattern' associated with each function

→ Relationship between the diffusion rate of each function and the number of accidents

Calculation of reduction rate taking into account the diffusion rate and use rate

Diffusion rate estimated by the diffusion simulation model × Actual use rate for each functions

The policy of linking functions including driving safety assist functions to accident patterns and taking into consideration the diffusion rate and use rate of the function to estimate the impact was confirmed.

Traffic Congestion

Basic policy

Following the discussions up to now

+

Reflect the latest situation, and update partially

The discussions that have been conducted for the past 10 years will be followed. Prior research will be cited as much as possible.

- The impact on congestion of changes in vehicle interval distance due to ACC will be analyzed.
- Vehicle behaviors, such as settings of the time clearances, basically follows previous research.

Update in accordance with the vehicle / function diffusion models

- Vehicle / function diffusion models will be updated based on the discussions of this project .

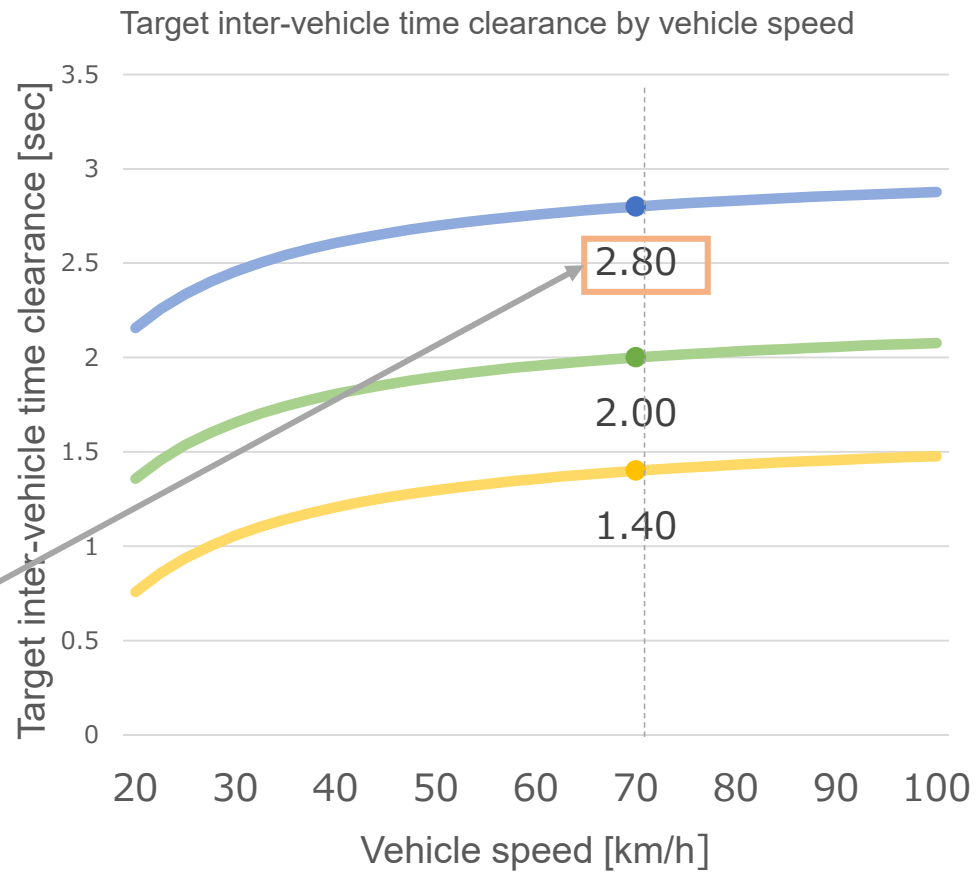
Consideration of use rate

- Information related to function use rate has already been linked from other SIP projects.

Add a pattern that increase the inter-vehicle time clearances

- It was pointed out that, in the previous phase, the possibility that early automated-driving vehicles have a longer space clearance than manned-driving vehicles due to safety reasons.

Example of setting the inter-vehicle time clearance



With regard to congestion, participants agreed that the content of discussions up to now and prior research will be followed, but the latest developments will be reflected, and updates will be added in places.

CO_2 Emissions Resulting from Congestion

Scope refinement

- **Participants agreed to calculate changes in CO_2 emissions resulting from changes in congestion volume, which will be calculated as a part of congestion.**
  - Increase or decrease of CO_2 emission throughout the life cycle of automated-driving vehicles, fuel and electricity costs, the impact of EV conversion, changes in traffic demand will not be calculated.
  - However, if EV conversion has an impact on the CO_2 reduction effect described below, only this effect will be considered.
- **Participants agreed to further narrow the scope despite the aforementioned changes in CO_2 emissions.**
  - The primary focus will be on CO_2 reduction on expressways.
  - The CO_2 reduction effect due to the effect of traffic congestion reduction resulting from the behavioral changes caused by automated driving will be calculated.

Calculation procedures

	Assumptions of behaviors of automated-driving vehicles	Calculation of congestion reduction	Calculation of energy consumption reduction	Conversion to CO_2 emission	Estimated expansion to Japan nationwide
Des-cription	Prevention of unconscious deceleration due to sags improvement of acceleration / deceleration behavior during traffic congestion	Calculation of the effect of reducing congestion by preventing unconscious deceleration Calculation of the effect of eliminating congestion by improving acceleration and deceleration Calculation of the effect of accident congestion reduction effect of accident reduction due to automated driving	**Calculation of the amount of energy consumption reduction by vehicle types** • Gasoline vehicles XX% • HV, PHV XX% • EV XX%	**Calculation of the energy reduction by vehicle types will lead to how many percent of CO_2 reduction** • Gasoline vehicles XX% • HV, PHV XX% • EV XX%	**Estimation of expansion of CO_2 emissions reduction to Japan nationwide**
(Major) Input data			Energy consumption by speed and acceleration by vehicle type	(For EV calculation) Energy mix/ electric supply/ charge loss	EV conversion rate Traffic congestion nationwide

Participants agreed to limit the scope when calculating CO_2 emissions resulting from congestion and calculate the reduction in CO_2 emissions resulting from reduced congestion on expressways.

Main Road Logistics (1/2)

Background situation

- **Needs: Replace trucks on long-distance sections with large volume of cargo with unmanned vehicles**
  - The adverse working environment for long-haul truck drivers (e.g. not being able to go home every day) has led to the driver shortage. Meanwhile, it is comparatively easy to attract drivers for sectors that are close to intraregional delivery.
  - Tokutsumi (special consolidated freight carrier) route vehicles could be replaced with unmanned vehicles.
- **Infrastructure construction**: There is comparatively little difficulty in introducing unmanned operation **in sectors with shoulders as emergency evacuation areas.**

Assumptions for calculation

- **Vehicle-only expressways connecting major cities (not including urban expressways) will be given priority for conversion to unmanned operation.**
  - First, prioritize the development between Tokyo-Nagoya and Nagoya-Osaka, except for areas with poor shoulders such as the Metropolitan Expressway.
  - After that, the area centering on motorways between metropolitan cities will be gradually expanded.

- **For the time being, it is assumed that human workers are expected to be required for freight operation in the warehouses.**
  - Even now, there are many places where the drivers handle freight operations in the warehouse.
  - There is a trend to accelerate the matching of cargos and trucks to avoid empty transportation. Based on that premise, in the future one truck will have to handle freight operations in many places, and it is highly possible that it will be difficult to handle everything automatically.
- **For the time being, logistics facilities that currently exist will need to be used.**
  - In the future, it may be possible to use logistics facilities that are linked directly to vehicle-only roads. However, it will take a long time to transfer all functions to such facilities.

- **For the time being, unmanned operation will be provided only on vehicle-only expressways, and calculations will not be conducted for placement on ordinary roads.**
  - The presumption is that facilities for changing between unmanned and manned operation that are linked directly to vehicle-only expressways will be constructed.
  - For the time being, it is assumed that the facilities will be those that are comparatively small in scale, such as driver boarding locations and platoon driving docking stations. In the future, these can be provided with warehousing functions.

With regard to main road logistics, the needs of logistics companies and other background circumstances will be organized based on interviews, in order to derive hypotheses for calculation based on this information.

Main Road Logistics (2/2)

Background situation

- Private trucks are more numerous in terms of the number of trucks owned, but **commercial trucks are more numerous in terms of kilometers traveled.**
- The greatest need for unmanned vehicles is on the part of companies that operate vehicles on regular routes.

Assumptions for calculation

- Calculations will be conducted for **commercial trucks.**

- In the current configuration, vehicles are only profitable if they have been operated for as long as possible after amortization is complete. There is little need to replace vehicles with the latest models after a short period of time.
- Conversely, to a **certain extent subsidies can be anticipated for replacing vehicles with carbon neutral vehicles**, so some elements exist that can promote vehicle replacement purchases.

- **The premise is that there will be subsidies or tax incentives for replacement with the latest models.**
- A diffusion curve will be prepared for replacement of 75% of commercial main road transport trucks operating in permitted unmanned operation sectors with vehicles capable of unmanned operation by 2050 (after calculation, the results will be submitted to the WG).

- **It is possible that small-scale companies may be integrated with one another or form groups.**
  - Approximately 90% of logistics companies are small companies. Even now, the inefficiency of small-scale companies is a problem.
  - If we assume that transport will include some unmanned operation sectors, it is difficult to believe that a trip will be completed entirely by a single small-scale company. It is very possible that, for example, a large company will conduct transport operations by grouping together small-scale companies.

- Companies that own vehicles eligible for replacement are presumed to be those with the capacity to conduct vehicle replacement purchasing.

With regard to main road logistics, the needs of logistics companies and other background circumstances will be organized based on interviews, in order to derive hypotheses for calculation based on this information.

Intraregional Delivery

Background Situation

- **It would be difficult to automate cargo handling even in 35 -50 years.**
  - Matchings between freights and trucks will be further promoted compared to trunk transportation. It is expected that the variation of freight operations will increase.
  - In the case of regional delivery, the delivery destinations are not logistics company facilities. The greatest issue is whether the delivery destinations will be able to accommodate unmanned transport shipments. Delivery destinations and delivered cargo will vary in size.
- Unmanned operation / delivery may be considered in in-company transportation, and as upstream as possible in the supply chain. However, this may be **less than 10%** of the total

This will be implemented in situations where it is needed, but the impact is judged to be small from the perspective of social impact in Japan as a whole.

Policy

- **While keeping the purpose of solving the labor shortage, we should think of a method to enable various people to conduct delivery work, rather than dealing with unmanned operation.**
  - **Focusing on how to support humans** (e.g. power assist suit, support vehicles, etc. to enable even senior citizens to conduct transport operations.)
  - Consider delivery robots only at the places where human drivers cannot handle

This will be implemented in areas where it is needed, but the impact is judged to be small from the perspective of social impact in Japan as a whole.

Two approaches to resolving the driver shortage

A Unmanned vehicles (logistics services using Level 4 unmanned vehicles)

B Increasing the number of drivers (Level 2, 3 driver assist)

Automated-driving technology can contribute to either approach

For intraregional delivery, participants agreed to focus on providing operational support using automated driving technologies rather than unmanned operation.

Economic Impact

Direct impact		Indirectly affected industries
Change in transportation condition	**Accidents**	● **Damage and injury response**: Vehicle maintenance, insurance, medical care, lawyers ● **Regulations etc.**: Police, court
	Congestion & Environment	● -
Change in transportation demand	**Movement of goods** (Logistics)	● **Main road logistics**: Material / product transportation ● **Intraregional Delivery**: Package delivery service Current scope of productivity analysis (quantitative assessment from the standpoint of resolving the driver shortage in logistics operations is converted to productivity)
	Movement of people (Travel behavior)	● **New transportation demand**: Public transport, retail, education, real estate ● **In-car time utilization**: Retail, advertising, digital media
	Other than the movement of goods and people (vehicles themselves, etc.)	● **Movement automation**: agriculture, real estate management, security ● **Spatial movement**: nursing, medical care
Supplier change	**Vehicle & Vehicle Operation**	● **Hardware**: Automobile manufacturing, sensors, communications equipment ● **Software**: System, IT Scope of current inter-industry analysis
	Infrastructure	● **Public infrastructure**: Road maintenance, communications infrastructure, electricity transmission ● **Private infrastructure**: Parking lot, gas station

The scope of analysis and method to be used to assess economic impact will be finalized upon submission.

Objectives and Overview

Objectives

To organize highly feasible policies, etc. for promoting self-driving vehicles at individual ministries and agencies, private companies etc. and reach general consensus with the WG and so on, in accordance with the overall policy noted in "A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact," **set the objective to formulate multiple scenarios for estimation and sensitivity analysis scheduled to be implemented in FY 2022.**

Overview

- As a result of the discussions at the WG, it was decided to adopt a policy of establishing "without cases," "backcast cases," "base scenarios," "promotion scenarios," and "breakthrough cases" as scenarios/cases for conducting sensitivity analyses. The results of these analyses will be compared to derive a message for external communications.
- The scenarios relating to traffic accidents, traffic congestion and the resulting CO_2 emissions as well as logistics were prepared in accordance with the aforementioned policy, and a tentative plan was submitted to the WG. Furthermore, participants shared the policy of working to refine this tentative plan while continuing to pursue model calculations.

Definitions of Cases / Scenarios

A "scenario" is defined as a sensitivity analysis of diffusion promotion measures based on a diffusion simulation; and a "case" is defined as qualitative analysis and examples.

		Definition	Sample Message
Without cases		● **Introduce functions if introduction of them is mandatory; not introduce if introduction is not mandatory.**	● Mandated AEB will continue to be provided in vehicles for which it is mandated.
Backcast cases (Multiple Patterns)		● **Draw multiple patterns of the ideal future and back-calculate the diffusion of functions necessary to realize that future** ● This is an assumption at a certain point in the future; calculations are not performed in chronological order.	● If the goal is to reduce accidents by 90%, for instance, the diffusion rate of vehicles equipped with XX function must be XX%.
Scenarios from the viewpoint of diffusi-on	**Base Scenario**	● **Driving safety assist functions and automated driving functions are introduced at the most feasible introduction speed that can be currently ed from the perspective of vehicle suppliers.**	● On the other hand, if it diffuses in the current market, the reduction rate for 50 years will be only XX%, resulting in a huge gap as compared to the "backcast" case.

	Diffusion Promotion Scenario	● **Promotional measures that can be promoted by government decisions**
		  ● (due to tax / subsidy) Change of selling price / early launch of sales
		  ● (due to regulation / deregulation) Mandatory & Review of legal system and administrative jurisdiction
		  ● (Logistics related) Promotion of infrastructure development
			● If XX function can be diffused and expanded to XX% by making it mandatory by XX, this effect can be expanded to XX%.

Breakthrough cases		● **Significant changes in the socio-economic environment**
		  ● e.g. Changes in social norms
		  ● e.g. Technological and institutional innovation (technological innovation accompanying the progress of VR and AI, etc.)
		  ● E.g. Changes in driving operation such as low speed driving
			● Furthermore, innovations such as XX and XX can be considered as method and situation changes for more closely approaching the "backcast" case.

Case / scenario definitions will continue to be improved in order to visualize impact while incorporating views from the WG.

Objectives and Overview

Objectives

To revise the diffusion simulation models developed in the previous project, in accordance with the organization of preconditions for study of various impacts and diffusion measures, etc. Additionally, to use the revised models to estimate the number of vehicles diffused, etc., taking into consideration new sales and replacement of old vehicles, for each passenger vehicle automated driving function and vehicle type category, in order to analyze the impact of promotion measures and conduct a sensitivity analysis for important parameters.

Overview

- In FY 2021, for the purpose of model revision, **model preconditions, model revision points and revision methods were studied, such as the automated-driving vehicle categorization methods to be used for diffusion simulation models.**
  - Review the types of automated-driving vehicles (automated-driving vehicle category) of the diffusion simulation model developed in the previous project and set a new category
  - In order to revise the diffusion simulation models using this new automated-driving vehicle category, it is necessary to reconstruct the consumer automated-driving vehicle category selection model. Therefore, in FY 2021, we designed the consumer questionnaire survey.

Diffusion of Private Cars: Detailed Function List

Tentative category in the previous project

Category	expressways	Ordinary roads
C0	Below SAE Lv.1[1]	Below SAE Lv.1[1]
C1	SAE Lv.1 Driver Assistance	SAE Lv.1
C2	SAE Lv.2 Partial driving automation	SAE Lv.1
C3	SAE Lv.3 Conditional driving automation	SAE Lv.2
C4	SAE Lv.4 High driving automation	SAE Lv.3 on the main roads
C5	SAE Lv.4 High driving automation	SAE Lv.4 on the main roads
C6	SAE Lv.4 / 5 Equivalent Full driving automation	

Functions classifications proposed in this project

Driving safety assist	Restricted acceleration in the event of an accelerator pedal / brake pedal error		
	Lane departure warning		
	Inter-vehicle distance warning		
	AEB[2]	Vehicle Target	(1) Short distance ahead
			(2) Omnidirectional long distance
		Pedestrian & bicycle Target	(1) Pedestrian
			(2) Crossing bicycle
			(3) Omnidirectional long-distance bicycle
Driving assist	ACC[2]		(1) Vehicle-only roads
			(2) Ordinary roads
	LKAS[2]		(1) Vehicle-only roads
			(2) Ordinary roads
	Lane change assist		(1) Vehicle-only roads
			(2) Ordinary roads
System driving	System driving Lv.3		(1) Vehicle-only roads during congestion
			(2) Vehicle-only roads
			(3) Ordinary roads
	System driving Lv.4		(1) Vehicle-only roads
			(2) Ordinary roads

Note 1: Category C1 vehicles are equipped with collision damage reduction brakes, acceleration reduction system in the event of accelerator pedal / brake pedal errors, lane departure warning system and vehicle interval distance warning system. Here levels beneath C1 are described as "Below Level 1." Note 2: AEB: Autonomous Emergency Braking (indicating a collision damage reduction brake). ACC: Adaptable Cruise Control. LKAS: Lane Keep Assist System.

Regardless of SAE level, detailed functions were set suitable for impact calculation

Function Details (1/3) Driving Safety Assist

Functions and activation scenarios categorized according to difficulty level of technology

Assuming a reasonable installation start time

	Driving safety assist functions							
	Restricted acceleration in the event of an accelerator pedal / brake pedal error	**Lane departure warning**	**Inter-vehicle distance warning**	**AEB** (vehicle target)		**AEB** (pedestrian & bicycle target)		
				(1) Short distance ahead	**(2) Omnidirectional long distance**	**(1) Pedestrian**	**(2) Crossing bicycle**	**(3) Omnidirectional long distance bicycle**
Activation scenarios	When a vehicle is stopped, the accelerator pedal is suspected to be mistakenly operated, and there is a high possibility of a collision in the front.	When vehicle has departed the lane or has come close to doing so	When there is a high likelihood of a collision with the vehicle in front		- When a vehicle is turning right and there is a high likelihood of a collision with a vehicle coming from the other direction - When there is a high possibility of a side collision at the time of encounter	When there is a high possibility of a collision with a pedestrian	When there is a high possibility of a collision with a bicycle crossing in the front	- When there is a high possibility of a collision with a bicycle coming from a distance (e.g. collision with a bicycle running in the oncoming lane when turning right, collision with a bicycle coming in the front, entanglement when turning left) - When there is a high possibility of a side impact collision at the time of encounter
Function	Engine power control and brake control	Driver warning		Automatically control the braking device				
Time to start installing in mass-market vehicles (Mass-market vehicles: Model of about 3 million yen without options)	Already realized	Already realized	Already realized	Already realized	Already realized	Already realized	Already realized	**2025**
Timing for making mandatory	-	-	-	After FY2021	-	After FY2021	After FY2024	-

Functions and activation scenarios are categorized in detail based on the difficulty level of the technology and the scope of impact (contractor interpretation based on interviews).

Function Details (2/3) Driving Assist

✓ : Expected to be activated
- : Outside ODD

● Note 1: Sidewalks and vehicle lanes are clearly separated by fences and plants, etc. However, it will be a mixed space at intersections and at left or right turnings.
● Note 2: Vehicle flow at normal speed. ● Note 3: Stand-alone activation without using dynamic maps or V2X.

Presumed appropriate ODD patterns

Assuming a reasonable installation start time

				Driving assist functions						
				ACC[3]			LKAS[3]		Lane change assist[3]	
				(1) Vehicle-only road	(2) Ordinary road without signal recognition	(3) Ordinary road with signal recognition	(1) Vehicle-only road	(2) Ordinary road	(1) Vehicle-only road	(2) Ordinary road
Road Classification・Congestion situation	Vehicle-only road	On the main line	Congestion	✓	✓	✓	✓	✓	✓	✓
			Non-congestion[2]	✓	✓	✓	✓	✓	✓	✓
		On-ramps and off-ramps (when going straight)	-	✓	✓	✓	✓	✓	✓	✓
		On-ramps and off-ramps (when merging or diverging)	-	-	✓	✓	-	-	✓	✓
		Toll booth	-	-	-	-	-	-	-	-
	In rest area / parking area		-	-	-	-	-	-	-	-
	Ordinary road (Main road) [1]	When going straight (Other than signalized intersections)	Congestion	-	✓	✓	-	✓	-	✓
			Non-congestion[2]	-	✓	✓	-	✓	-	✓
		When going straight (At signalized intersections)	-	-	-	✓	-	-	-	-
		When turning	-	-	-	-	-	-	-	-
	Ordinary road (Other than main road)		-	-	-	-	-	-	-	-
Time to start installing in mass-market vehicles (Mass-market vehicles: Model of about 3 million yen without options)				Already realized	2025	30	Already realized	25	25	30

ACC for ordinary roads on which no signal recognition is available is theoretically possible as a function, but may actually increase danger, so not studied in this project.

Functions and activation scenarios will be categorized in detail based on the difficulty level of the technology and the scope of impact (contractor interpretation based on interviews)

Function Details (3/3) System Driving

✓ : Expected to be activated
- : Outside ODD

● Note 1: Evacuation spaces where vehicles can stop in the event of an emergency (road shoulder, etc.) have been constructed. Driving is possible only in the lane adjacent to the evacuation space. ● Note 2: Sidewalks and vehicle lanes are clearly separated by fences and plants, etc. However, it will be a mixed space at intersections and at left or right turnings. In addition, pedestrians and bicycles are prohibited from entering the lane. On this road, when the system is driving, accidents caused by the entry of pedestrians will not result in vehicle negligence. ● Note 3: Vehicle flow at normal speed.

Presumed appropriate ODD patterns

Assuming a reasonable installation start time

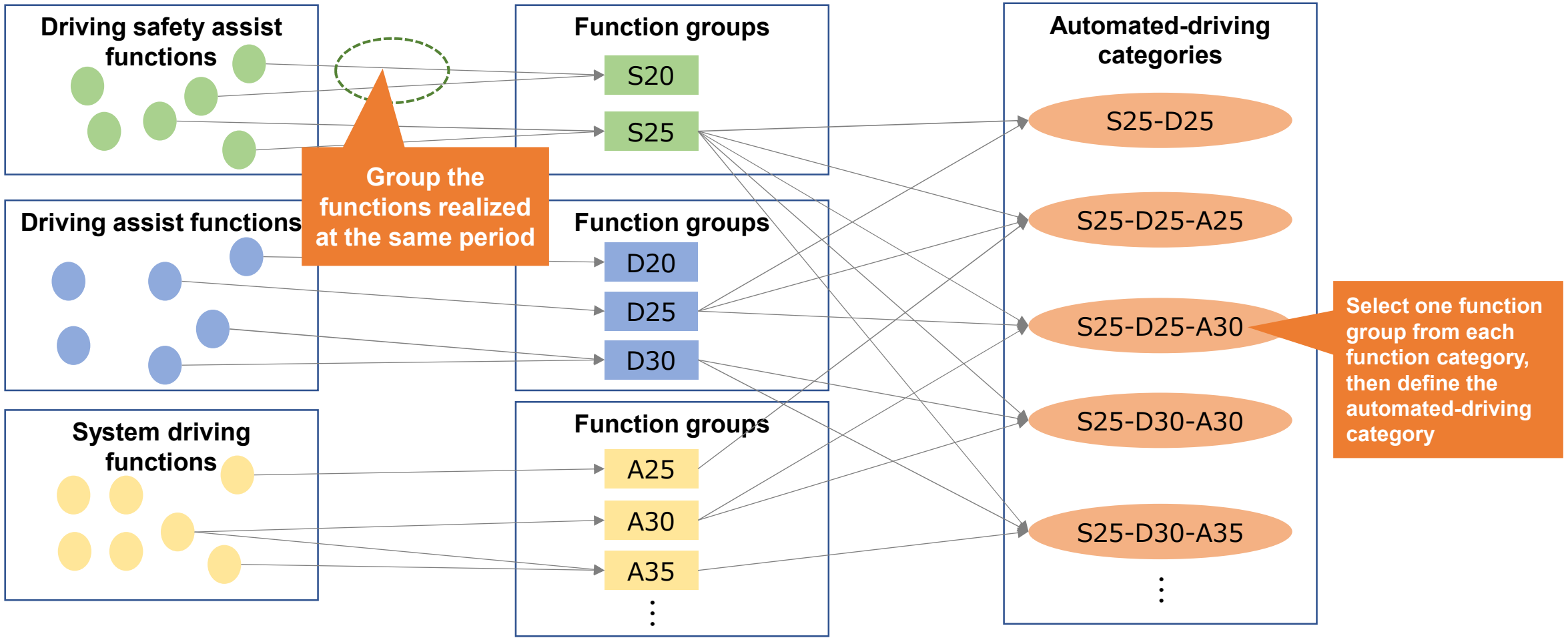
				System driving functions					
				System driving (Lv.3 equivalent)				System driving (Lv.4 equivalent)	
				(1) Vehicle-only road during congestion	(2) Vehicle-only road	(3) Ordinary road during congestion	(4) Ordinary road	(1) Vehicle-only road	(2) Ordinary road
Road Classification • Congestion situation	Vehicle-only road	On the main line	Congestion	✓	✓	✓	✓	✓	✓
			Non-congestion[2]	-	✓	✓	✓	✓	✓
		On-ramps and off-ramps (when going straight)	-	-	✓	✓	✓	✓	✓
		On-ramps and off-ramps (when merging or diverging)	-	-	-	✓	✓	-	✓
		Toll booth	-	-	-	-	-	-	✓
	In Service area / parking area		-	-	-	-	-	-	-
	Ordinary road (Main road)[1]	When going straight (Other than signalized intersections)	Congestion	-	-	✓	✓	-	✓
			Non-congestion[2]	-	-	-	✓	-	✓
		When going straight (At signalized intersections)	-	-	-	-	✓	-	✓
		When turning	-	-	-	-	✓	-	✓
	Ordinary road (Other than main road)		-	-	-	-	-	-	-
Time to start installing in mass-market vehicles (Mass-market vehicles: Model of about 3 million yen without options)				2025	30	35	40	35	? (45)

Level 3 only when there is a congestion on an ordinary road.
Since it has a possibility not to be released as a product because it is not attractive, it will not be considered in this project.

Functions and activation scenarios will be categorized in detail based on the difficulty level of the technology and the scope of impact (contractor interpretation based on interviews)

Establishment of Automated Driving Categories

(1) Technologies will be divided into three categories: driving safety assist functions, driving assist functions and system driving functions.
(2) Within each category, functions that can be achieved during the same five-year time period will be grouped together.
(3) From each of the three categories, each function group will be selected and automated driving categories will be defined as combinations of functions that can make up a vehicle.



Correspondence of Automated Driving Categories and Detailed Functions

Category		Driving safety assist		Driving assist			System driving					Time of market entry
		S20	S25	D20	D25	D30	A25	A30	A35	A40	A45	
		Forward short distance sensing	**Omnidirec-tional long distance** sensing	**Vehicle-only road** ACC, LKAS	**Vehicle-only road** ACC, Lane change assist, **Ordinary road** LKAS	**Ordinary road** ACC, LKAS, Lane change assist	**Vehicle-only road** during congestion Lv.3	**Vehicle-only road** Lv.3	**Vehicle-only road** Lv.4	**Vehicle-only road** Lv.4、**Ordinary road** Lv.3	**Ordinary road** Lv.4	
Category	**S20-D20 (Base)**	✓		✓								Existing
	S25-D20	✓	✓	✓								2025
	S25-D25	✓	✓	✓	✓							2025
	S25-D30	✓	✓	✓	✓	✓						2030
	S25-D25-A25	✓	✓	✓	✓		✓					2025
	S25-D25-A30	✓	✓	✓	✓		✓	✓				2030
	S25-D30-A25	✓	✓	✓	✓	✓	✓					2030
	S25-D30-A30	✓	✓	✓	✓	✓	✓	✓				2030
	S25-D30-A35	✓	✓	✓	✓	✓	✓	✓	✓			2035
	S25-D30-A40	✓	✓	✓	✓	✓	✓	✓	✓	✓		2040
	S25-D30-A45	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	? (2045)

Note 1: The basic model to be equipped with automated driving category functions is expected to be a model that sells for approximately JPY 3 million.
Note 2: In addition to the 11 categories shown in this table, there are also "S20" vehicles without driving safety assist, and vehicles without driving assist functions, for a total of 13 automatic vehicle categories.

The function groups that have been defined will be combined to organize and consolidate automated driving categories.

Diffusion of Privately Owned Vehicles: Conducting Consumer Questionnaires

New options presented to consumers

Three options

First stage selection

However, a simplified version of the second stage menu will also be displayed.

- Equipped with driving safety assist and driving assist functions
- Equipped with Level 3 system driving function on vehicle-only roads
- Equipped with Level 4 system driving function

More detailed options

Second stage selection

ADC[1] S20-D20	ADC S25-D20	ADC S25-D25	ADC S25-D30	ADC S25-D25-A25	ADC S25-D30-A25	ADC S25-D25-A30	ADC S25-D30-A30	ADC S25-D30-A35	ADC S25-D30-A40	ADC S25-D30-A45
JPY X_0	JPY X_1	JPY X_2	JPY X_3	JPY X_4	JPY X_5	JPY X_6	JPY X_7	JPY X_8	JPY X_9	JPY X_{10}

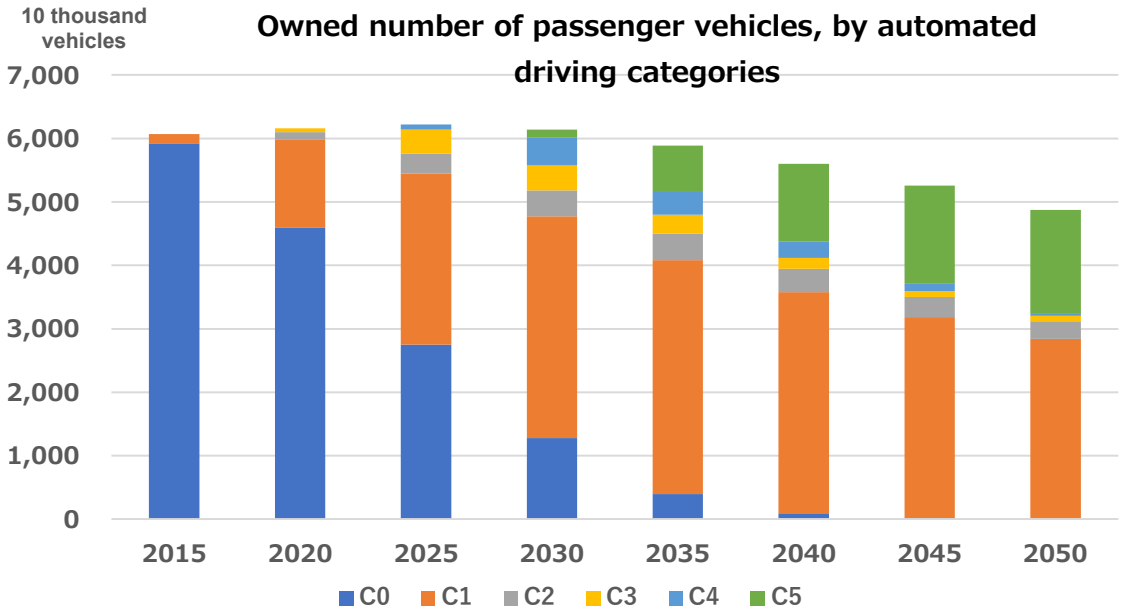
Note 1: Automated Driving Category

Design consumer questionnaires based on summarized automated-driving car categories

Diffusion of Privately Owned Vehicles: Model Output

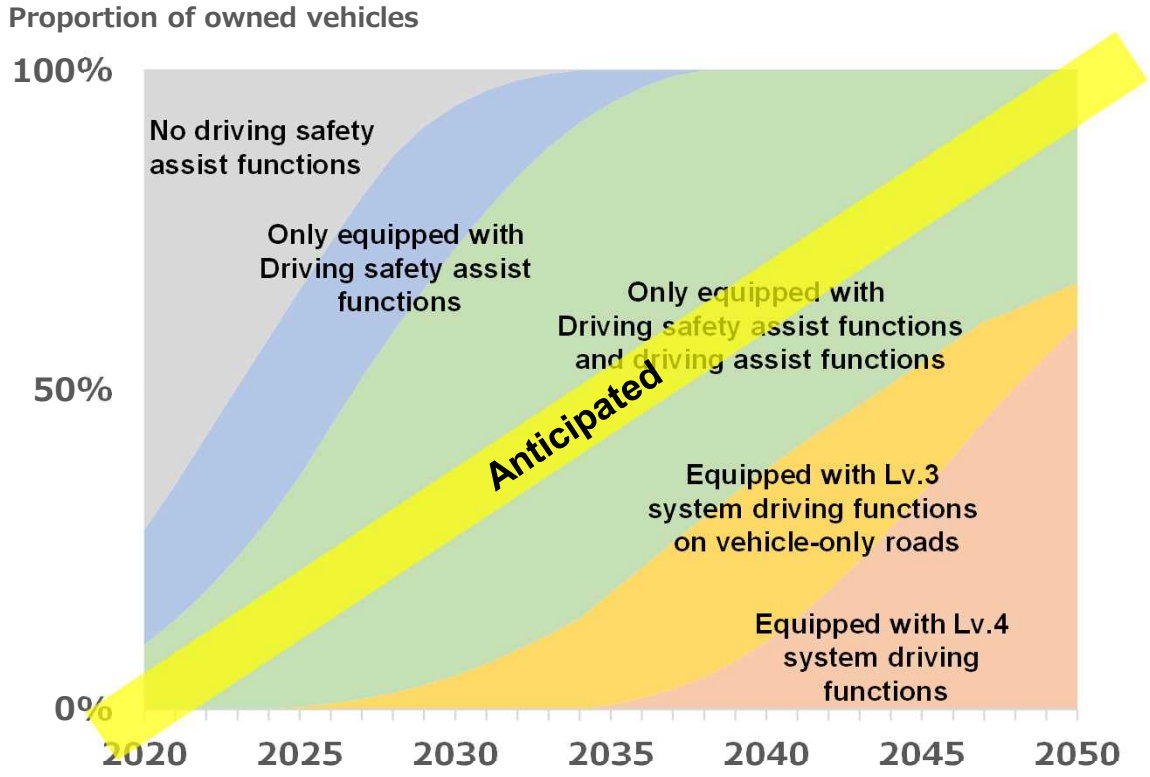
The results of selection of the three options in the first stage will be used to prepare the external communications.
(The results of the second stage selection will be used to calculate accidents, congestion, CO_2 emissions etc.)

Output of the previous phase



Source: The second phase of SIP-Automated Driving for Universal Services Study of the Impact of Automated Driving on Reducing Traffic Accidents and on Others Report Summary Version

Output in this phase (anticipated)



Research outcomes will be organized into categories that are intuitive and easily understandable even to people on the outside, in preparation for external communications. Behind the scenes, these will be linked to detailed functions that are directly connected to calculation of traffic accidents, traffic congestion and CO_2 emissions.

Objectives and Overview

Objectives

To estimate each type of impact based on the content organized in "A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact" through "D. Estimated diffusion rate corresponding to promotion measures in multiple scenarios" and make it the input for "G. Research output" scheduled to be conducted in FY 2022.

Overview

- For "i. Estimated impact on traffic accidents," the calculation policy was noted in "B. Organization of preconditions for diffusion and impact prediction simulation models," so the report will be omitted from this chapter.
- For "ii. Estimated impact on traffic congestion and CO_2 emissions," calculations are planned to be conducted in FY 2022, so **the report for this fiscal year will consist primarily of a report on the preparation of the environment for calculation.**
  - Impacts on traffic congestion that should be assessed and can be suitably assessed will be identified, based on the preconditions for the behavioral characteristics, etc. of self-driving vehicles due to technical innovation, which were organized in "B. Organization of preconditions for diffusion and impact prediction simulation models." Subsequently, the models developed in the previous project will be used to estimate the impact of the reduction in traffic congestion nationwide and the impact of the resulting reduction in CO_2 emissions.
  - Each estimate will be implemented in accordance with the multiple promotion measure, etc. scenarios formulated in "C. Organization of promotion measures (scenario formulation)" and using the self-driving vehicle diffusion rate estimated by means of the models reported in "D. Estimated diffusion rate corresponding to promotion measures in multiple scenarios," and a sensitivity analysis will be conducted for the presence or absence of promotion measures, etc.

Environment for Calculation

Simulator selection

MicroAVENUE (by i-Transport Lab. Co., Ltd.), which has used to assess impact in previous SIP-adus projects, was selected.

Creation of simulation data

- The data is created assuming a section where typical sag congestion occurs frequently in intercity expressways.
- Following the previous years, we created two types of data sets with a two-lane section and a three-lane section, where the conditions for the occurrence of traffic congestion are considered to be different.

Section with 3 lanes in each direction

- The target was a sector measuring approximately 16 km on the Tomei Expressway outbound lanes starting before the Yokohama Aoba IC and extending to just before the Ebina SA. In the simulation, the deceleration component in the uphill sector with a 2.5% uphill grade starting from the Yamato Sag was considered.
- The traffic volume was presumed to be that for a weekday in October, held in the Road Transport Census as well to constitute average traffic conditions.(24 hours from 4:00 a.m. Thursday, October 19, 2017 to 4:00 a.m. of the following day, the target of the previous case study)

Section with 2 lanes in each direction

- The target was a sector measuring approximately 5 km on the inbound lanes of the Kan'etsu Expressway on either side of the Shibugawa-Ikaho IC. In this sector, the deceleration component in the uphill sector from the Shibugawa-Ikaho IC where the sag causes congestion was considered.
- For the traffic volume, a day on which congestion actually occurred due to heavy traffic in the area near the target sector was selected. (24 hours from 4:00 a.m. Sunday, March 4, 2018 to 4:00 a.m. of the following day, the target of the previous case study)

Map source: Prepared by contractor based on map from Geospatial Information Authority of Japan.

Objectives and Overview

Objectives

To estimate each type of impact based on the content organized in "A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact" through "D. Estimated diffusion rate corresponding to promotion measures in multiple scenarios" and make it the input for "G. Research output" scheduled to be conducted in FY 2022.

Overview

- For "i. Quantitative assessment from the perspective of resolving the driver shortage in logistics and transport services," the calculation policy was noted in "B. Organization of preconditions for diffusion and impact prediction simulation models," so the report will be omitted from this chapter.
- For "ii. Quantitative assessment from the perspective of the productivity of Japanese economy and the ripple effects of automated driving on production, etc.," calculations are planned to be conducted in FY 2022, so the report for this fiscal year will consist primarily of an overview of calculations.
  - The method developed in the previous project will be followed. Specifically, the shift to self-driving vehicles and the change in parts due to electrification will be estimated, and then interindustry tables will be used to estimate the impact of the parts change on domestic products and employment in the automotive industry and Japanese industry overall .
  - Although the estimation method will follow the method used in the previous project, input data will be updated to make the data consistent with "A. Qualitative organization of overall approach relating to the assessment of socioeconomic impact" through "E. Estimated no. of traffic accidents, traffic congestion and CO_2 emissions" (calculations are expected to be conducted in FY 2022).

Calculation Method

Approach to Analysis of Economic Ripple Effect

1

- Necessary parts will be estimated based on "what functions should a vehicle in a certain automated driving category be equipped with?“
- The vehicle part configuration for base model parts will be estimated based on the FY 2016 Updated Input-Output Tables.

2

- The economic ripple effect will be estimated, taking into consideration indirect impacts.

Approach to economic ripple effect

Demand of passenger vehicle increase

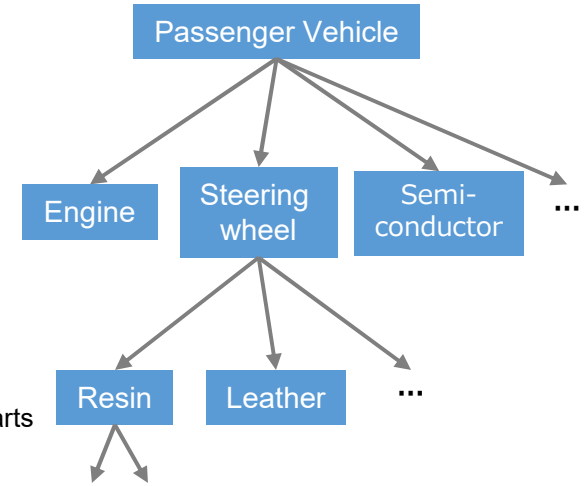
Direct effect
- (1) Production of passenger vehicle increase

+

First order Indirect effect
- (2) Production of passenger vehicle parts increase
- +
- (3) Production of things that produce passenger vehicle parts increase

+

...

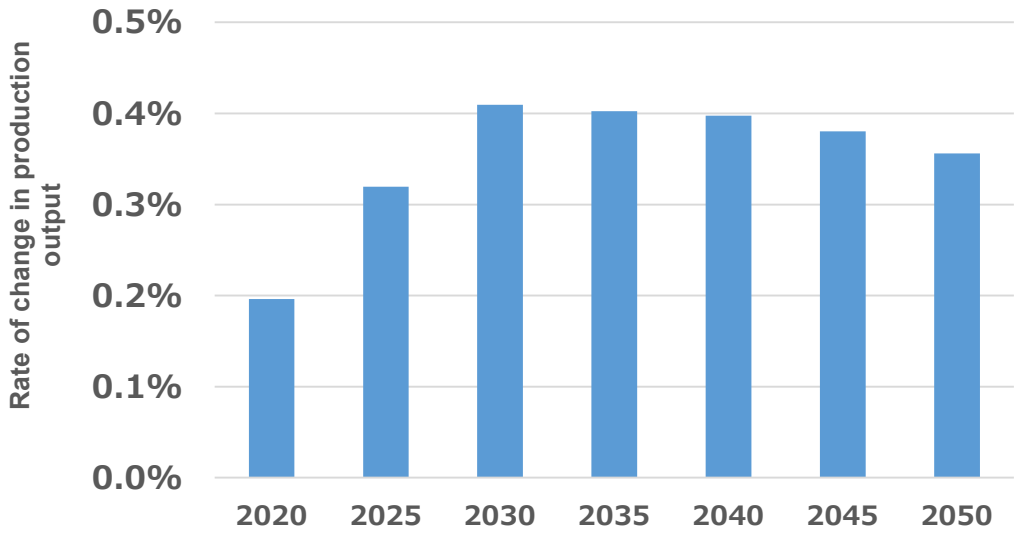


Anticipated Results

Based on the number of new vehicles registered for each automated driving category in the results of the diffusion simulation for each scenario, the impact on domestic products and employment in the automobile industry and Japanese industry overall will be estimated.

Changes in domestic products due to shift to automated driving vehicles and electrification

(as compared to 2015 and the results of trial calculation in the previous project)



Note 1: Direct effect + First order indirect effect
Note 2: The effect of changes in production volume was not included. Only the effects of automated driving and electrification was presented

Research on assessment of the impact of automated driving on society and the economy and on measures to promote deployment

END

This report documents the results of Cross-ministerial Strategic Innovation Promotion Program (SIP) 2nd Phase, Automated Driving for Universal Services (SIP-adus, NEDO management number: JPNP18012) that was implemented by the Cabinet Office and was served by the New Energy and Industrial Technology Development Organization (NEDO) as a secretariat.