4 A Society with Automated Driving

(1) Automated Driving Mobility Services in Regional Communities

Automated Driving Transportation Services in Rural Areas (Overview)

Yoshiyuki Kato (Highway Industry Development Organization)

1 Social Issues in Rural Areas and the Significance of Automated Driving Transportation Services

Japan's population is declining and aging, and rural areas in particular are facing financial pressures and a lack of skilled personnel. Public transportation services have been particularly hit hard by these social conditions. The number of people transported by bus services has been on a significant downward trend across the board, with particularly severe declines in rural areas. (Fig.1)[1] This trend is expected to continue in the future, making it difficult to maintain public transportation services. Therefore, in rural areas, especially in rural areas, where people are increasingly dependent on automobiles, these services may not be able to adequately meet the mobility demands of the elderly after they relinquish their driver's licenses.

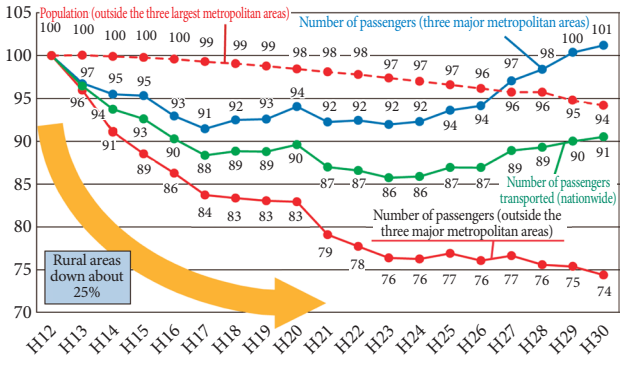


Fig.1: Number of people transported by bus (with the year 2000 as 100)[1]

In the future, it is desirable to build a society in which people who want to travel can travel to their destinations when they want to and by the means of transportation they want to use. Particularly in rural areas, it is also desirable to create a society in which people can travel stress-free without relying on private vehicles. Automated driving transportation services are expected to have a significant effect toward the realization of such a society.

2 Results and Challenges Obtained from the FOTs (Field Operational Tests) in Rural Areas

2.1. Outline of the FOTs in Rural Areas

In order to respond to the challenges of an aging population in rural areas and nationwide, a project called "FOTs of Automated Transportation Services Based on Michi-no-Eki in Rural Areas" has been conducted since September 2017, with the aim of introducing automated transportation services using automated driving technology and ensuring the flow of people and things in rural areas. As of July 2022, automated vehicles have been driven on public roads at 18 locations throughout Japan as part of the FOTs. Based on the results of FOTs with regard to the technical aspects and business models, in November 2019, Michi-no-Eki "Kamikoani" (Akita Prefecture) became the first roadside station in Japan to provide a regular automated driving transportation services to users under a system operated by the local government and other local entities, and has achieved safe operations to date.

In addition, automated driving transportation services were introduced in earnest at Michi-no-Eki "Okueigenji Keiryu no Sato" (Shiga Prefecture) in April 2021, at the Miyama City Hall Yamakawa Branch Office (Fukuoka Prefecture) in July of the same year, and at Michi-no-Eki "Akagi Kogen" (Shimane Prefecture) in October of the same year. (Fig.2)

2.2. Activities in each test field

For the FOTs of automated driving transportation services based at Michi-no-Eki roadside stations, short-term FOTs

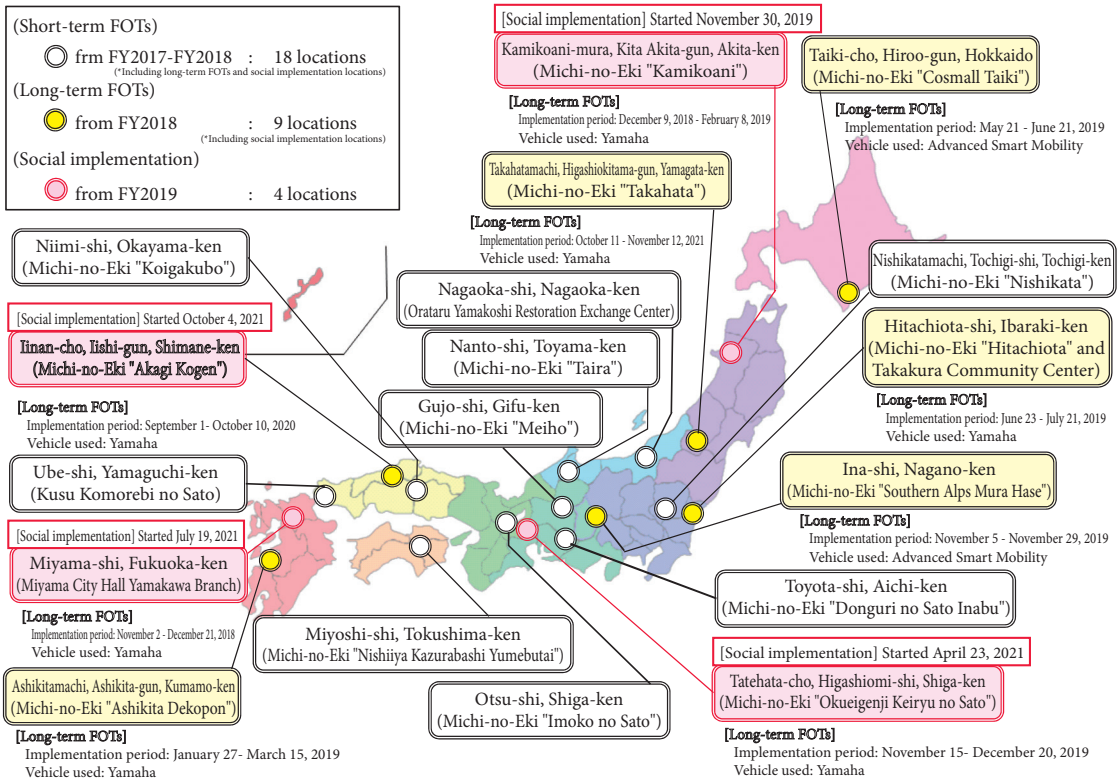
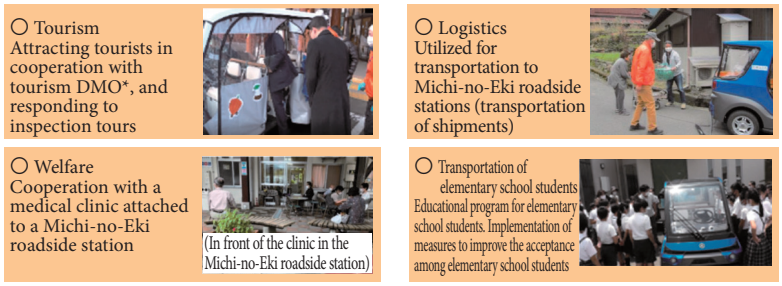


Fig.2: FOTs areas for automated driving transportation services based at such locations as Michi-no-Eki (roadside stations)



*DMO: Destination Management/Marketing Organization

Fig.3: Future plans for multi-purpose use of automated driving transportation services

Fig.4: Efforts by the regions to improve acceptance of automated driving transportation services

lasting approximately one week were conducted at 18 locations nationwide to verify the following five items: (1) roads and traffic, (2) local environment, (3) cost, (4) public acceptance, and (5) regional effects. In addition, with the aim of socially implementing automated driving transportation services, we conducted long-term FOTs of approximately one month at nine locations nationwide to verify the technical aspects (securing of driving space, driving management system) and business model aspects (business implementation system, collaboration with other businesses for multipurpose use, business profitability, etc.). Based on the results of the FOTs, social implementation has been carried out where the various aspects have been proven ready.

In the four regions where the system has been socially implemented, efforts are being made to implement multi-purpose use (Fig.3) for the purpose of improving business continuity and to implement automated driving transportation services (Fig.4) for the purpose of improving public acceptance. In addition, studies are being conducted to contribute to the application to other areas throughout the country.

During the short-term FOTs, types of automated vehicles other than the cart type were also used, but because of their high cost burden and the difficulty of driving them in narrow sections, in areas where the system was socially implemented, cart type (electromagnetic induction line type) vehicles were used.

2.3. Results and Issues from the FOTs

In areas where the system was socially implemented, stable operations of automated driving transportation services over a long period of time were confirmed. In addition, by implementing the services as public transportation services within the framework of private paid passenger transportation, it was confirmed that even automated vehicles can provide sustainable services within community-run operation systems centered on the local governments.

Table 1: Things that need to be passed on to the operating entity in the social implementation area

Number	Items for study	State of progress	Future issues
(1)	Study of multitasking and business continuity of automated driving services	Examination and implementation of initiatives for multitasking in each region	Exploration of the possibility of further multitasking Study of measures to increase the number of users Evaluation of ripple effects on the local economy
(2)	Ordering of the items that must be addressed when operating automated driving services.	Create manuals for automated driving services (vehicle operation manuals) to be referred to by service providers and specialized companies	Conduct workshops for local operating entities and specialized companies Updated based on opinions of operators
(3)	How to respond when a problem occurs in an automated vehicle	Clarify the response flow in the event of a failure, assuming the case of a malfunction of the automated vehicle	Coordinate with automated vehicle manufacturers and local specialist companies on how to respond Consideration and establishment of a maintenance system The results of repairs and such are reflected in the vehicle operation manual
(4)	Methods of responding to accidents that occur during operation of automated driving services	Assuming that an accident has occurred, the parties involved and the boundary points of responsibility for automated driving services are clarified	Verify the appropriateness of the response flow by interviewing experts, insurance companies, etc. Clarify how to respond when an accident occurs and reflect it in the vehicle operation manual
(5)	Clarify facilities, etc. that need to be handed over to the community for the operation of automated driving services.	Creation of road ledgers (listing of locations of infrastructure facilities) Clarify goods and facilities currently in use.	Surveying is carried out in each area and a ledger is prepared showing the locations of the automated driving support facilities

At the same time, as shown in Table 1, in order to continue providing public transportation services using automated vehicles after the completion of this project, it is necessary to examine business continuity, respond to system problems and accidents, and build facilities that need to be handed over to the local communities, and to otherwise ensure that the services are reliably handed over to the operators in areas where social implementation is to take place. Because automated vehicle transportation services are operated throughout the year in the socially implemented areas, there were cases where automated driving became difficult, especially during the winter season, and this became an issue for the continuous provision of the services. (Fig.5)

Fig.5: Challenges in winter driving

3 Future Efforts to Expand Social Implementation of Automated Driving Transportation Services

Many local governments and private companies that are considering the introduction of automated driving transportation services are interested in such services, but lack the know-how to proceed with such projects. We believe that we can support local governments and private businesses that are considering the introduction of automated driving transportation services by making use of the knowledge we have accumulated through our FOTs to date. To this end, we have established "Jidosapo" a contact point for inquiries aimed at municipalities and private businesses that are considering the introduction of automated driving transportation services. (Fig.6) Jidosapo portal site provides an implementation manual for automated driving transportation services and information on business flow, etc. on the Web.

So far, Jidosapo has received inquiries from several local governments and private companies about automated driving transportation services, and in some cases, meetings

Fig.6: Inquiries for automated driving transportation services [2]

have been held to exchange opinions. In order to expand social implementation of automated driving transportation services, we at Jido Support plan to continue receiving inquiries and updating the contents of the Jidosapo website. This includes updating the implementation manual and information on available subsidy programs.

4 Conclusion

In order to address the challenges of an aging of society nationwide, including in rural areas, a study titled "Field Operational Tests of Automated Driving Transportation Services Based on Michi-no-Eki and Other Facilities in Rural Areas" was conducted from September 2017. Short-term FOTs were conducted at 18 sites nationwide, while long-term tests were conducted at nine sites. Based on the results of these FOTs, automated driving transportation services were socially implemented in four areas nationwide.

In the socially implemented areas, it was confirmed that it is possible to sustain the operation of the automated driving transportation services within the operational system of the local government and other such local entities. On the other hand, it became clear that there are things that need to be handed over to the operating entities in order to continue providing the service after the project is complete. It is necessary to ensure that the things required for service provision are handed over to the local operators during the remaining period of the project.

To utilize the knowledge we have accumulated to date, a point of contact for inquiries regarding automated driving transportation services has been established. This contact point will continue to be used to implement the implementation of automated driving transportation services in society.

[References]
(1) Ministry of Land, Infrastructure, Transport and Tourism: FY2021 White Paper on Land, Infrastructure, Transport and Tourism, 2021.6
(2) Highway Industry Development Organization: "Jido Support," a portal site for inquiries on automated driving services https://www.hido.or.jp/jidosapo/, (2022.9)

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1) Establishing the Environment for the Deployment of Transportation Services Relying on Automated Driving

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(Abstract) This project aims for social implementation of automated driving services, which have been started in limited areas, in multiple areas throughout Japan for the purpose of permanent implementation of automated driving mobility services, by examining the sustainability of the project, updating the manual on automated driving mobility services as needed, and contributing to the expansion of examples of social implementation of mobility services with automated driving. First, we will address issues related to social implementation, such as securing road space and operation management, in rural areas where there is little other traffic, as areas where automated driving mobility services can be introduced on prefectural and municipal roads at the current technological level. Four areas that have been socially implemented and one experimental area where a long-term field operational tests (FOTs) was conducted were selected as the target areas for verification. These target areas will sequentially begin offering automated driving mobility services from November 2019, and are implementing measures such as collaboration with other businesses and improving the acceptance of local residents that will contribute to the sustainability of the business. This paper outlines the purpose of introducing automated driving mobility services, the areas selected for studies for practical application, the vehicles to be used, the definition of requirements for social implementation, and the initiatives being taken in each of the social implementation sites and long-term FOTs sites.

Keywords: public transportation, mobility services, social implementation, selected for studies

1 Purpose of introducing automated driving mobility services

The objective of this project is to implement automated driving mobility services, started in limited regions, in multiple regions throughout Japan in view of its permanent implementation. In addition, the sustainability of the project will be studied by solving local social issues in social implementation and by horizontally developing measures to secure driving space, which was considered a common issue during the FOTs. Furthermore, we will update the manuals on automated driving mobility services that we have developed, and contribute to the expansion of examples of practical applications of mobility services with automated driving, which is our ultimate goal.

For the social implementation of mobility services with automated driving, we will first consider rural areas with minimal other traffic as areas where such services can be introduced on prefectural and municipal roads at the current technological level, with the aim of commercializing mobility services with automated driving and logistics services, and solve problems in social implementation such as securing road space and operation management. In addition, guidelines for the introduction of automated driving services in rural areas and standards for road space for automated vehicles will be developed for horizontal deployment throughout Japan. To this end, in cooperation with local governments and related businesses, the project will conduct verification and the necessary studies and research to establish a business model that will enable the continuous operation of mobility services with automated driving.

2 Definition of target areas for practical application, vehicles to be used, and requirements for social implementation

2.1. Areas selected for the tests

In this study, four sites for social implementation using electromagnetic guide wires and one site from the long-term FOTs sites as an example of a magnetic marker were selected for study from among the sites with FOTs conducted in FY2017 and later, based on the selection policy described below. (Fig.1, Table 1)

[Social implementation]

- In implementing this project, a highly feasible business plan can be developed to create a sustainable business model.
- In the region, there are entities that are expected to be the future providers of mobility services and can form a partnership as one of the central implementers of this project.
- Even with the current level of automated driving technology, the driving environment is one in which social implementation of automated driving mobility services is considered possible.
- We can work with local governments and other organizations to implement this project.

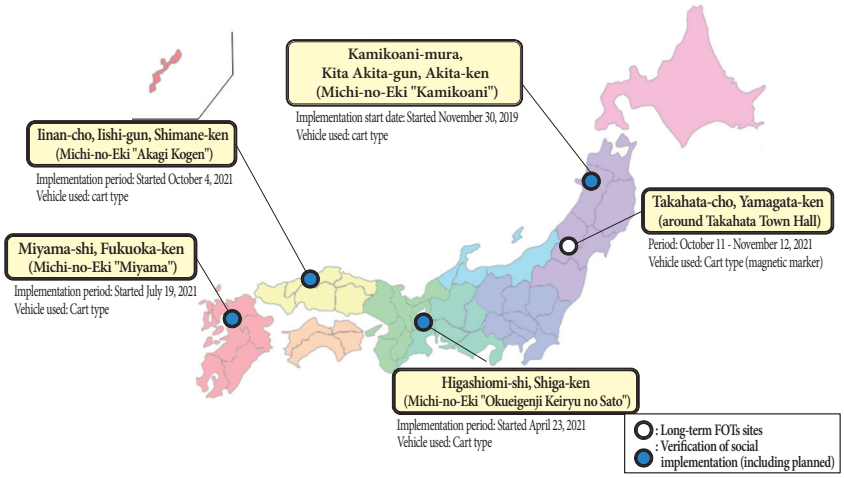


Fig.1: Locations where FOTs were conducted

Table 1: Status of implementation of FOT locations

Test site	Features of long-term experiments/social implementation tests	Operating entity
(1) Kamikoani	・Development of organizational structures with management by local NPOs, Michi-no-Eki (roadside stations), and local companies ・Support for procedures for transfer of infrastructure facilities to municipalities, etc. ・Securing users by providing services in each of the four seasons	・Kamikoani Mobility Service Association (NPO)
(2) Okueigenji Keiryu no Sato	・Study of modes of operation that meet the needs of local residents, tourists, cargo transport, etc. ・Establishment of a management structure that involves various stakeholders within the community ・Study of measures to improve profitability through appropriate operational settings	・Higashiomi City
(3) Akagi Kogen	・Building a sustainable management structure with existing organizations and local volunteers ・Securing of stable income and consideration of services that are easy for residents to use ・Verification of service models to meet diverse mobility demands	・Iinan Town
(4) Miyama	・Transportation service to and from service locations and a service to meet and greet senior citizens ・Home delivery service to assist people with shopping difficulties and shopping behavior under COVID-19 pandemic ・Study of an energy management system utilizing power generation at a biomass center	・Miyama City
(5) Takahata	・Securing means of transportation to support daily outings for the elderly ・Development of mobility services linked to existing transportation that promote tourism and the economy ・Building mechanisms for mobility and service linkages to promote local industry and economy	・No verification of the operational structure will be conducted.

[Long-term FOTs]
- The project should introduce new technologies that will lead to the solution of social implementation issues according to the region.
- Although not a prerequisite, there are places where automated driving FOTs have been conducted in the past and data from these tests can be utilized.


Fig.2 Vehicles used

2.2. Vehicles used

In this project, we used a cart-type vehicle that travels along a predetermined route (equivalent to Level 2 automated driving) by sensing the magnetic force from electromagnetic guide wires buried in the road surface. (Fig.2) In addition, at the long-term FOTs site (Michi-no-Eki "Takahata"), a vehicle that uses a magnetic marker to identify its own location was used instead of the electromagnetic guide wire method to evaluate the feasibility of driving.

In conducting the FOTs, we are making necessary improvements in cooperation with the vehicle manufacturer, such as measures for user comfort, including measures to prevent cold and heat stroke, and the addition of functions that contribute to management and operation.

2.3. Definition of requirements for social implementation

In order to contribute to the resolution of issues and the identification of measures for the practical and permanent introduction of automated driving mobility services, we are studying the requirements that should be defined for the FOTs environment. Specifically, the items required for the introduction of mobility services with automated driving in rural areas are categorized into "items required for permanent installation" and "items related to securing driving space for automated vehicles." In addition, in order to comprehensively verify the categorized issues, we have clarified the issues to be verified in FOTs in each region. The results of defining the requirements for social implementation are shown in Tables 2 and 3.

Table 2: Items required in permanent automated driving mobility services

Verification items	Specific verification details
(1) Establish routes, diagrams, transit methods, etc. based on the needs of users, such as cooperation with public transportation and other vehicles.	1. Improve the overall environment for public transportation in the village by reviewing its secondary transportation system 2. Transit support based on shared roles with key transit systems (community bus) 3. Consider adding shortcut routes to improve convenience and usage promotion 4. Mobility services linked to community buses, mobility support in disaster areas 5. Coordination with existing JR and other means of transportation, dispersion of demand for existing transportation
(2) Diversified fee collection methods	1. Verification of the possibility of diversifying revenues such as publicity income by setting up a monthly or child fee, small volume freight transportation, etc. 2. Increase revenues through setting appropriate freight rates and revenues from freight transportation, etc. 3. Investigate introduction of cashless services and linkage with local currencies
(3) Examine and verify the stable operation of a management system and a system for monitoring operation status and making reservations, etc.	• Simplify reservation and operation methods and establish an operation manual in cooperation with the architecture project
(4) Studies of sustainable business feasibility	1. Investigation of an operation plan with future operators, and the use of the system for self-paid use, etc. 2. Reduce operating costs with service every other day, taking into account the season, etc., and by using a reservation system, etc. 3. Operate about 4 days a week, focusing on holidays when tourism demand is expected to be high 4. Add shortcut routes to promote convenience and usage 5. Home delivery service to residents along the route
(5) Compliance with various laws and regulations	• Establish manuals for guide wires and vehicle maintenance, and provide education and training to local companies, etc.

Table 3 Items related to securing driving space for automated vehicles

Verification items	Specific verification details
(1) Measures to secure driving space using vehicle-toinfrastructure cooperation technology, etc.	1. Securing permanent dedicated space in farm road sections (consideration of operation by making the space free of people, etc.) 2. Check and study solutions for car and infrastructure issues such as magnetic marker control, etc. 3. Separation structure considering the speed difference from the national highway, installation study of entrance/exit breakers
(2) Measures to ensure traffic safety in areas where non-cooperated automated driving is difficult	1. Installation of road markings, signboards and vehicle alerting signboard using vehicle-to-infrastructure cooperation system 2. Consideration of a separate structure and dedicated space for pedestrians and bicycles 3. Consideration of installing a waiting area for passing and overtaking 4. Study on the installation of measures to guide ordinary cars to bypass and to control the speed
(3) Appropriate division of roles between car and road for implementation	• Based on the results of (2) above, we are planning to compile a plan for the road environment, roadside environment, etc.
(4) Effective communication methods (HMI) to harmonize with surrounding traffic	1. Penetration of services to diverse generations in cooperation with educational institutions (fostering understanding and awareness of automated driving services to multiple generations through educational programs for children) 2. Consideration of providing information (sound and light) on alerts from the car through collaboration with SIP-adus (HMI Team), etc.
(5) Evaluation of the driving environment	1. Study of operational conditions based on regional characteristics, season, climate, etc. 2. Study on the impact of laying guide wires, RFID, etc. on pavement

3 Status of efforts by region

3.1. Social implementation of automated driving mobility services at Michi-no-Eki "Kamikoani"

(1) Overview of the Project

Michi-no-Eki "Kamikoani" has been implementing the service socially since November 2019 to revitalize local communities and provide mobility support mainly for the elderly through automated driving. The service operates on a route that connects the Michi-no-Eki, medical clinic, and other locations with three villages, using Michi-no-Eki "Kamikoani" as a base. (Fig.3) (As of July 2022, the service has been in operation without accident for more than two years.

(2) Status of other business collaborations

In anticipation of the transfer of automated driving mobility services to local communities, the possibility of collaboration with tourism businesses and new collaborative projects are being studied to improve business continuity when the service is transferred to a local operator. In addition, based on local transportation needs, the project is transporting foodstuffs from the Michi-no-Eki to the meal service center and collaborating with convenience stores along the operation route. (Fig.4)

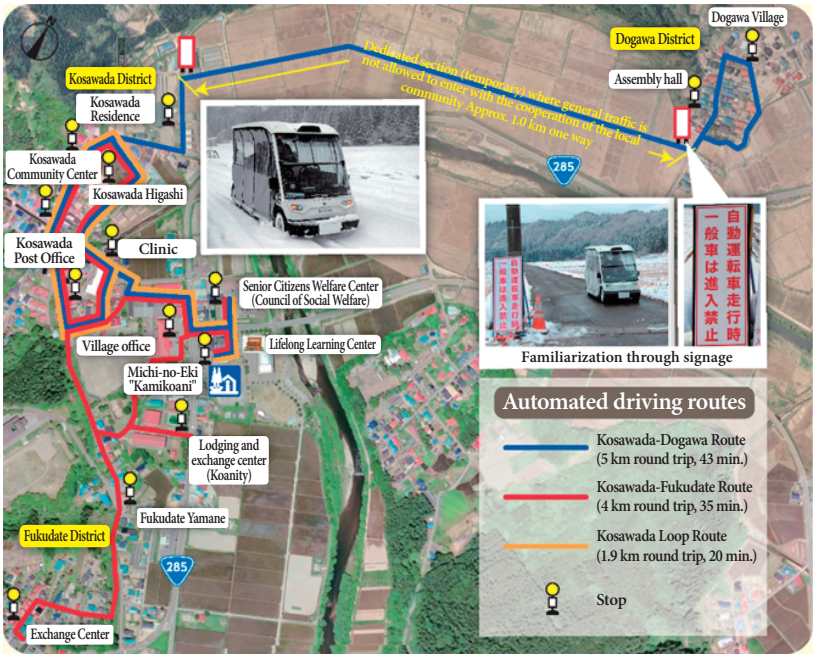


Fig.3: Operational route at Michi-no-Eki "Kamikoani" (Map source: NTT Spatial Information)

Fig.4: Examples of initiatives linked to automated driving services

(3) Efforts to improve social acceptability

The project is implementing both programs for residents along the route and for tourists. Specifically, the project is soliciting nicknames for automated vehicles, holding agricultural experience tours in cooperation with residents along the route, and holding a photo exhibition of automated vehicles.

3.2. Social implem entation of automated driving mobility services at Michi-no-Eki "Okueigenji Keiryu no Sato"

(1) Overview of the Project

Michi-no-Eki "Okueigenji Keiryu no Sato" has been implementing the service socially since April 2021, with the objectives of (1) regional revitalization and mobility support mainly for the elderly via automated driving, and (2) service utilization by tourists (visitors to the Michi-no-Eki, mountain climbers, and campers). The service is based at Michi-no-Eki Okueigenji Keiryu no Sato," and operates over a distance of 4.4 km (approximately 30 minutes) between the Michi-no-Eki and the entrance to Choshigaguchi. (Fig.5) The automated driving mobility service is operated by Higashiomi City and Eigenji Taxi, a transportation company, as the operator and manager, respectively, under the "Private Paid Passenger Transport Service with the Cooperation of Transportation Companies" system.

(2) Status of other business collaborations

In anticipation of the transfer of automated driving mobility services to the region, and in order to improve the continuity of the business, measures are being implemented to promote use, such as publicizing model courses in cooperation with restaurants along the route, transporting shipments to morning markets (mountain village markets) held at Michi-no-Eki, and supporting transportation for residents to COVID-19 vaccination sites (clinics). (Fig.6)

(3) Efforts to improve public acceptance

The project is implementing initiatives targeting both local residents and tourists. Specifically, the project is planning automated driving tours in collaboration with restaurants along the automated driving route, collaborating with traveling clinics for COVID-19 vaccinations, and collaborating with a salon held at a Michi-no-Eki.

3.3. Social implementation of automated driving mobility services at the Yamakawa Branch Office of the Miyama City Hall

(1) Overview of the Project

The Yamakawa Branch Office of the Miyama City Hall has been implementing the service socially since July 2021 with the objectives of (1) creating a base for people to gather (LeFranc, etc.) and revitalizing human flow through a transportation service, and (2) building a safe, secure, and sustainable regional public transportation system in the future. The service is based at the Yamakawa Branch Office of the Miyama City Office and the Biomass Center LeFranc, and operates on a route connecting the A-Coop Yamakawa store and the Biomass Center LeFranc. (Fig.7) This location is

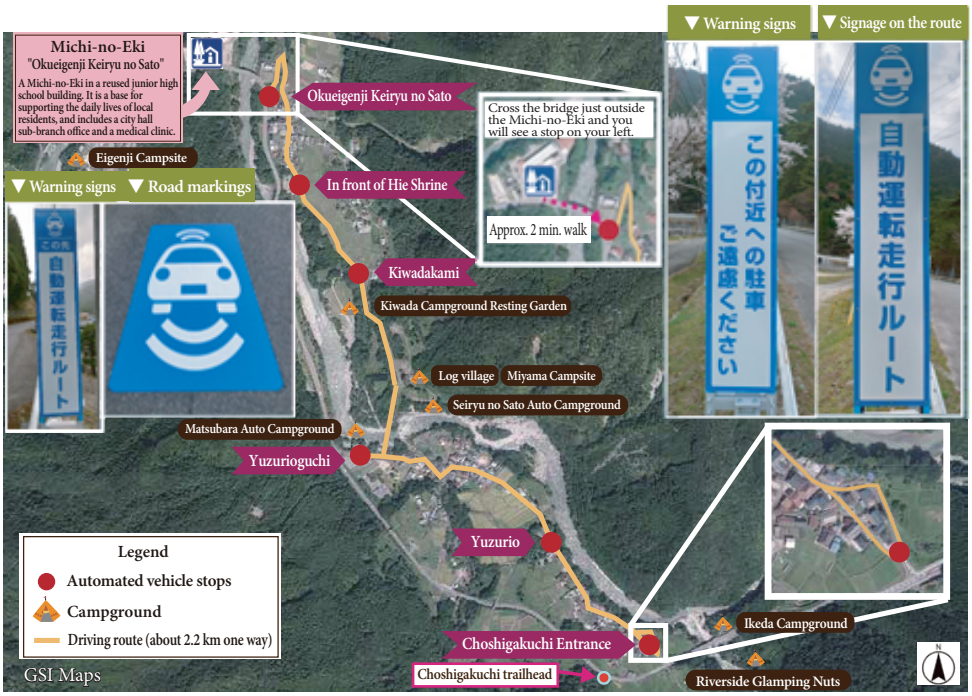


Fig.5: Operational route at Michi-no-Eki "Okueigenji Keiryu no Sato" (Map source: NTT Spatial Information)

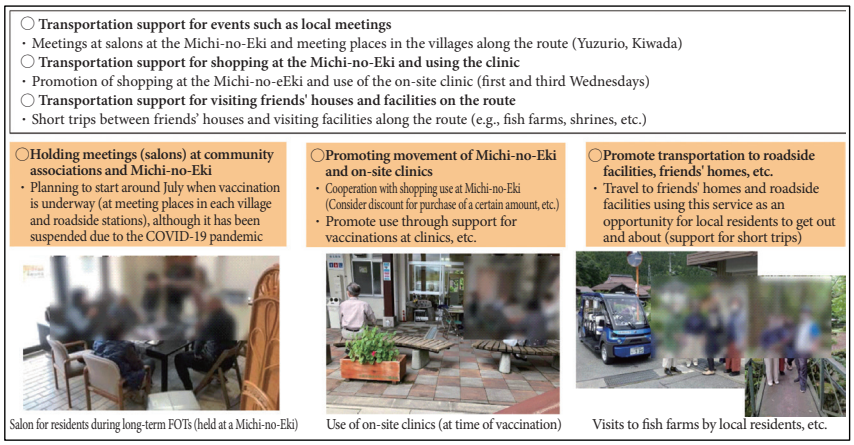


Fig.6: Status of other business collaboration efforts

operated under the "Private Paid Passenger Transport Service with the Cooperation of Transportation Companies" system, with Miyama City acting as the operator and the transportation operator (Setaka Taxi, which is commissioned to operate the community bus) acting as the operator of the service.

(2) Status of other business collaborations

At this location, a system called "Mobisuke" has been introduced to comprehensively support automated driving mobility services by performing various analyses such as fare collection, operation management, and boarding/exiting data. Miyama City's automated driving mobility services are operated as one of the community bus services, and since there are transfers to and from the community buses, the entire community needs to have a bird's eye view of the operation management. Therefore, "Mobisuke" was introduced to the community bus service, and a system was constructed to check the operation status on a map. An overview of the operation management system is shown in Fig.8.

(3) Efforts to improve public acceptance

In order to operate automated driving services sustainably, it is important to create momentum for the acceptance of automated driving in the community as a whole and to improve the public acceptance of automated driving among local residents. In order to improve social acceptance, it is necessary to make automatic driving known not only to the elderly in the community but also to the community as a whole. Therefore, as a program to promote

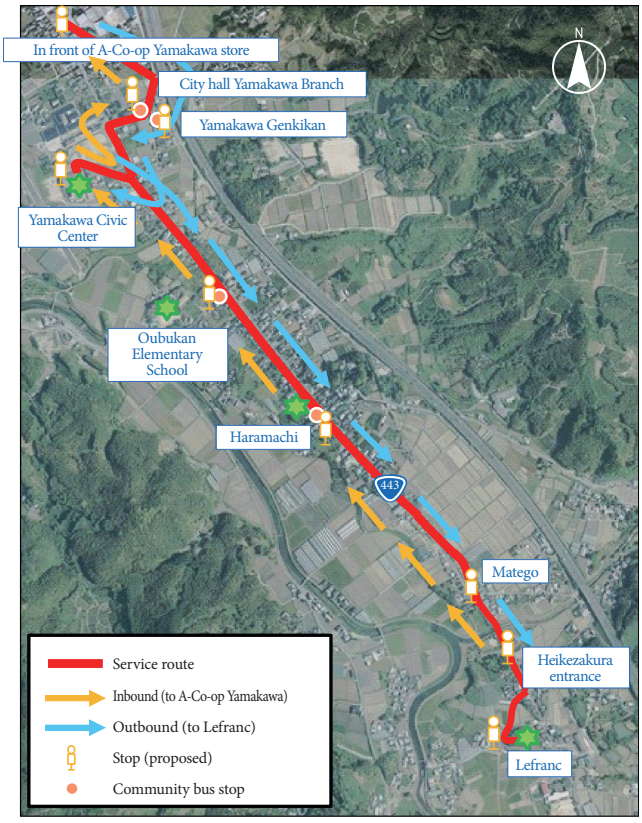


Fig.7: Operational route at the Yamakawa branch office of the Miyama City Hall (Map source: NTT Spatial Information)

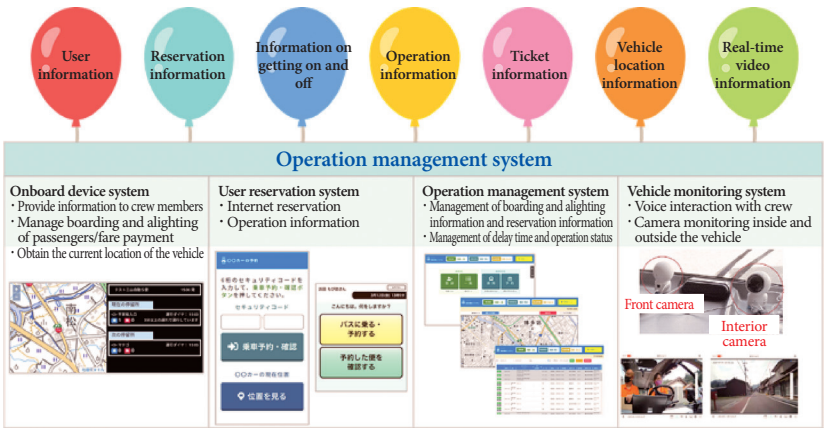


Fig.8: Overview of the operation management system

understanding of automated driving mobility services, we held an on-site lecture on the mechanism of automated driving for fifth graders on June 30, 2021, and for sixth graders on November 16, 2021, at Oubukan Elementary School along the route. (Fig.9)

■ Classes

Fig.9: Onsite lecture

3.4. Social implementation of automated driving mobility services at Michi-no-Eki "Akagi Kogen"

(1) Overview of the Project

Michi-no-Eki "Akagi Kogen" has been implementing the service socially since October 2021 with the following objectives: (1) to build a sustainable management system centered in Iinan Town with existing organizations and local volunteers, (2) to secure stable income such as commuter passes, and to brush up the service (operation format) for easy use by residents. The service operates along the Akana-juku route, which is based at Michi-no-Eki "Akagi Kogen," and circles the Michi-no-Eki, Iinan Town Hall, and other locations. (Fig.10) In addition, a shortcut (branch) is provided in the center of the route, and three routes are used: the northern route, the southern route, and the all-around route. This location is operated under the "Private Paid Passenger Transport" system, with Iinan Town acting as the operator of automated driving mobility service.

(2) Status of other business collaborations

For publicity and promotion of automated driving services, the local community actively conducts its own publicity in cooperation with Michi-no-Eki and tourist associations. The means of publicity include posters, flyers, banners, social media, and handwritten publications, etc. (Fig.11) In order to avoid one-way information transmission, the company is working on publicity that takes into consideration the interests and concerns of everyone from children to the elderly by creating a coloring corner and a board game with the route as a motif.

(3) Efforts to improve public acceptance

In order to improve public acceptance of automated driving mobility services among local residents, the project is fostering affection for the vehicle by publicly soliciting nicknames, and is also promoting user guidance, trial rides, and even registration of users at salons where elderly people gather to facilitate their use when shopping and participating in community activities.

Fig.11: Diverse public relations activities

Fig.10: Route operated at Michi-no-Eki "Akagi Kogen" (Map source: NTT InfraNet)

3.5. Long-term automated driving mobility service FOTs at Michi-no-Eki "Takahata"

(1) Overview of the Project

Long-term FOTs were conducted at Michi-no-Eki "Takahata" for 33 days from October 11 to November 12, 2021, to (1) confirm adaptability and operability as a means of public transportation, (2) confirm the effectiveness and acceptability of short-distance mobility services and identify issues in building a business model, and (3) verify the technology behind automated driving support. The route started and ended at the Takahata Public Hospital, with the Takahata Town Hall as the base. (Fig.12)

At this location, FOTs were conducted using an automated vehicle with a magnetic marker system instead of the conventional electromagnetic guide wire system. The vehicle's position is determined by repeated estimation and correcting the estimated value using the magnetic marker. In addition, the vehicle's travel route is set in advance, and the target steering angle and speed are determined according to the vehicle's travel position by associating the vehicle's speed and stop commands. Fig.13 shows an image of the vehicle's own vehicle location determination method and traveling method.

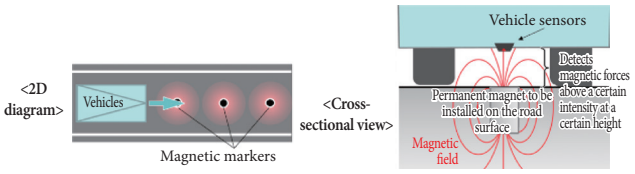
(2) Technical verification of automated driving support

At this location, we conducted FOTs using an automated vehicle with a magnetic marker system and analyzed the occurrence of manual intervention. (Fig.14) The number of occurrences of switching to manual operation and pauses due to manual operation of the brake and steering wheel during automated driving was 137 (0.57 times per trip, 0.76 times/km over a total automated driving distance of 180 km) for a total of 240 trip. Of these, 18 were due to stoppages caused by the automated driving system (GPS and magnetic sensors).

In the aisles of facilities and parking lots, manual interventions such as stopping to ensure safety and overtaking off the path occurred due to the erratic behavior of other vehicles and pedestrians. On the other hand, no emergency intervention to avoid collisions occurred.

(3) Efforts to improve public acceptance

On October 30, 2021 (Saturday), a seminar on automated driving and a trial ride were held along the route of the



▲ Image of magnetic marker reading

Fig.13: Image of magnetic marker reading

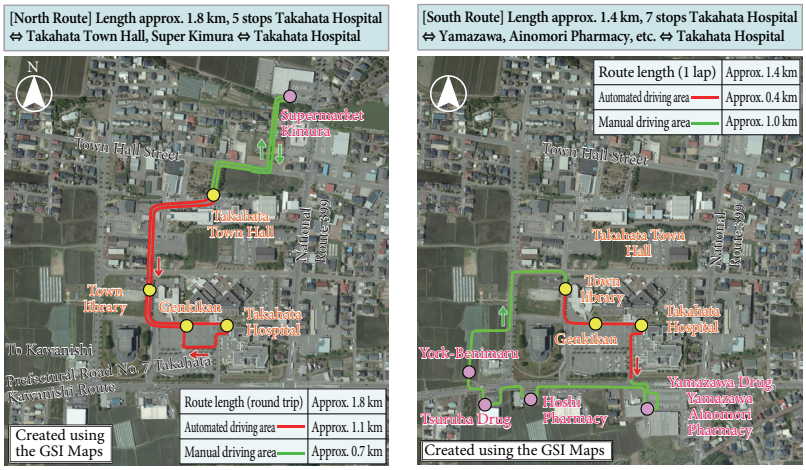


Fig.12 Experiment route at Michi-no-Eki "Takahata" (Map source: NTT Spatial Information)

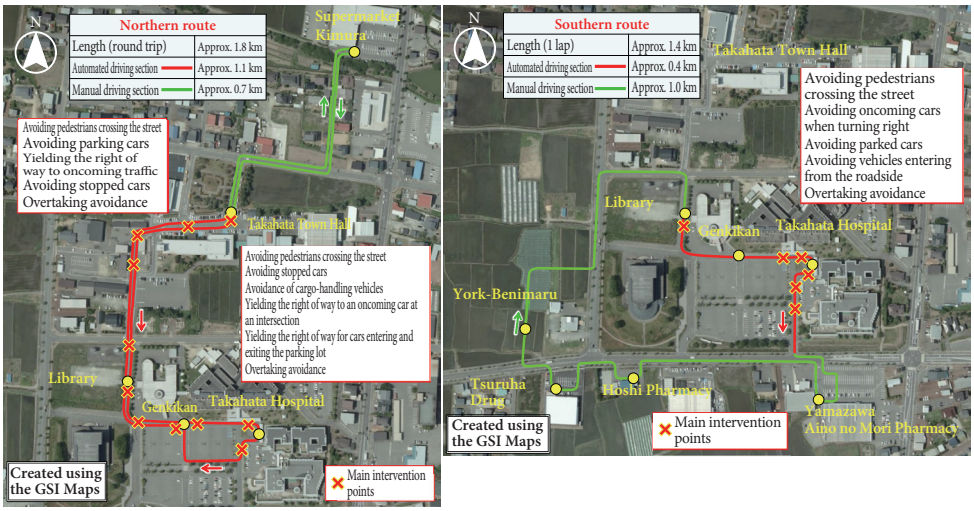
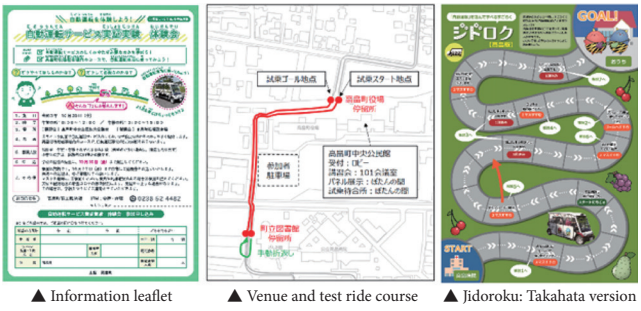


Fig.14: Manual intervention locations and main reasons (Map source: NTT InfraNet)

automated driving FOTs with 78 elementary and junior high school students and their guardians participating. (Fig.15) The results of the questionnaire confirmed positive opinions such as "I felt safe at low speeds," "I want to tell my family about it," and "It would be good if it could be used at school and in other places around me."



▲ Information leaflet ▲ Venue and test ride course ▲ Jidoroku: Takahata version

▲ Status of trial ride ▲ Exhibition description ▲ Automated driving board game

Fig.15: Automated driving seminar and trial ride

4 Conclusion

In this project, we verified the practical application of the automated driving mobility services at four social implementation sites and one long-term FOTs site, with the aim of implementing the service, which had already been started in limited areas, in multiple areas throughout Japan on a permanent basis.

The first social implementation of automated driving mobility services in Japan began at the Michi-no-Eki "Kamikoani" in November 2019, followed by Michi-no-Eki "Okueigenji Keiryu no Sato" in April 2021, the Yamakawa Branch Office of the Miyama City Office in July of the same year, and Michi-no-Eki "Akagi Kogen" in October of the same year. The above four areas use electromagnetic guide wire automated vehicles, but at the long-term FOTs site (Michi-no-Eki "Takahata"), we conducted FOTs using a vehicle that uses a magnetic marker to locate its own position.

In social implementation at four locations nationwide and the long-term FOTs at one location, various efforts are being made to improve the sustainability of the project, including collaboration with other projects and increasing the acceptability of the project among local residents. In addition, the long-term FOTs confirmed the feasibility of a new type of automated vehicle. In the future, it will be necessary to organize the items to be handed over to the local operating entities in order to continue providing automated driving mobility services after the project is completed. In addition, we will continue to work on horizontal development utilizing the know-how cultivated through this project in order to expand the number of cases of automated driving mobility services.

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4 A Society with Automated Driving

(2) Public Acceptance of Automated Driving

Initiatives for Fostering Public Acceptance (Overview)

Yuichi Araki, Hiroaki Kimura (Cabinet Office)

1 Background and Overall Strategy

In order for the public at large to accept the new innovation of automated driving and use it with confidence, it is necessary to promote a correct understanding of automated driving, present quantified benefits, raise awareness, and develop supporting systems such as insurance. The SIP-adus (Cross-ministerial Strategic Innovation Promotion Program (SIP) Automated Driving for Universal Services) has focused mainly on the dissemination of information and the quantification of effects, while also promoting initiatives aimed at a wide range of targets based on a long-term plan.

In terms of information dissemination, test-ride events were held in conjunction with the FOTs (Field Operational Tests) in the Tokyo waterfront area, and online events were held in conjunction with FOTs of an automated driving mobility services in rural areas. Furthermore, while clarifying the target audience communication has been strengthened through interactive information dissemination.

On the other hand, we have also worked on quantifying the effects of automated driving on society in order to provide a more complete explanation of the impact of this technology. We have developed a method for estimating the social and economic impact of the spread of automated driving, and also developed a method for measuring the effect of activities to foster public acceptance itself.

2 Information dissemination via the Internet, social media etc.

We have had a Website since the first phase of SIP-adus, which has disseminated information primarily on research results and the SIP-adus Workshop, as international conference. It was pointed out, however, that the website is for specialists and somewhat difficult for the general public to understand.

From the perspective of fostering public acceptance, we therefore opened the SIP-café, a community for considering an automated driving society (Fig.1), in October 2019, in conjunction with the start of the FOTs in the Tokyo waterfront area and to disseminate information and promote understanding among the general public and others. Under the responsible editorial supervision of Kazuo Shimizu, an international automotive journalist, information on automated driving was actively and

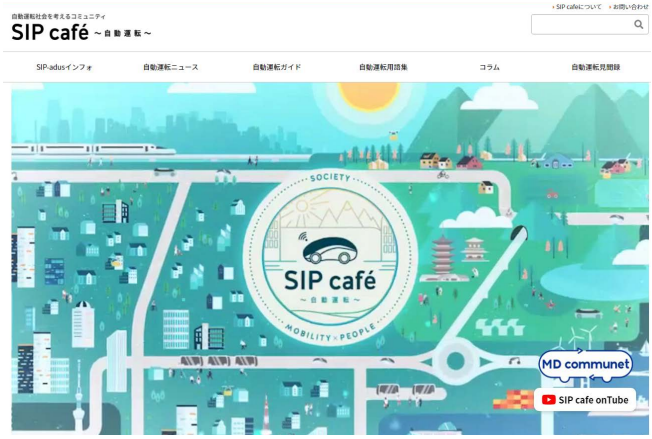

Fig.1: SIP-café internet website top page [1]

continuously distributed through content relating to automated driving, focused on the medium of video but also including other easy-to-understand information on automated driving for the general public in the form of articles and editorials by experts who are well versed in automated driving. Since its establishment, the website has consistently published an average of more than 10 articles per month on automated driving related efforts by related ministries and agencies, including the SIP-adus, as well as articles by columnists and other experts on automated driving, and information on efforts for automated driving technology development by private companies.

We have also created other video content. This includes videos on the future vision for society through the realization of automated driving and the details of the testing conducted by the participants in the FOTs in the Tokyo waterfront area. We have also disseminated information in conjunction with each of the SIP-adus projects, including other information on the FOTs in the Tokyo waterfront area and rural areas, a portal site for geographic data architecture (MD Communet®), an app contest (KYOTO Raku Mobi Contest), and virtual safety validation technology (DIVP®).

Interactive communication has also been promoted by linking with social media such as Twitter and Facebook.

On the other hand, for the website for specialists, we tried to disseminate the research results of the first and second phases of SIP-adus in English in a timely manner, with an awareness toward international cooperation. (Fig.2)

Fig.2: SIP-adus website top page (Japanese and English) [2]

3 Media /Public Events

3.1. Events for media & automated driving professionals

The SIP-adus has conducted various events for the media and automated driving professionals, both in real life and online, as shown in Table 1.

Table 1 : List of Events

Date	Event Name
October 2020	Webinar "Automated Driving Related Laws"
November 2020	Status Report Meeting, SIP-adus Workshop 2020
March 2021	Webinar "Automated Driving Level 3 Law Revision and Technical Standards" Interim Results Presentation Event
April 2021	Test-ride event
June 2021	Webinar "Liability Issues in Automated Driving"
October 2021	Test-ride event
December 2021	Webinar "HMI and Driver Overconfidence"
January 2022	Webinar "Software Updates and Cybersecurity"
March 2022	Webinar "Cooperative Areas of Mobility Data Utilization and Data Provision"
From May 2022	Automated Driving Live News (10 times in total)
September 2022	Test-ride event
March 2023	Final Results Presentation Event

In November 2020, our results were reported at the Tokyo International Forum with the participation of policy implementers in order to promote collaboration among the various projects of the SIP-adus. The session was held as part of the SIP-adus Workshop 2020, and was broadcast online with English materials and simultaneous interpretation to more than 1,000 people in Japan and abroad.

In addition, a total of six webinars were held from October 2020 on the following themes: "Automated Driving

Related Laws" in October 2020; "Automated Driving Level 3 Law Revision and Technical Standards" in March 2021; "Liability Issues in Automated Driving" in June 2021; "HMI and Driver Overconfidence" in December 2021; "Software Updates and Cybersecurity" in January 2022; and "Cooperative Areas of Mobility Data Utilization and Data Provision" in March 2022.

In conjunction with the Tokyo 2020 Olympic and Paralympic Games, a test-ride event for the general public and an exhibition of the results of FOTs were scheduled to be held in the Tokyo waterfront area in cooperation with the Japan Automobile Manufacturers Association, but these were cancelled due to the spread of COVID-19. As a replacement, the Automated Driving Showcase to Change the Future was held in March 2021 in collaboration with the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure, Transport and Tourism, combining a symposium-style event and the presentation of interim results in a hybrid format of a real and virtual venue.

This interim results presentation event was intended mainly for operators and engineers involved in automated driving services, but sought to provide the interim results of the SIP-adus in a form that was also understandable to as many people as possible, including the general public. The exhibition featured exhibits of the results of technological development related to the building and distribution of traffic environment information, including SPaT (Signal Phase and Timing) information, merging lane assistance information, and road traffic information using vehicle probes. It also exhibited the vehicles used in the FOTs in the Tokyo waterfront area and rural areas, actual equipment and video clips related to the construction of a geographic data distribution portal, a safety evaluation environment in a virtual environment, and other related topics. In addition, online guided tours and virtual exhibits using a 3D walk-through were also used, creating an event that responded to the "new normal" of living with COVID-19. [See Section 4 (2) 3) for more details]

Furthermore, in April 2021, a media test-ride event was held in the Tokyo waterfront city area, staged with the cooperation of approximately twenty vehicles provided by nine companies who participated in the FOTs in the Tokyo waterfront area. The event was well-received by the media, who commented that they were able to deepen their understanding of the technology and concept due to being able to test-ride multiple automated vehicles at the same time. With that in mind, we held another test-ride event in the Tokyo waterfront city area in October 2021, again with the cooperation of approximately twenty vehicles provided by nine companies who participated in the FOTs in the Tokyo waterfront area, while expanding the range of the target media. The introduction of the vehicles on YouTube by a female journalist and tagging the content with "Work & Life" helped to expand dissemination of information on automated driving to a diverse range of people, including not only car enthusiasts but also people of child-rearing age and others.

In September 2022, a test-ride event was held again in the Tokyo waterfront city area under the theme of "Japan leads the world in traffic safety for the future Cohesive Society that respects diversity." It was targeted at media, Generation Z students, and local citizens, with the cooperation of vehicles provided by the participants in the FOTs in the Tokyo waterfront area. The final results of the five years of the SIP-adus will be presented to the general public during the Final results presentation event in March 2023.

3.2. Citizen dialogue

Table 2 : List of Events

Date	Event Name
December 2018	Citizen Dialogue: Shodoshima-cho, Shodo-gun, Kagawa
August 2019	Citizen Dialogue: Ina City, Nagano
January 2021	Citizen Dialogue: Maebashi City, Gunma
March 2021	Regional Automated Driving Summit
June 2021	Citizen Dialogue: Yokohama City, Kanagawa
April 2022	Citizen Dialogue: Tochigi
From May 2022	Automated Driving Live News (total of 10 times)

Symposiums and citizen dialogues have been held as interactive events with citizens, local government officials, and related businesses, as shown in Table 2.

In particular, during the second phase of SIP-adus one primary theme has been to solve local social issues, and so these dialogues were held not only in Tokyo but also in the regional areas where the aim is to solve social issues through automated driving.

"A Plan for the Future of Japan: Shodoshima, Mobility Services Tailored to Each Region" was held in December 2018 in Shodoshima-cho, Shodo-gun, Kagawa Prefecture. "The Role of Automated Driving in Supporting the Future of People, Towns, and Lifestyles: Toward the Realization of a Town Where People Want to Live Forever" was held in August 2019 in Ina City, Nagano Prefecture, where FOTs had also been conducted by the SIP-adus. "Ideal Cities and Automated Driving" was held in January 2021 in Maebashi City, Gunma Prefecture. "Traffic and Mobility Required in Urban Transportation: Toward Social Implementation of Automated Driving" was held in June 2021, in Yokohama City, Kanagawa Prefecture. "Toward the Construction of Sustainable Mobility Services that Respond to Local

Conditions: The Challenge of All Tochigi" was held in April 2022, in Tochigi Prefecture.

At the Regional Automated Driving Summit in March 2021, the leaders of Iinan Town, Shimane Prefecture; Eiheiji Town, Fukui Prefecture; Kamikoani Village, Akita Prefecture; Chatan Town, Okinawa Prefecture; and Higashiomi City, Shiga Prefecture spoke about their local governments' initiatives and thoughts on automated driving. This was followed by a two-part panel discussion on "Solutions to Local Issues" and "Next Generation Public Transportation Systems and Operators' Efforts," featuring stakeholders involved in automated driving in local communities, public transportation operators, and automated driving venture companies. The format of connecting various local stakeholders via the internet was an event that could only be held online.

In addition, from FY2022, in order to reach a wider range of people, including the members of Generation Z who will be the future leaders of the new mobile society, since May we have been released ten episodes of Automated Driving Live News, with a mix of real discussion on a variety of topics from the perspective of users and the younger generation and distributed live via Zoom and YouTube.

4 Quantifying the Effects of Automated Driving

We have organized and quantified the impact of automated driving in order to provide material for open discussion of the benefits and potential risks of such technology, based on factors such as the technology level and penetration of automated driving.

Specifically, economists have compiled quantitative evaluation methods for the social and economic impact of reducing traffic accidents and traffic congestion, improved the accuracy of simulations developed during the first phase of SIP-adus to estimate the effect of reducing traffic accidents, and compiled them into a method for calculating the overall impact. In addition, we held a contest for students to propose their visions for the future automated driving society, aiming to disseminate information from the leaders of the automated driving society themselves based on the results of this research. [See Section 4 (2) 2) for more details]

We also studied research as a medical-engineering collaboration on the evaluation of the effectiveness of driving support technology for people with visual field loss, and clarified the effectiveness of advanced driving support systems in reducing accidents involving people with visual field loss to the same level or less as normal drivers, making clear the importance of the field of vision in driving. We held a number of webinars on the relationship between visual field loss and driving, which is not widely known, and the role of automated driving and advanced driving assistance systems in this area; in July 2021, "The Intersection of Visual Field Loss and Automated Driving"; in September 2021, "Driving Licenses and Visual Field Loss - Considering Driving and Employment"; and in January 2022, "Visual Field Loss and Automated Driving Systems."

We also started to develop a method for measuring the effectiveness of public acceptance activities themselves, and conducted nationwide questionnaire surveys of 10,000 people in January 2020, January 2021, and January 2022 (in cooperation with the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure, Transport and Tourism). By continuously conducting the same scale questionnaire survey every year, we evaluated changes over time and analyzed the questionnaire results to quantify the current status of public acceptance factors (lifestyle changes, learning, costs, inherent characteristics/technological limitations, response to accidents, etc.). In addition, KPI/KGI indices were developed based on the past questionnaire surveys. The survey results will be used to evaluate efforts to foster public acceptance and provide feedback on such efforts in the future. [See Section 4 (2) 1) for more details]

In addition to this, opinions about buses were collected from passengers such as wheelchair users and people with poor eyesight, and then compiled and proposed to the Japan Automobile Manufacturers Association (JAMA). The hope is to make such vehicles kinder on people with disabilities or reduced mobility and orientation who have high expectations for automated driving. [See Section 4 (2) 4) for more details]

[References]

(1) SIP-café, a community for considering an automated driving society, https://sip-cafe.media/, (Ref. 2022.10.19)
(2) SIP-adus homepage, https://en.sip-adus.go.jp/, (Ref. 2022.10.19)

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1) Research and Evaluations for Fostering Public Acceptance

Yukiko Miyaki (DAI-ICHI LIFE RESEARCH INSTITUTE INC.)

(Abstract) In the social implementation of automated driving technology, it is essential to foster public acceptance in addition to the development of the technology and regulatory system. A correct understanding and a flexible and appropriate response by consumers will promote the early and effective use of the technology and ensure the safety of the new road traffic system. The author, in cooperation with related ministries and agencies, has conducted consumer awareness surveys on automated driving for several years, following up on the changes in awareness and exploring what information in which areas, and how to provide it, will lead to the fostering of public acceptance. Based on the focus on ADAS in the interim report, this paper looks closely at automated driving as a passenger transport service vehicle in local communities, and examines the relationship between the degree of acceptance of "lifestyle change," "learning," "cost," and "inherent characteristics and technological limitations," which are considered to constitute public acceptance, and awareness within the community. This paper then discusses action evaluation in fostering public acceptance and presents hints for fostering public acceptance of automated driving and the importance of a co-creation system.

Keywords: Public acceptance, consumer awareness, community mobility, social impact, visualization of effects

1 Project Execution Flow and Survey Contents

1.1. Background and objectives

In conjunction with the author's participation as an expert committee member in a METI/MITI project since 2016, the Dai-ichi Life Research Institute has conducted questionnaire surveys on automated driving for the purpose of understanding consumers. Based on these surveys, time-series data on consumer behavior and awareness have been collected as a METI/MITI project from the January 2019 (FY2018) survey and as a joint survey by the two ministries and the Cabinet Office SIP from the 2020 (FY2019) survey. Based on this data, proposals have been made regarding the KPI/KGI evaluation indices and processes for actions to foster public acceptance as an SIP-adus (Cross-ministerial Strategic Innnovation Promotion Program (SIP) Automated Driving for Universal Services).

Various factors are behind the use of automated driving technology in Japan, but the focal point is the aging society, which is said to be "era of 100-year-life". The baby boomer generation, which experienced the rapid increase in dependence on private cars, are now elderly, and whether or not they can continue driving from a safety perspective (e.g., the surrendering of driver's license) and securing the means of transportation to maintain their lifestyles have become social issues. In many regions, public transportation is being reduced and drivers are in short supply and are aging themselves, making the securing of sustainable means of transportation an urgent issue.

In addition, even if public transportation is offered as an alternative to people and communities that have long been dependent on private cars, there may be circumstances where it is not easy for their lifestyles to change, including it being difficult to get to a train station or bus stop.

Two possible solutions to these issues using automated driving technology are "extending driving life expectancy" in the sense of increasing the safety of travel using private cars, and the "creation of alternative transportation" that allows people to continue living in their community without using their own cars. (Fig.1)

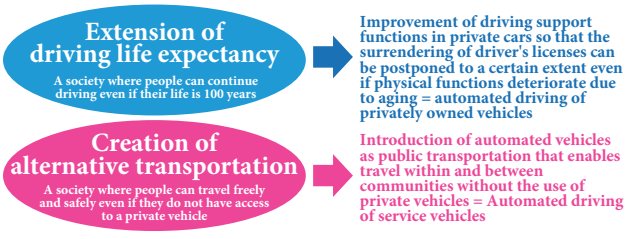

Fig.1: Two solutions aimed at mobility in the era of the 100-year-life using automated driving technology

As "SIP 2nd Phase: Automated Driving for Universal Services — Mid-Term Results Report (2018–2020) "focused on the "extending driving life expectancy" part, this paper focuses on the "creation of alternative transportation" and discusses the "Questionnaire Survey on Vehicles and Automated Driving" that has been conducted four times. The second phase of SIP-adus.

1.2. Summary of the Fourth Questionnaire Survey

The survey was conducted as a Cabinet Office SIP survey (late January to early February 2022), which re-surveyed 20,631 people as a sample of the men and women aged 18-69 from across Japan who participated in the internet survey by the Ministry of Economy, Trade and Industry and the Ministry of Land, Infrastructure, Transport and Tourism, and 10,357 responses were received and merged into one survey. In preparing the questionnaire, in addition to collecting opinions from the National Police Agency, there was collaboration with other contractors such as the University of Tsukuba and the University of Tokyo.

2 Recognition of Mobility Issues in the Community and Public Acceptance of Automated Driving

2.1. Mobility Issues in the Community

The local transportation environment and issues play a major role in the use of automated driving technology as alternative transportation. Regarding attitudes toward mobility in old age, a look at changes in survey results since 2019 shows that while the number of people who say that they "want to continue living in their current area in old age" has increased, the number of people who say that they "are concerned about transportation means in old age in their current area," that they "cannot live without a private car in their current area," that "moving in old age using buses or trains is inconvenient in their current area," and that they "want to move to another area if they do not have the means to move freely in their old age" has an increasing trend. In addition, the percentage of respondents who "think about the time when the means of transportation I currently use may not be available in the future", which is data that has been acquired since 2020, is also increasing, indicating that more people are aware of mobility issues in their old age. (Fig.2)

The hurdles to using public transportation as an alternative to private cars are not insignificant for people and communities that are highly dependent on private cars. However, when we think about the future, we must also assume a gradual shift to such a lifestyle, and a public consensus is gradually emerging on this issue. Under these circumstances, automated driving

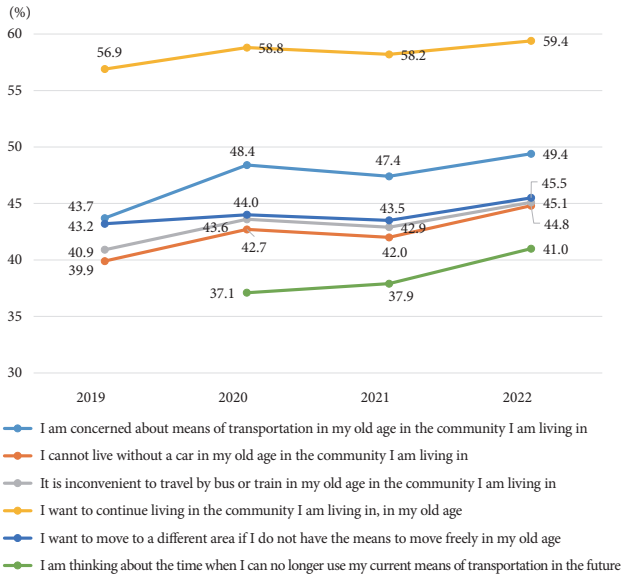

Fig.2: Changes in awareness regarding mobility in old age

service vehicles are expected to be one solution to solve the driver shortage and bring mobility to communities, even if their speed is slow.

2.2. Organizing Public Acceptance

In the area of automated driving, in addition to the perspective of technological safety and the development of laws and rules, another major challenge to be addressed is how to make automated driving accepted and used effectively in society from the perspective of public acceptance.

Regarding the public acceptance of automated driving, the author created and analyzed composite scores consisting of the following four categories: (1) Lifestyle changes: acceptance of changes in lifestyle due to the spread of automated driving, (2) Learning: acceptance of the burden of learning for the spread of automated driving, (3) Cost: acceptance of various cost burdens in the spread of automated driving, and (4) Uniqueness/technical limits: acceptance of the characteristics and technicall limits and risks particular to automated driving. (Fig.3)

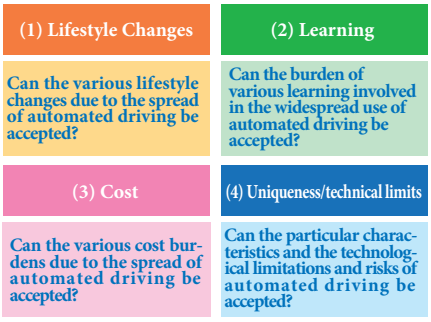

Fig.3: Four elements for public acceptance

2.3. Public Acceptance Scores and Community Awareness: Results of the Survey

Regarding the four acceptance factors, looking at their relationship with the characteristics of the community reveals that there is a relationship between people's community awareness and the acceptance.

In city planning, the concept of "civic pride" is considered important. Civic pride refers to the pride that citizens have in their city, but it is not merely a feeling of affection or attachment to their own community; according to Professor Kaori Ito from the Tokyo University of Science (representative of the Civic Pride Study Group), it is "a sense of pride based on a kind of party awareness in which one is involve in wanting to improve the community".

In the third and fourth surveys, respondents were also asked about their thoughts and ideas about their community, and these items are similar to the civic pride mentioned above.

In this analysis, the mean values of each acceptance score were compared for the four questions of "I like/am attached to the community I am living in," "I want to make the community I am living in a better place," "I am aware of the issues in the community I am living in," and "I want to live in the community I am living in for a long time," for affirmative ("applies" and "somewhat applies") and negative ("does not apply" and "does not apply at all") responses and it was confirmed that when overall awareness of the community was high then acceptance scores were also high. (Figures 4-7)

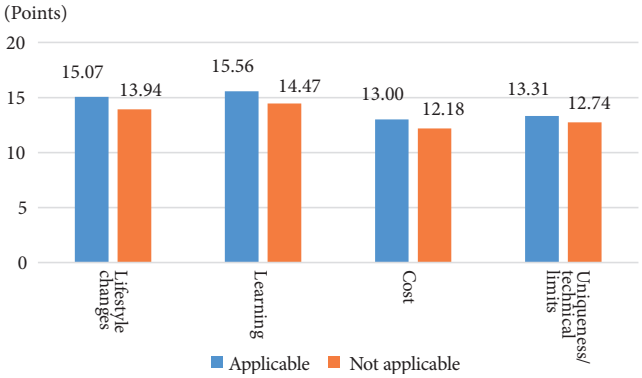

Fig.4: Community awareness and acceptance scores
(I like/am attached to the area I live in)

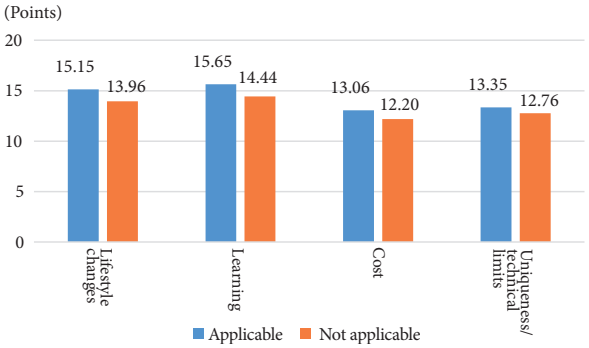

Fig.5: Community awareness and acceptance scores
(I want to make my community a better place)

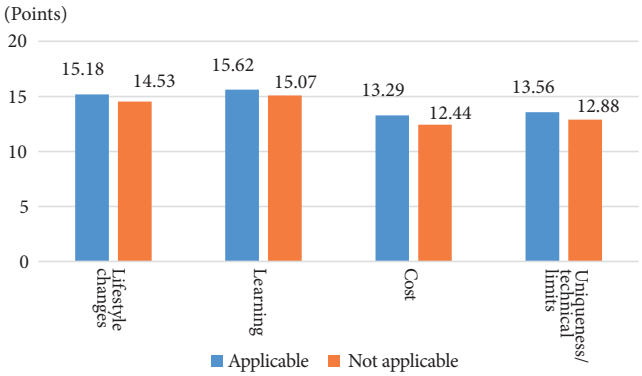

Fig.6: Community awareness and acceptance scores
(I am aware of the issues in the community I am living in)

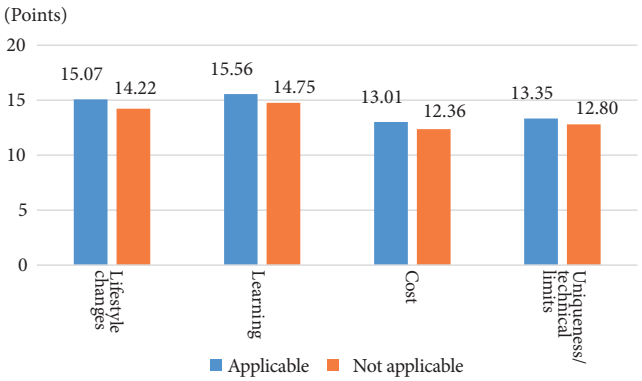

Fig.7: Community awareness and acceptance scores
(I want to live in the community I am living in for a long time)

Tentatively assuming these items to be civic pride, it can be said that in communities with high awareness, a relatively high percentage of people will accept the changes in their lifestyle that will be brought about by the social implementation of the new technologies and mechanisms for automated driving, accept the learning required for such changes, bear the necessary costs, and accept the inherent characteristics and technological limitations of automated driving.

In other words, it can be said that in pioneering the implementation of automated driving, it will be effective as a strategy to introduce it first in areas with high civic pride and to "foster it as a local mechanism".

3 How to express automated driving technology as a solution

3.1. Arousing People's Action Through Two Steps of Understanding and Acceptance

In the social implementation of new mechanisms and technologies such as automated driving, in addition to the understanding of users, consumers, and residents, it is essential to foster their awareness of "effective and safe use". It is tempting to take a passive stance when introducing technology, assuming that the technology will cover all safety issues.

However, as Goal 12 of the SDGs 'responsible consumption and production' says, consumers of the future are expected to

contribute to the sustainability of society by being involved in "responsible consumption" in the form of effective use while securing safety. In addition, 100% safe technology is practically impossible. There are significant risks even with existing vehicles, and users are expected to ensure greater safety in the form of obeying the rules when using them. It is also necessary to form a similar consensus for the introduction of automated driving. Regarding automated driving, which tends to be expected to be a completed technology, it is important to understand its characteristics and limitations, and consider what methods of use will compensate for its technological shortcomings and issues.

Further, as shown in Fig.8, it is also necessary to take into account the fact that "understanding" and "acceptance" are different. First, as Phase 1, action is required to increase the amount of information about automated driving for consumers and to raise their level of awareness and understanding. However, the level of acceptance does not necessarily increase as the level of awareness and understanding increases. Some people judge "non-acceptance" as a result of an increase in the level of understanding of automated driving. Accordingly, what is required as Phase 2 is a process that seeks a path to solving problems by identifying specific issues from those who are "non-accepting" due to some issues or risks, finds parts that can be complemented not only in terms of technology, but also by concessions and cooperation among people in terms of the establishment of usage methods and rules, and stimulating consumers to take action themselves.

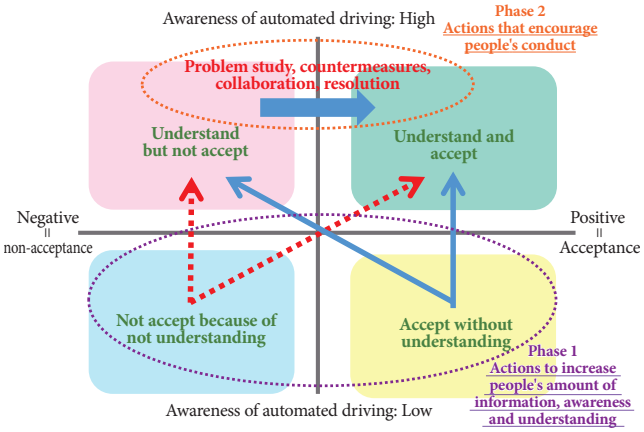

Fig.8: Two phases of understanding and acceptance

In this process, it is necessary to understand the background and issues of "why automated driving technology is being used in our community". In addition, it is necessary to correctly understand the current status of what can and cannot be done with automated driving technology. Only when there is an understanding that automated driving technology can be a promising solution to local problems can people face the challenge of how to implement this technology.

However, although there is a tendency to consider the 'How' of "how to implement it" first, initially there should be a process of first ascertaining the local issues (the 'Why') and then considering how automated driving technology can be used to solve those issues (the 'What'), including the points of what kind of technology will be used to drive what kind of vehicle and in what manner will be used to drive the vehicle. (Fig.9)

In practice, it seems that such a process and approach is being taken in communities where social implementation and FOTs (Field Operational Tests) are successful.

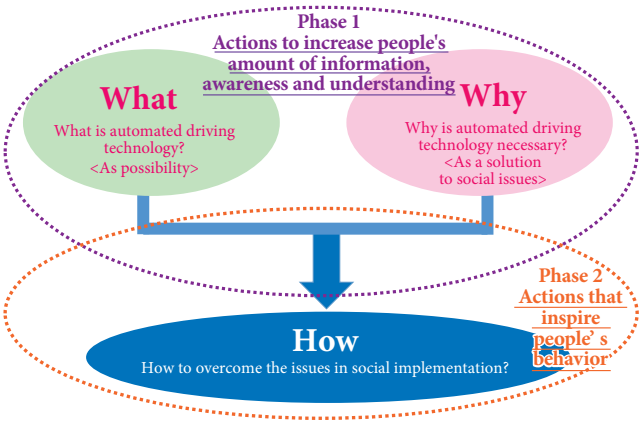

Fig.9: The 'How' derives from the 'What' and the 'Why'

3.2. Visualization of the value and effect - social impact assessment

In order to promote understanding and acceptance, when selecting the solution of "automated driving" as a result of considering the 'Why' and the 'What', it is necessary to visualize the value and effect of mobility and automated driving. In particular, in the formation of a consensus on the investment of public funds, it is essential to consider from the perspective of what degree of investment effect can be expected. From this point of view, regional public transportation basically operates at a loss, and even if it were replaced by automated driving, it cannot be expected to be profitable, at least in terms of fare revenue, and is unlikely to become profitable in the short term.

Also, it is more than a theory that if people give up their private cars, they can apply the cost of purchasing and maintaining them to public transportation. Private cars do not demonstrate their value simply through transportation only; their value as an object of desire and preference is also great, in addition to the convenience and psychological security of being able to drive it at any time.

In this way, while costs should not be taken in a narrow sense, they are not always measurable quantitatively, so it is necessary to take the social impact into account when visualizing them.

For example, in addition to the economic benefits of improved community accessibility, the invigoration of mobility can prevent frailty and extend the healthy life expectancy of the elderly, thereby reducing medical and nursing care costs and manpower (mainly for family members). Many people also enjoy seeing and photographing mobility. If mobility becomes a community icon, it will not only increase the flow of people from outside the community, but also improve commitment to the community. Thus, the enhancement of mobility will improve the quality of life of community residents and citizens.

In order to put the effects of the introduction of automated driving technology, including the impact assessment, into the context of fostering public acceptance, it is necessary to visualize the effects financially from a multifaceted and long-term perspective, from both the perspective of "enlivening" in the sense of protecting the sustainability of people's lives by maintaining and sustaining mobility in the community, and the perspective of "utilizing" in the sense of creating various spillover effects through the use of mobility. (Table 1)

It is the consumers themselves who will benefit greatly from the spread of automated driving. In light of this point, it is thought that increasing the number of opportunities for consumers themselves to be proactively involved and consider how to incorporate and use the technology in their daily lives and how safe and effective social implementation can be achieved (the 'How'), and fostering an awareness of the issues as being their own issues, will lead to the creation of prompt and safe mobility, and the realization of a sustainable society.

Table 1: Ensuring sustainability and visualizing the effects of community mobility

Viewpoint	Actions	Keywords
Viewpoint of "enlivening" community mobility Maintaining its existence	● Create and maintain means of transportation that fit the community environment and needs ● Development of mobility infrastructure that enables people to continue moving after they have surrendered their driver's license or have lost physical functions due to aging, illness, disability, etc. ● Ensure safety during movement ● Fostering awareness of the use of diverse mobility by a diverse range of people	● Sustainability ● Maintain daily life ● Safety and security ● Acceptance of inconvenience
Viewpoint of "utilizing" community mobility Utilizing it	● Recognition and visualization of the impact (financial and non-financial value) of mobility (1)Economic effects (direct and indirect) Examples: Fare revenue, improved accessibility, community revitalization, reduced social security costs (2)Health Benefits Examples: Disease prevention, maintenance and improvement of mental health, extension of healthy life expectancy (3)Creating connections and fun Examples: Creation of opportunities for face-to-face contact and communication, vehicles as objects of preference	● Economic Effects ● Extension of healthy life expectancy ● Wellbeing ● Improvement of quality of life ● Pleasant, fun, happy experiences ● Awareness of inconvenience

4 Steps for public acceptance - setting KPIs and KGIs

This process is summarized in the action evaluation sheet in Table 2. The purpose of this project was to establish and evaluate what points should be kept in mind and what benchmarks should be set in the process of fostering public acceptance of automated driving. As part of this effort, a consumer survey was conducted, and interviews and workshops have also been held.

The entire process has been classified into ten processes, and items to be considered for each process have been set as checkpoints.

Table 2: Action evaluation sheet

Step		Activity item	Checklist (2022 updated version)
1	Foundation study	**Creation and coordination of the overall framework and strategies for the individual projects (Frame & Strategy)**	1. Has an annual activity plan been formulated after devising a comprehensive medium to long-term strategy based on the existing information, situation, and the previous fiscal year's outputs? 2. Has a process with clear goals been formulated for each project? 3. Are projects cooperating so there is no waste or duplication? (comprehensiveness, appropriate target selection, etc.)
2		**Information collection and understanding of the targets and circumstances (Target Grasp)**	1. Has sufficient information (culture, characteristics, issues, etc.) collection and understanding been conducted in advance about the targets (society, community, people, etc.) in which public acceptance will be fostered?
3	Transmission	**Selection, editing, and processing of transmitted information (Adaptation)**	1. Has the selection of appropriate information for the target audience been considered for information transmission? 2. Has appropriate information suited to the target audience been edited and processed for transmission?
4		**Means, media, and venues for information transmission (Means)**	1. Have the most appropriate means, media, and venues been used for information transmission to the targets? 2. Was the Society 5.0 perspective (fusion of the physical and virtual) considered?
5		**Experience Opportunity Creation/UX (Experience)**	1. Was an opportunity created for the target to personalize the issues through a realistic customer experience in accordance with local issues and needs?
6	Reception and diffusion	**Feedback and bidirectionality (Communication)**	1. Could the impact of information transmission be verified through the response of the targets and interaction with them? 2. Were areas for improvement of the content and methods of information transmission discovered and new ideas gained through the response of the targets and interaction with them?
7		**Information diffusion and social interest (Expansion)**	1. Did the activities and information transmission lead to the diffusion of relevant information through mass media, social media, etc.? 2. Did it create the effect of communicating information between people? 3. Were you able to elicit a derivative effect by improving the degree of satisfaction of existing users?
8	Goals	**Consumer understanding (Understanding)**	1. Verification of whether consumers' understanding ('What') of automated driving and ADAS functions has improved 2. Verification of understanding ('Why') about the background of introducing automated driving and ADAS functions into society 3. Were consumers' intrinsic behavior to understand automated driving and ADAS functions aroused?
9		**Consumption and use behavior (Use)**	1. Did the consumers understand the social issues and their own situation, and do they show willingness to adopt technology effectively and safely in their own lives? 2. Do the consumers show willingness to think about how they should act in order to effectively and safely adopt technology into their own lives ('How')?
10		**Social acceptance among consumers (Acceptance)**	1. Do consumers appear to be receptive to each of the factors that may arise from the introduction of automated driving technology? (1) Lifestyle changes (2) Learning (3) Costs (4) Characteristics and technological limitations

Phase 1
Why: Background/needs
What: Instillation of mechanisms and rules

Phase 2
How
* How to implement it in a form that suits the community
* How consumers will be involved and act to achieve this

4.1. The process for Phase 1

Steps 1 through 7 correspond to the "Phase 1" referred to in Figures 8 and 9.

Steps 1 and 2 are defined as the "foundation study" for the "creation and coordination of the overall framework and strategies for the individual projects". Step 1 is to conduct the management, such as ascertaining the overall picture of the SIP until now and considering the strategy, and allocating the necessary resources to the necessary sections while watching over each project. Step 2 is "information collection and understanding of the targets and circumstances," which refers to information collection and understanding of the targets (society, communities, people, etc.) in which public acceptance is to be fostered. Until now, the author has attempted to gain an overall understanding by collecting quantitative data through nationwide surveys, but it will be more important in the future to collect detailed information for each community.

Steps 3 through 5 are "transmission," which questions whether the information content and appropriate media were selected to match the target audience, and whether real experience value was provided so that the target audience could personalize the issues.

Steps 6 and 7 are "reception and diffusion," which measures the impact and level of understanding of the information through two-way communication with the target audience, and furthermore, asks whether communication among the target audience has been created as a derivative effect.

4.2. The process for Phase 2

Steps 8 to 10 correspond to "Phase 2" in Figures 8 and 9 and indicate, based on consumers' understanding, that consumers are proactively involved in utilizing it effectively and safely themselves, and accepting the associated lifestyle changes, learning, costs, inherent characteristics and technological limitations.

5 Transmission and sharing of information and consensus formation toward public acceptance of automated driving

5.1. Information transmission tailored to communities and targets

In regional areas, awareness of mobility issues is particularly high, and the social implementation of automated driving services vehicles as one of the solutions requires that the significance of this issue be transmitted through a variety of means.

To this end, it is necessary to first understand the awareness, culture, and history of the people living in the community, and then to recognize what specific issues they are facing. Since local media such as regional newspapers have significant influence in regional areas, collaborating with such media to effectively communicate the 'Why' and 'What' aspects should be effective. In addition, since the media with high affinity differs depending on the attributes and community, it is also important to select the most appropriate media and process the information into the most appropriate form. It is important to create a system that uses a variety of media to effectively spread information while creating connections among people and communities.

There are some cases in which regional automated driving events attract only those who are involved in or interested in automated driving, such as business operators and related parties, so ingenuity is required so that information reaches a diverse range of people and arouses their interest, such as by holding joint events with other fields.

5.2. Sharing information and case studies

In recent years, many FOTs of automated driving service vehicles have been conducted throughout Japan, and some of them have progressed to social implementation, so it is also important to systematically share such cases. Since the needs and backgrounds of each community differ, it is natural that a large part is tailored to the community in the implementation of automated driving services, but there are many cases where examples from other communities can be used as references. It goes without saying that successful examples should be shared, but also sharing cases that did not go well will add significant value to the FOTs overall. Furthermore, the value of the FOTs will be maximized by aggregating this information in a centralized manner and deploying it in a cross-cutting manner.

5.3. Consensus building for co-creation and complementation between people and technology

In the transmission of information regarding technology, it is necessary to share not only "what can be done," but also the technological limitations and specific risks to obtain a social consensus. Just as human error is inevitable, system error is also inevitable. In the same way that it is presupposed that there are dangers that accompany conventional cars and that users are expected to make efforts to reduce the risks by wearing seatbelts and child restraints and obeying traffic rules, the process of introducing automated driving into society must be conducted in a form where the users incorporate the technical limitations of automated driving.

By adopting a style in which humans compensate for the limitations and inadequacies of the new technologies, and by adopting an attitude of nurturing the technologies and

mechanisms throughout society, measures can be taken as a result to resolve social issues at an early stage. Increasing awareness of "mobility," which is one of the major issues in the era of 100-year lives, will ultimately lead to the creation of safe, secure, and sustainable mobility and contribute to maintaining the quality of life and wellbeing of people.

Automated driving technologies are a "means" to this end, and it is necessary to review the point that social implementation and fostering public acceptance are not "ends" in themselves, and for industry, government, academia, and the private sector to collaborate toward co-creation.

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2) Development of Assessment Methodology for Socioeconomic Impacts of Automated Driving Including Traffic Accident Reduction

Yoshihiro Suda (The University of Tokyo), Hiroaki Miyoshi (Doshisha University)

(Abstract) The evaluation of the social and economic impact of automated driving is extremely important in terms of fostering social acceptance, government policy making, and application to corporate management regarding automated driving. Based on this recognition, the purpose of this paper is to present an overview of "Study of socioeconomic impacts of automated driving including traffic accident reduction" and its successor project, "Research on assessment of the impact of automated driving on society and the economy and on measures to promote deployment." This paper first introduces two models (dynamic model and static model) of the "diffusion simulation" of automated vehicles, which is the basis of the socioeconomic impact assessment, following overview of the impact assessment on road traffic, transportation services, and industry and society, which were conducted using the results of the diffusion simulation.

Keywords: socioeconomic impact assessment, diffusion simulation, traffic accident, traffic simulation

1 Purpose and contents of the study

The practical application and expansion of automated driving can contribute to solving social issues such as reducing traffic accidents, reducing traffic congestion, ensuring mobility for those with traffic constraints, and improving driver shortages and reducing costs for logistics and transportation services. Aiming to realize a society in which all people can lead a high quality of life through the widespread use of automated driving, this research sets the following two objectives and works to evaluate the socioeconomic impact of automated driving: The first is to foster social acceptance of automated driving. To promote the practical application and social diffusion of services and vehicles that utilize automated driving technology in the future, public understanding of automated driving is a prerequisite. In order to gain public understanding, it is necessary to quantitatively understand the impact of automated driving on people's lives and the Japanese economy in terms of both utility and potential risk. Second objective is to contribute to government policy making and corporate management. For example, it is extremely important for government and corporate decision-making to understand how the speed of automated driving diffusion and the resulting socioeconomic impact will differ depending on economic incentives for automated driving and how automated driving vehicles are introduced to the market.

Based on those purposes, the research shown in Fig.1 was conducted in the first project, "Study of socioeconomic impacts of automated driving including traffic accident reduction." First, for the purpose of organizing basic information, the relationship between automated driving and the 17 goals, and 169 targets of the Sustainable Development Goals (SDGs) set forth by the United Nations was organized, and the significance of automated driving for sustainable society was confirmed. Next, a "diffusion simulation" of automated driving vehicles was conducted to use its outputs as common basic figures when analyzing the socioeconomic impact of automated driving. Finally, quantitative analysis of the socioeconomic impact of automated driving from three angles were conducted: the impact on road traffic, the transportation service sector, and the industrial and social sectors.

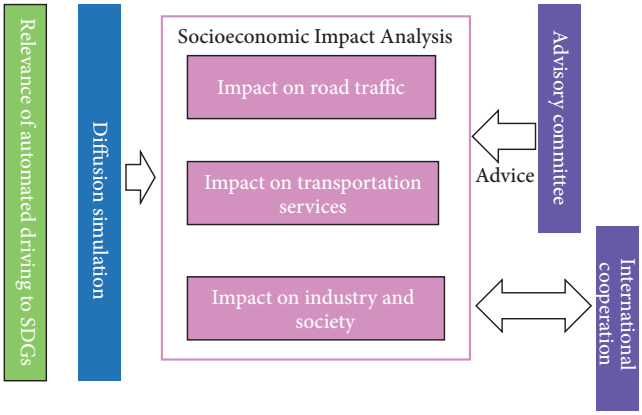

Fig.1: Overall Picture of the Research Project

In the second half of the project, "Research on assessment of the impact of automated driving on society and the economy and on measures to promote deployment," various simulation models constructed in the first half of the project were improved, assumptions were reviewed, and the effects of various promotion measures were analyzed.

The model developed in the projects has the following five characteristics, and is able to analyze a wide range of socio-economic impacts in a theoretical and consistent manner:

1) Model building combining knowledge of traffic engineering and economics;
2) Common data on the socioeconomic environment (population, GDP, etc.) are used uniformly as simulation assumptions;
3) Construct a simulation model for the diffusion of automated vehicles based on microeconomic theory that takes into account consumers' willingness to pay (WTP) and the learning effect of production;
4) Possible to estimate the diffusion rate of automated vehicles in response to various diffusion promotion measures; and
5) Utilize the results of diffusion rate estimation as common data for socioeconomic impact assessment.

Since the main objective of the first half of the project was to construct a model, an advisory committee involving academics from a wide range of fields, including engineering, was established, and the study was conducted based on the discussions in the study group. On the other hand, since the final purpose of the latter half of the project was to disseminate information to the public, the research was conducted mainly based on the discussions in the Working Group for Service and Business Implementation. In addition, "Simulation of the diffusion of automated driving vehicles" and "Consumer choice changes regarding car ownership, use, and mobility" were studied in cooperation with a German research institute as part of the Japan-Germany collaborative research. This Japan-Germany collaborative research is based on the fact that the Socio-Economic Impact Assessment was listed as one of projects of the Japan-Germany joint research project at the Steering Committee meeting between the Japanese Cabinet Office and the German Federal Ministry of Education and Research in January 2019, conducted based on "Joint Declaration of Intent on Japanese - German Cooperation on the Promotion of Research and Development on Automated Driving Technologies" (January 12, 2019). For more detailed information on the activities of the Japan-Germany Cooperative Research, please refer to Section 6 (8) "Socio-Economic Impact" of this report.

In the following, the results of this study were presented, focusing on the features and concepts of the simulation model developed in this study.

2 Simulation of diffusion

The S-shaped growth curve model is a model often used to simulate the diffusion of goods and services.[1][2] However, when assuming a situation in which several levels of automated driving coexist, as in this study, it is not appropriate to simply use the parameters set by such a model. In addition, the S-shaped growth curve model has an extremely simple structure, making it difficult to use when simulating the effects of policy measures and OEMs' market launch measures on the diffusion rate of automated vehicles. Therefore, in this study, original diffusion simulation model for passenger cars was decided to be constructed.

When considering the diffusion of automated vehicles, the timing of introduction of SAE level 1 to 4 has already been discussed, but the feasibility and timing of the introduction of SAE level 4 and SAE level 5 automated vehicles that are capable of automated driving on all general roads cannot be predicted. Based on these points, the diffusion simulation model in this study is divided into two parts: a model for estimating the diffusion of automated driving vehicles up to SAE level 4, for which the timing of market launch can be predicted to some extent; and a model for estimating the diffusion of self-driving vehicles (equivalent to SAE level 4/5). The former is a dynamic model that captures the diffusion process of automated driving vehicles while showing the year, and the latter is a static model that estimates the diffusion rate of self-driving vehicles in a steady state when self-driving vehicles are realized.

The dynamic model classifies automated vehicles as shown in Table 1. In the first half of the project, automated vehicles were classified based on the combination of SAE levels and feasible roads, but this has been completely revised in the second half of the project.

The columns in Table 1 indicate the functions of vehicles. The functions are classified into three major categories: safe driving support (S), driving support (D), and system driving (A), and then the functions are further classified in terms of the roads on which the functions can be realized. The last two digits of S20, D20, A25, etc. indicate the year when the function is expected to be introduced to the market. On the other hand, the rows in Table 1 indicate the categories of automated driving vehicles which are composed of combinations of the above-mentioned functions. Here, the categories of automated vehicles are classified into three types: "driving support vehicles," "limited automated vehicles," and "advanced automated vehicles." Driving support vehicles are vehicles that have driving support functions added to vehicles already on the market (S0 and

Table 1: Classification of automated vehicles in the dynamic model

		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[1]	Omnidirectional long distance sensing[2]	ACC, LKAS on national expressways and limited highways	ACC, Lane change assist on national expressways and limited highways, LKAS on ordinary roads	ACC, LKAS, Lane change assist on ordinary roads	Lv.3 on national expressways and limited highways during congestion	Lv.3 on national expressways and limited highways	Lv.4 on national expressways and limited highway	Lv.4 on national expressways and limited highways, Lv.3 on ordinary roads	Lv.4 on ordinary roads	
Without safety support functions	S0											Existing
Equipped with safety support functions only	S1	△										Existing
Driving support vehicles	D1	✓		✓								Existing
	D2	✓	✓	✓								2025
	D3	✓	✓	✓	✓							2025
	D4	✓	✓	✓	✓	✓						2030
Limited automated vehicles	R1	✓	✓	✓	✓		✓					2025
	R2	✓	✓	✓	✓		✓	✓				2030
	R3	✓	✓	✓	✓	✓	✓					2030
	R4	✓	✓	✓	✓	✓	✓	✓				2030
Advanced automated vehicles	A1	✓	✓	✓	✓	✓	✓	✓	✓			2035
	A2	✓	✓	✓	✓	✓	✓	✓	✓	✓		2040
	A3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	2045

1. Acceleration control for pedal error, lane departure warning, lane distance warning, AEB for vehicles (short distance in front), AEB for pedestrians, AEB for bicycles crossing the road
2. AEB for vehicles (all-around, long distance), AEB for bicycles (all-around long distance)
✓: Equipped △: Partially equipped

S1). Limited automated vehicles are vehicles with SAE level 3 functions added to driving support vehicles. Advanced automated vehicles are limited automated vehicles with SAE level 4 functions added. For each of these three types, the automated driving category is set as a combination of feasible functions.

In the static model, on the other hand, two types of vehicles are set for simulation analysis: automated vehicles that realize SAE Level 2 on all roads, in which humans are the main driver of the vehicle, and automated vehicles that realize self-driving.

(1) Dynamic model

The dynamic model estimates the number of vehicles in each of the automated driving categories shown in Table 1 for passenger cars, logistics services (trucks), and transportation services (e.g. buses) every five years from 2025 to 2050. The estimation method differs for each of the three categories, but this article introduces the estimation method for passenger cars. The estimation model for passenger cars has been completely reconstructed following the review of the automated vehicle categories conducted in the latter half of the project.

In the simulation for passenger cars, the number of cars needed in each year is first calculated (A). By subtracting the number of remaining cars of the previous year from A, the number of new cars in each year is calculated. The composition of the number of new cars in each year by automated driving vehicle category is determined by the consumer's automated driving vehicle category choice model shown in Fig.2. In the first step of the selection model, the composition of new cars in the three groups of "driving support vehicles," "limited automated vehicles," and "advanced automated vehicles" is determined under the exogenously given price of each category. In the second step, the composition ratios of each automated driving vehicle category among the groups selected in the first step are determined. The parameters of this model are set by conducting a consumer's stated-preference survey (Web questionnaire) targeting approximately 7,500 consumers.

On the other hand, the price of each category of automated driving vehicles, which is exogenously given to the automated vehicle category selection model, is determined by the experience curve effect of production. The experience curve effect refers to the phenomenon in which an increase in cumulative production leads to an improvement in production technology and a decrease in production cost.

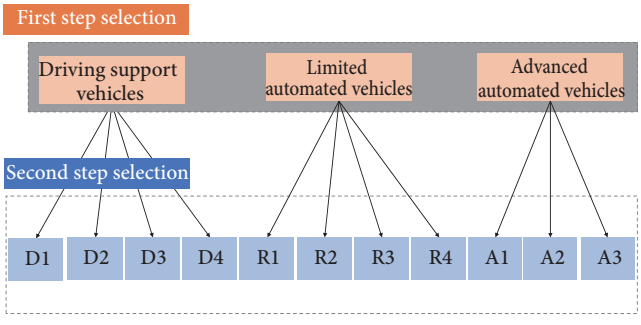

Fig.2: Model of Consumer Choice Behavior Regarding Automated Vehicle Categories

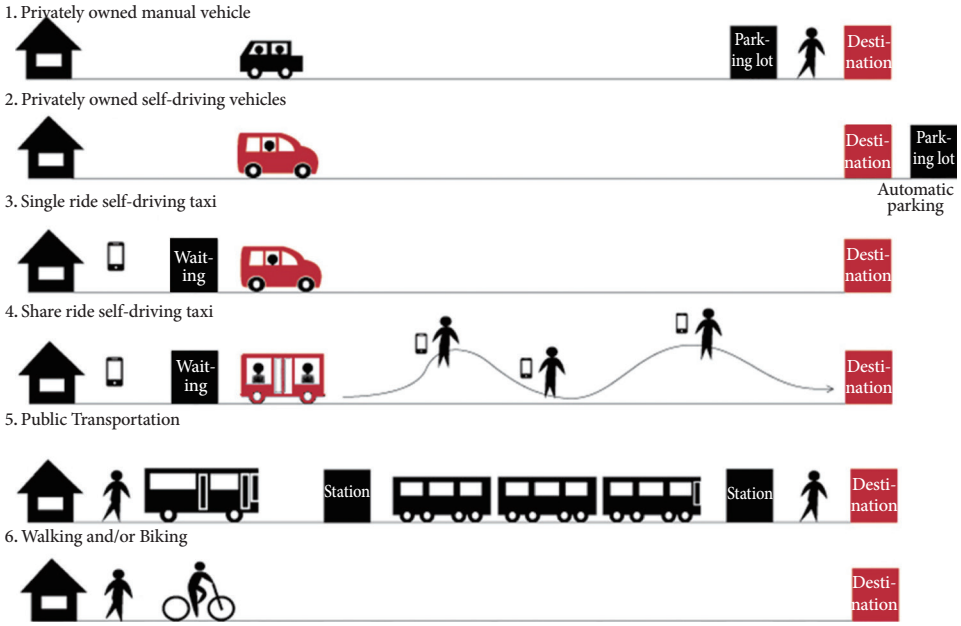

Fig.3: Traffic modes in the statics model

(2) Statics model

The static model differs from the dynamic model in that it only includes passenger vehicles and estimates the stationary state ownership and use of vehicles when self-driving vehicles (equivalent to level 4/5) are realized.

The model assumes the introduction of self-driving taxis that use self-driving vehicles as well as share automated taxis that charge lower fares due to shared rides and can estimate how the use of each transportation mode is affected by various factors such as their fares and waiting times.

This model was constructed using the results of a consumer preference survey (Web-based questionnaire) conducted in the "Analysis of the Impact on the Transportation Service Sector" section of "Changes in Consumer Choice Structure Related to Car Ownership, Use, and Mobility. As shown in Fig.3, the survey set up six transportation modes, and investigated how travel time, travel cost, and waiting time for dispatch of an automated taxi (including share taxis) affect ordinary citizen mode choice by weekday, holiday, purpose of travel, and travel distance zone. The static model utilizes as its core the transportation mode choice model constructed using the results of this survey.

3 Socioeconomic impact assessment

3.1. Road traffic

(1) Traffic accidents reduction

Two analysis methods were developed for the analysis of the reduction effect of traffic accidents. The first method is the one used in the first half of the project, in which we obtained the results of estimates of the effect of the automated vehicle diffusion on the number of accidents, as well as fatalities and injuries from by a measure of SIP automated driving "Visualization of the Traffic Accident Reduction Effects through Automated Driving and Driving Assistance project" and adjusted those using ITARDA traffic accident macro data. In the measure, the reduction effect of traffic accidents was estimated using the agent-based simulation method.

The second method is the one used in the latter half of the project, which calculates the diffusion rate of driving safety support functions such as AEB and LKAS from the diffusion rate estimation results for each category of automated vehicles, and estimates the traffic accident reduction effect by referring to the accident-avoidance rate for each driving safety support function set by the Advanced Safety Vehicle (ASV) Promotion Plan Phase 6 Report.[3] Since the accident-avoidance rate in this ASV report was calculated under ideal conditions, the effect calculated by this method should be understood as the accident reduction potential of automated driving, but it has the advantage of allowing more accident types to be estimated than the first method.

Whichever method is used, the unique feature of this study is that the monetary value of the traffic accident reduction effect, including the non-financial losses of the traffic accident perpetrator, is included.

There are two major differences between active safety technologies (e.g., safety support systems and automated driving) and passive safety technologies (e.g., airbag systems) in terms of benefits to society. First, while both technologies share the same benefit of "reducing injury to user himself,"

active safety technologies also reduce injury to the other party to an accident as an additional external economy. The second difference is that users of active safety technology also reduce the psychological burden (non-financial loss) of the perpetrator according to the reduction of bodily injury to the other party to the accident. The first benefit can be estimated by using the amount of economic loss per traffic accident victim obtained from the Cabinet Office survey[4] and the reduction in the number of traffic accident victims due to the diffusion of automated vehicles. On the other hand, the second benefit cannot be estimated because there is no data of "the amount of economic loss of the perpetrator per victim of a traffic accident." However, the ability to avoid becoming a perpetrator is extremely important in evaluating the value of automated driving. For this reason, this study newly estimated the psychological burden (non-financial losses) of being a perpetrator monetarily through a web-based questionnaire survey.

This Web-based survey consists of a perpetrator survey and a victim survey. In the perpetrator survey, the WTP (one- year usage fee) for a device that reduces the probability of killing the other party (one person) by 50% (or 90%) due to his/her own driving error (assuming his/her fault ratio is 100%) in a four-wheeled vehicle accident was asked in a double-bounded dichotomous choice. On the other hand, the victim survey asked about the WTP for a device that reduces the probability of death by 50% (or 90%) due to the other party's driving error (assuming zero fault) in a four-wheeled vehicle accident. The results of this analysis showed that the median WTP did not differ significantly between the perpetrator survey and the victim survey. This study incorporates the results of this survey into a monetary valuation of the traffic accident reduction effect of automated driving.

(2) Reduction of traffic congestion and CO_2 emissions

After setting assumptions on characteristics of automated vehicles during such as following and free driving behavior, lane change conditions and decisions, and reaction delay time, etc., traffic simulation on the road was conducted considering the diffusion rate of automated vehicles calculated by the simulation of diffusion (dynamic model). And the coefficients of a model,[5] in which Electric Vehicles (EV) can be considered, were used to estimate the effect of reducing traffic congestion and the resulting reduction in CO_2 emissions.

Specifically, the study consists of a two-stage structure; the first stage is traffic simulation that considers the spread of automated driving to estimate the intensity of congestion reduction and CO_2 emission reduction; and the second stage is a nationwide extrapolation.

Traffic simulations were conducted on ordinary way, and two-lane/three-lane sections of expressways, mainly considering the sag areas on expressways. In particular, the three-lane section was selected because it was the section where much knowledge was obtained in the "Visualization of Local Traffic CO_2 Emissions" in the first phase of SIP. In addition, the estimation of the CO_2 emission reduction effect was conducted taking into account the diffusion of EVs.

3.2. Transportation services sector

(1) Ensure mobility for people with transportation constraints and in areas with inconvenient transportation such as depopulated areas

In rural areas, services originally provided by businesses and residents are now being performed by the local government due to the declining birthrate and aging population, the exodus of young people to urban areas, and the deterioration of business management and the resulting withdrawal of businesses. For example, services such as traffic safety awareness and publicity and crime prevention patrols are provided by neighborhood associations and residents' groups in urban areas but are often provided as administrative services in rural areas. Such administrative services require a large amount of labor and expense, but the services currently provided by the local government are not considered highly sustainable because of the growing shortage of human resources in the local government. Therefore, one of the most important issues in rural areas is how to maintain administrative services while saving labor and costs. From the viewpoint of administrative services, this study examines which fields of application automated driving technology can be introduced and how it is expected to be utilized in rural areas, based on the actual usage of vehicles used for administrative services. In addition, the effects of the introduction of automated driving technology and its issues were discussed through dialogue with local government officials in mountainous areas.

(2) Drivers for logistics services

The number of truck drivers in supply and demand in the future were estimated under multiple GDP transition assumptions, and the number of driver shortages in logistics services was calculated as the difference between the two.

Specifically, firstly the future number of drivers who will provide logistics services was estimated, using the number of truck drivers by age group, the percentage of drivers who continue to work (continuation rate), and the percentage of new drivers in the younger age group (new driver employment rate). Next, the number of truck drivers in demand in the future was estimated by obtaining the value

of production and imports by item and by category from future GDP, estimating the volume of freight generated using this value of production and imports, and estimating future freight vehicle transport tonnage and freight vehicle kilometers traveled.

Based on the results of interviews with experts involved in the logistics industry, a Level 4 automated vehicle operation permit scenario for logistics services shown in Fig.4 was set up, and the amount of driving that can be replaced by automated operation and the number of drivers that can be reduced by automated operation were estimated.

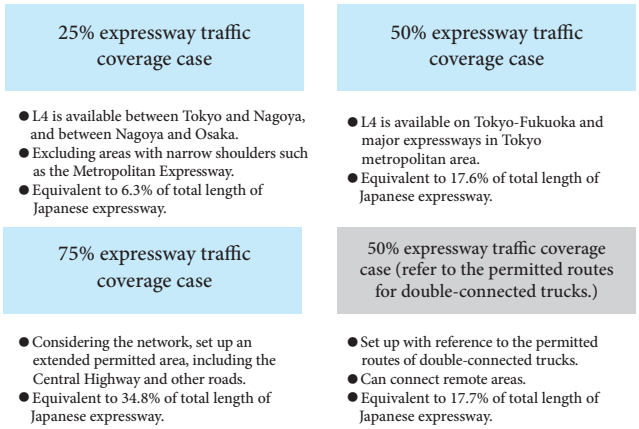

Fig.4: Level 4 Automated Vehicle Operation Permit Scenarios for Logistics Services

3.3. Industrial and social sectors

(1) The automotive industry and the industry as a whole due to changes in the automobile ownership structure, etc.

The realization of automated vehicles requires the incorporation of many sensors and software, and the inputs required for production are different from those of conventional vehicles. In this study, how changes in the components of automobiles required for automated driving will affect the automobile industry and the Japanese economy was analyzed, using an Input Output Table with reference to the methodology of a previous study[6] on electrically driven vehicles.

Specifically, first, the components required for automated driving and the industry sectors for those components were identified and estimated the increase in component costs by automated vehicle category and by input industry sector. Next, based on this cost information and the number of new vehicles per automated vehicle category obtained from the diffusion simulation (dynamic model), an input coefficient table for Input Output Table was identified considering the future shift to automated driving. Using this input coefficient table, the impact of the shift to automated driving on the production value and the number of employees in the "passenger car sector," the "automotive parts and accessories sector," and all industrial sectors in Japan was analyzed. In addition, a sensitivity analysis was also conducted when the cost of automation is changed.

(2) Contribution to productivity improvement

To achieve sustainable growth in an era of declining population, it is necessary to sustainably increase labor productivity, and technological progress or innovation is important for this purpose.

To increase labor productivity, economists believe that either an increase in the capital equipment ratio (the amount of capital per worker) or an increase in total factor productivity (TFP) through technological progress and innovation is necessary. Here, the effect of automated driving on labor productivity and total factor productivity in the Japanese economy was analyzed. In general, factors that increase the rate of increase in total factor productivity can be categorized as improvement in the "quality of capital," "quality of labor," and "management efficiency," etc. The main factor that increases total factor productivity due to automated driving is thought to be the quality of capital. As shown in Section 3.2 (2), "Drivers for logistics services," if the introduction of SAE Level 4 automated driving makes it possible to replace drivers who are in short supply with automated driving, this will indeed correspond to the effect of improvement in the quality of capital. In this study, using the results in Section 3.2 (2), the increase in labor productivity and total factor productivity due to the introduction of automated driving was estimated separately for commercial use and private use.

On the other hand, an example of "improved management efficiency" is the use of automated driving cabs for mixed freight and passenger transport. If institutional conditions are met and both passenger and freight transportation can be provided, automated driving cabs will be able to efficiently transport people and goods in the same vehicle by using an advanced dispatch system. This would result in an increase in total factor productivity, mainly due to improved management efficiency.

4 Conclusion

This paper presented an overview of the "Study of the impact of automated driving on reducing traffic accidents and on others" and its successor project, "Research on assessment of the impact of automated driving on society and the economy and on measures to promote deployment."

The analysis outlined in Sections 2 and 3 was based on

discussions with automobile manufacturers, the logistics industry, and other related parties, and several dissemination scenarios were set up and estimated for the purpose of fostering social acceptance of automated driving, and for use in corporate management and government policy making.

Although it is difficult to evaluate quantitatively, the "Mobility Business Innovation Contest (M-BIC) 2022"[(7)] was held as a co-host event of the SIP-adus Workshop to extract possible examples of how automated driving change people's lives and society in the future. In addition, this event was used to disseminate information about this research project to the public.

The results of this research will be disseminated to the world through presentations at international conferences and meetings, and through submission and publication in international journals.

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3) Projects to Foster Public Acceptance

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(Abstract) Japan faces a mountain of issues related to mobility, including lack of transportation options in isolated areas as the population becomes older as well as a shortage of drivers in the logistics industry. As such, there are rising expectations that social implementation of automated driving technology can solve these issues. One priority for social implementation is the R&D of automated driving technology and the fostering of public acceptance along with constructing the system infrastructure. Therefore, as an activity to foster public acceptance, SIP-adus (Cross-ministerial Strategic Innovation Promotion Program (SIP) Automated Driving for Universal Services), form its first phase, have taken efforts to promote proper understanding of automated driving in society through communication and dialogue related to automated driving with citizens, local government officials, and business operators in the traffic industry. We also widely shared the activities of local governments and businesses related to social implementation of automated driving and promoted cooperation across Japan to learn about issues and successful case examples. This document provides an overview of these activities.

Key words: Public acceptance, citizen, dialogue, region, test ride event, exhibition

1 Information Transmission, Media Activities, and Videos

1.1. Website construction/operation: SIP-café

Fostering public acceptance of automated driving means raising awareness and delivering objective and fair information related to automated driving to a wide range of ordinary citizens. Based on this concept, we constructed a website as the main pillar to our activities. Construction of this website would fulfill the role of sharing public information and organizing content in one place. It also served to ensure that the compiled information remained there.

The public homepage was named "SIP-café" based on the motif of a cafe where people and information intermingle in order to give the general public as a sense of familiarity. (https://sip-cafe.media)

The top page uses illustrated animation and dynamic movement to catch the eye. The illustration is based on the idea of how people's lives will change after social implementation of automated driving. However, the illustration has a soft and comforting tone and color palette to make it easy for the general public to accept. (Fig.1)

At first, the website had 5 categories of pages: "SIP-adus Information", "Automated Driving News", "Automated Driving Guide", "Automated Driving Glossary", and "Columns". From FY 2021, a page for "Automated Driving Journey" was added.

The "SIP-adus Information" page transmit information and trends of agencies related to SIP-adus, such as events for the general public and FOTs (Field Operational Tests) aimed at commercial use of automated driving. It functions as information transmission that is the main purpose of this site.

The "Automated Driving News" is not limited to SIP-adus-related news, but rather sends a wide-range of information, including news about safety driving support technology, automated driving technology, and new vehicles (passenger cars, trucks, buses) that have adopted this technology.

Fig.1: SIP-café top page image

The "Automated Driving Guide" and "Automated Driving Glossery" are pages that explain basic knowledge and terms related to automated driving. These pages aim to fulfill the role of "encyclopedia" and "dictionary" to improve literacy among people with no expert knowledge.

The "Columns" aims to stir interest in the automated driving by publishing easy-to-read articles on this topic.

The "Automated Driving Journey", which was added later, is for serialized reportages of FOTs carried out at various local areas in visiting each test sites to give more realistic view to the accounts.

In terms of these articles, 108 were published in FY2019, 203 in FY2020, 174 in FY2021, and 62 by July 2022 for a total of over 500 articles. These articles receive over 10,000 views a month and play a role in widely transmitting information.

1.2. Introduction of activities for social implementation and R&D of automated driving on "SIP-café on Tube"

We engaged in activities to deliver information related to efforts for automated driving technology development and social implementation by industry, academia and government to the general public through videos for easier understanding. In order to make these videos more casually accessible whenever and wherever viewers in broader generations are, the movies are made available to the public on the "SIP-café on Tube" in YouTube as video-sharing website. Not only the activities that SIP-adus had led such as "Memoirs of Automated Driving Trials", "Citizen Dialogue" and "FOTs in the Tokyo waterfront area" to be mentioned below, but also those for development of related technologies and new products by automotive manufacturers and suppliers have been included in 144 shared movies as of the end of August, 2022, as shown in Fig.2.

1.3. Memoirs of Automated Driving Trials

As the number of local governments and businesses conducting FOTs for social implementation of automated driving is increasing, we began the "Memoirs of Automated Driving Trials" project in FY 2021 that aims to foster public acceptance of automated driving by grasping realistic issues in implementation and voices of residents, local governments, and business operators in as many regions as possible and transmitting this information to a wide range of society. Specifically, as shown in Table 1, the project interviewed key persons in each region taking on FOTs for automated driving and released reports and videos summarizing the results on the SIP-café website for the SIP-adus. As seen in Figure 3, these interviews sought stories of on-the-ground struggles and creative techniques related to social implementation that could be a good reference for other regions who attempt to take on implementation.

Fig.2: Test ride Advanced Driving Assistance System report: Toyota MIRAI Advanced Drive (published June 20, 2022)

Table 1: Automated Driving Journey interview report (as of October 1, 2022)

FY2021 interview report
Higashiomi, Shiga / Automated driving services experience based in "Okueigenji Keiryu no sato"
Miyama, Fukuoka / Automated driving services based on clean energy and communities facilities
Kamikoani, Akita / "Kamikoani" in Akita prefecture establishing automated driving services
Iinan (Akagi Kogen), Shimane / Automated driving services for children who hold the key to build the future
Takahata, Yamagata / FOTs of automated driving services in core area in Takahata town
Chatan, Okinawa / Driving experience in "Mihama Shuttle Cart" early model of automated driving services in tourist areas
Nishi-Shinjuku, Tokyo / FOTs in Nishi-Shinjuku for practical implementation of automated driving buses in "Future Tokyo" Strategy - 2025
Eiheiji, Fukui / Eiheiji-cho, Fukui prefecture utilized abandoned railway tracks for "Realization of Mobility Space Services" for level 4 automated driving
Kasugai, Aichi / Automated driving services for comfortable driving and the resolution of issues in Kozoji, Kasugai City New Town
Yokohama, Kanagawa / Can this save Japan !? "C+pod Yokohama" Super compact EV experience with short-term car rental
FY 2022 interview report
Fujisawa, Kanagawa / FOTs at Shonan i-Park "Future of healthcare MaaS"
Nishi-Shinjuku, Tokyo / "Future of Tokyo" Strategy - Automated driving FOTs for infrastructure cooperation by Taisei Corporation, and others.
Nasushiobara, Tochigi / "Unprecedentedly elaborated planning" - Unique initiative for automated buses in Tochigi prefecture

1.4. Up-to-date current status report (webinar) on technology for automated driving implementation: Technology seminar

In order to foster public acceptance, it is ultimately necessary to enhance literacy and recognition by general consumers. However, it is difficult to achieve this directly. As of now, activities to foster public acceptance have been developed targeting "early adaptors" as called in marketing.

In order for a new system like automated driving to be established in society, there are not only technological themes but also various surrounding issues that can be considered. We designed and conducted technological seminars to generate opportunities for early adopters to learn about the status of these issues and what solutions are being developed to address them.

The first seminar was based on the theme of "issues with

自動運転見聞録

“類を見ない計画性”ユニークな栃木県の自動運転バスの取り組み

2022/1/27

2025年度の本格導入に向けて，県，市町，事業者が一体となって進めている地域がある．栃木県だ．どのような考え方なのか，ロードマップ，全体計画，組織などの詳細について，

栃木県県土整備部交通政策課 主査 安生真人氏，那須塩原市市民生活部生活課 課長 鈴木正宏氏，那須塩原市市民生活部生活課交通対策係 主査 山田慎太郎氏，那須塩原市市民生活部生活課交通対策係 主査 平野純氏に聞いた．

県下でのノウハウ共有のために

楠田 栃木県ABCプロジェクトとは何ですか？

栃木県 自動運転システム（Autonomous）の「A」，路線バス（Bus）の「B」，挑戦（Challenge）の「C」の頭文字からとっています．「無人自動運転移動サービス導入検証事業」のことで，県民が親しみやすいように命名しました．

Fig.3: Automated Driving Journey:
Activities for automated bus in Tochigi prefecture
(Published July 27, 2022)

responsibilities during automated driving." It presented a legal perspective based on criminal responsibility, ethical issues, and key issues in the Road Traffic Act, which was revised in April 2020. The speakers were Mr. Makino of the National Police Agency and Professor Imai of Hosei University.

The second was taken place with the theme "HMI and overconfidence of drivers" to explain how drivers should communicate with evolving technologies, how much the automated technology can understand drivers' intent, and how vehicles can be in the next generation. Mr. Hiraoka as specially appointed professor from the university of Tokyo and Mr. Tochioka of Mazda motor corporation.

The third seminar focused on "software updates and cybersecurity." It explained environmental changes, importance, issues, and initiatives surrounding software updates, and corresponding cybersecurity issues. The speakers were Mr. Asahi of Toyota motor corporation and Mr. Niikuni of the National Traffic Safety and Environment Laboratoty.

The fourth seminar was based on the theme of "cooperative areas of data provision and effective usage of mobility data." It was a lecture on cutting-edge data utilization as new services are expected to be generated by the sharing, linking, and utilization of a wide range of data corresponding with the popularization of connected cars. The speakers were Mr. Matsui of Sumitomo Rubber Industries and Mr. Iso of NTT Data.

1.5. Awareness of relationship between visual field loss and driving through "visual field loss webinar"

We held a total of three webinars in FY 2021 regarding the relationship between driving and visual field loss, which isn't widely known, and the expected contributions of automated driving and advanced driving assistance technology. We invited researchers and specialists in this field to the webinars and took efforts to raise awareness of these issues.

■ Session 1 (July 8, 2021)

Theme: "Crossing of visual field loss and automated driving"

Overview of discussion: The discussion was carried out on themes such as: What is visual field loss? What is the impact on driving? What future initiatives are needed as social issues to respond to demands of general drivers.

■ Session 2 (September 2, 2021)

Theme: "Driver's licenses and visual field loss - Considering driving and employment of disabled persons"

Overview of discussion: Introducing cases of companies that have already begun efforts to support employees with visual field loss, the discussion was proceeded for the themes such as how the driving licenses framework should be based on the visual field loss and the techniques demanded of companies related to employees with visual field loss, as shown Fig.4.

■ Session 3 (January 11, 2022)

Theme: "Visual field loss and driving assistance system - Current and future technology-"

Overview of discussion: Studies to extend driving life expectations, and development status of technologies for

Fig.4: Discussion at No. 2 visual field loss webinar

preventive safety, driving assistance and automated driving were introduced. The panel discussion in the second half of the event was focused on expectations and issues from users' view points.

1.6. Reaching a wide-range of generations through "Automated driving LIVE News"

In FY 2022, "Automated driving LIVE News" was held ten times (expected as of end-August, 2022) as a monthly live show about hot topics related to automated driving. In FY 2022, as the final year of the SIP-adus, we have kept working to create and operate contents more attractive for general users and younger generation to enlarge the number of viewers including the generation Z who will be the leader of the future mobility society, for a successful conclusion of the project.

■ Program 1 (May 6, 2022)

Theme: "A world where towns, roads, and cars talk together - Infrastructure cooperated traffic system with automated driving"

Overview of discussion: Following experts' session to introduce governmental policies and latest FOTs activities related to technologies supporting automated driving such as infrastructure cooperation technologies and communication technologies, a talk session with younger generations was carried out.

■ Program 2 (July 4, 2022)

Theme: "Future to be realized by mobility data plus something - Road traffic environment data web portal, MD communet®, and Activities taken place in Kyoto"

Overview of discussion: The discussion was carried out following introduction of MD communet, which is a web portal opened to the public in April 2022 to promote matching between users and creation of new business with shared information, as well as "KYOTO Raku Mobi contest," which is a new app idea contest to solve mobility issues and tourist-related transport issues in Kyoto.

■ Program 3 (July 21, 2022)

Theme: "Facing mobility for elderly relatives – Elderly Driving Issues due to visual field loss and cognitive decline -"

Overview of discussion: The experts talked about accounts related to "visual field loss and car driving", including measures taken through driving behaviors, importance of early detection, possibility of driving assistance with technologies, and also efforts for elderly driving issue, then the discussion followed this as shown in Fig.5.

Fig.5: Discussions at Automated Driving LIVE News No. 3

2 Exhibition/Symposiums

2.1. Dialogues with residents through "Citizen Dialogues"

As shown in Table 2, from FY 2017 we conducted "Citizen Dialogues" to provide a place for dialogue aimed at exchange of opinions with citizens and promotion of understanding for social implementation of vehicles and services that utilize automated driving technology. Citizens of all ages and genders participated in these dialogues, as well as various stakeholders such as public transportation business representatives, academics, and public officials as discussions were held based on richly diverse perspectives. From FY 2020, in consideration of the COVID-19 infection prevention measures, the discussion and Q&A with listeners occurred online using online conferencing systems. Also, at end-FY 2020, as an interim report for the past activities as seen in Fig.6, we invited persons

Table 2: List of Citizen Dialogues (as of October 1, 2022)

Fiscal year	Format	Event location
FY2017	Symposium	Koto Ward, Tokyo (Tokyo Motor Show)
	Symposium	Institute of Industrial Science, The University of Tokyo
FY2018	Symposium	Koto Ward, Tokyo (Tokyo International Exchange Hall)
	Citizen dialogue	Shodoshima, Kagawa prefecture
	Symposium	Koto Ward, Tokyo (TFT Hall)
FY2019	Citizen dialogue	Ina City, Nagano prefecture
	Symposium	Koto Ward, Tokyo (Tokyo Motor Show)
FY2020	Citizen dialogue (online)	Maebashi City, Gunma prefecture
	Regional Automated Driving Summit (hybrid event)	Local governments across Japan (Kamikoani, Akita prefecture, Eiheiji-cho, Fukui prefecture, Chatan, Okinawa prefecture, etc.)
FY2021	Citizen dialogue (online)	Yokohama City, Kanagawa prefecture
FY2022	Citizen dialogue (hybrid event)	Tochigi prefecture (*)

*Prefecture organized FOTs at its 10 cities and towns.

Fig.6: Discussions at Regional Automated Driving Summit (held March 25, 2021) held

from local governments, traffic businesses, and startup businesses from across the country who are engaged in FOTs for automated vehicles, shared their activities, and held a "local automated driving summit" to discuss issues.

For the discussion, we used a graphic recording to do visualization that anyone could intuitively understand, publish on websites such as SIP-café, etc., and share with local governments in venue areas so that the information could be used widely in public awareness activities for citizens even after the event. (Fig.7)

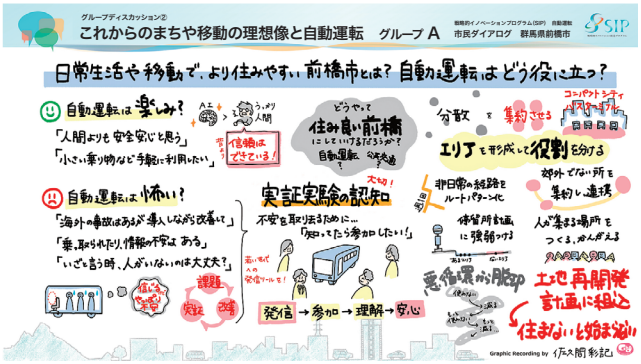

Fig.7: Maebashi citizen dialogues (held on January 17, 2021) graphic recording results

2.2. Share the achievement of the program: Joint test ride events

For fostering social acceptance, as one of our efforts to make media interested in automated driving, we consider that it is important to offer a test ride opportunity to ride on automated driving for media reporters and journalists. In the second phase of SIP-adus, we originally planned a test-ride event and exhibition with the cooperation of the Japan Automobile Manufacturers Association (JAMA) and support of OEM companies on the Tokyo waterfront city area where the Olympic and Paralympic Games Tokyo 2020 would be held. But, under the COVID19 pandemic, as the games were postponed, our event was also rescheduled to 2021. On the other hand, though the test-ride and exhibition were originally considered as just one-time event, for social circumstance declining direct communication opportunities but increasing importance of communication through media, we eventually have a plan even for third event aiming for further appeal to media reporters and journalists.

This plan change was started from cancelation of collaboration with JAMA then followed by ask each of automobile manufacturers to provide exhibits to the event which wiill be organized only by SIP-adus. Under the circumstances in which various events where automobile manufacturers comme together, such as Tokyo motor show, were cancelled, we aimed to offer a place worth publicly reporting as an event attracting automotive manufacturers, supplliers, software develop companies and universities.

The first joint test ride event was held on April 20-21, 2021 in one part of the parking lot of Ooedo Onsen Monogatari, a hot springs facility in the heart of the Tokyo waterfront area. Targeting media and journalists, we encouraged media coverage by information releases to media companies and public notices for the Automobile Journalists Association of Japan.

The exhibitors were consited of 8 organisations such as Valeo, Kanazawa University, Subaru, Tier IV, Toyota, Nissan, Honda, showing the total of 18 vehicles as test-ride vehicles and exhibits on the venue. And also asking support to TOYOTA Motor Corporation and HINO motors as participant to the FOTs in the Tokyo waterfront area, their automated bus based on "SORA" with fuel cell were carried in to the venue to exhibit.

At the time, there were concerns about trends in COVID-19 infections. However, thankfully, infections had dropped around the time of the event and it went smoothly by adapting infection countermeasures at the venue and confirming with emergency contacts.

The number of the visitors from media and journalists were the total of 106 in 2 days event with test-ride schedule fully reserved. As the ride to the commercial vehicles by automated makers had attracted many people under the condition of 90 minutes ride per trip, meaning only 5 trips maximum in a day, we struggled to make orders for them in advance.

As unexpected event, Mr. Shinji Inoue, as then Minister of State for Science and Technology Policy of Cabinet Office came to and walk around the venue to see and talked with exhibitors at each of their booth.

The rating by reporters and journalists are good overall with comments such as: "it was helpful to well understand development policies and originality of each exhibitor in seamlessly switching the test-ride vehicles to ride and evaluate," "it was good occasion to make access to automated technologies developed by suppliers," "the event showed realistic image with not only test vehicles but also latest model of vehicles already in the market equipped with automated technology." This gave us confidence to the result of the event as meaningful effort.

In addition to being broadcast on Nihon TV and TV Asahi, it was also picked up by online news outlets like the Kyodo News and Nikkei xTECH, creating opportunities for a wide

Fig.8: Commemorative photo at first event venue

range of consumers to be exposed to the information. (Fig.8)

The second event was held for three days from 18 to 20 October, 2021 at the Tokyo International Cruise Terminal and its second parking lot, along with nearby Aomi F1-S zone. The 19th and 20th were for media as we did at the previous event, and the 18th as the first day of the event was reserved for SIP-adus members who came to the venue for the occasion of their regular meetings exceptionally scheduled to be held there for this test-ride.

The timing of the event was settled to position the event as an activity to open a new season with FOTs in the Tokyo waterfront area from November 2021. And also following the amendment to the Road Traffic Act/Road Transport Vehicle Act in April, the month of November, when the AEB installation was made compulsory for new vehicles in accordance with the newly adapted WP29 regulation ahead of the world, was the best timing to appeal "the global leading Japanese safety philosophy" to the world.

There were nine companies who participated in the exhibition: Suzuki, Daihatsu, Toyota, Nissan, Honda, Continental, Valeo, Tier IV, and BMW for a total of 20 vehicles as the test-ride vehicles and exhibits. (Fig.9)

Fig.9: Commemorative photo at second even

Also in the Aomi F1-S Zone venue, a press room was introduced for the convenience of media reporters and journalists when taking a break or refreshments, as well as for briefing held twice a day for the first time. The one-hour briefing was for presentations on SIP-adus and seminars about newly standardized AEB (Automatic Emergency Breaking) installation and legislative trends by officials from relevant department of the Ministry of Land, Infrastructure, Transport and Tourism, invited for the event.

Further, as another new attempt, we established a visual field loss experience area in the press room for visitors to experience visual field loss by a driving simulator during their free time between test rides and briefings.

An exhibition with experience of AEB and pedal misapplication prevention system was also new in the event. A rather large space of 70m x 18m was reserved for this exhibition to experience the pedal misapplication prevention system by Toyota and the AEB systems by Suzuki and Daihatsu. (Fig.10)

Fig.10: Test-ride on vehicle with AEB

The total of 104 reporters and journalists came together in the two days for press, and the event was featured in articles by 24 publishers including online car magazines such as "ahead" and "cliccar", and "IT media Web" as online business magazine among others.

The third test-ride event was held for three days from Thursday 29 September to Saturday 1 October, 2022 at Aomi R zone in the Tokyo waterfront city area. As conclusion and transition of activities of the second phase of SIP-adus, the event was planned and carried out under the theme "Japan takes a global leadership role of traffic safety in the new cohesive society with inclusion and respectful diversity"

The Saturday event was planned to attract a generation of undergraduate and graduate students, who represent the general public and will be leaders of the society when the automated driving technologies are commercialized..

The exhibits and explanatory sessions by the event organizer were more enhanced than before, with the core exhibits by JARI (Japan Automobile Research Institute) who is working on creation of a real place for the performance evaluation and by DIVP® of a virtual space, associated with other exhibits for V2N that had been studied at the Tokyo waterfront area and those by HIDO (Highway Industry Development Organization) who lead FOTs in rural areas. These were closed by offering something useful even only through watching and talking together at the venue, other than test-ride experience.

2.3. Show achievements of research activities: Results presentation event and magazine book (tentative)

As mentioned in previous sections about the test-ride events, we had preliminary plan to carry out an event at the Tokyo waterfront city area, one of the venues of the Olympic and Parlympic games Tokyo 2020. Other than test-ride event, we

had a plan to show achievements made through the second phase of SIP-adus. This was realized in March 2021 as "the Showcase of SIP automated driving changing the future - the interim results presentation event of the second phase of SIP-adus"

This was to demonstrate latest status of researches proceeded by SIP-adus for practical implementation of automated driving in an easy to understand manner, and to offer opportunities to feel current environment where these achievements were materialized. For these, we started from organizing and categorizing each of researches then worked to define story structure of the exhibition. As a result of this, five major themed areas were settled.

"Welcome Zone (Society5.0 and automated driving)" as the entrance showed the future society concept with Society5.0 through realization of automated driving society and introduced outline of SIP-adus activities, along with a message video from Mr. Kuzumaki, the program director of SIP-adus, projected on a large screen.

"01 Technologies to realize automated driving society" was mainly for exhibits on studies of cutting-edge technologies related to automated driving, such as studies at the Tokyo waterfront are to generate traffic environment information for infrastructure-cooperated automated driving, those to create virtual environment for automated driving safety evaluation, and also research studies on Intrusion Detection System (IDS) against cyberattack. In this area, test vehicles used through studies and a symbolic exhibit with a large display to offer easy-to-understand description on the FOTs at the Tokyo waterfront area, such exibits helped visitors to deepen their understanding with arosed interests to the technologies.

The zone "02 Social implementation of automated driving" had exhibits on FOTs for social implementation of automated driving mobility services in depopulating rural areas and studies for sustainable business models of such services, and also exhibits concerning to creation of MD Communet®, a web portal for future multi-purpose use of geographic data linked to transportation environment with broadly adapted automated driving. A golf cart-type automated vehicle used in rural area FOTs was displayed together with a movie on studies carried out in remote areas to facilitate understanding like other zones.

In the zone "03 Automated driving familiar to people", the exhibits related to the society in which all the people can move around safely and securely, introducing studies on knowledges to learn and effective education methods about automated vehicles and popularizing driver-assistance vehicles, as well as studies on effectiveness of advanced driving assistance system for people with visual field loss.

Lastly, "04 SIP-adus keeping an eye toward the society" was focused on communication activities promoted by SIP-adus to realize automated driving society and other efforts to enhance industry-academia-government collaboration and global cooperation.

Fig.11: Exhibitions

We introduced 4 key pillars: i) generation and transmission of transport environment information, ii) establishment of virtual environment for safety evaluation, iii) creation of evaluation method for cybersecurity (IDS), iv) development of web portal for geographic data distribution. Also technological developments for generation and transmission of transport environment information such as merging assistance information, traffic information utilized vehicle probe data and others were shown along with activities such as FOTs in the Tokyo waterfront area and in rural area for automated driving services, and others to disseminate social acceptance and to strengthen international cooperation.

As shown in Fig.11, we deployed various exhibits such as actual vehicles and equipment, explainer videos, and others to facilitate understanding and access to information in complementing figures and descriptions on walls, while exhibitors gave explanation of details of their activities to communicate with visitors as two-ways exhibitions. In Fig.12, it is shown that the venue guided tour of around 50 minutes were organized. A party of ten visitors could visit each zone with a guide who assists visitors to communicate with exhibitors and deepen their understanding.

As the event was taken place under COVID-19 pandemic, we applied infection prevention measures in the venue, requesting visitors to indicate their contact information, to sanitize hands, and also to check their body temperature, while always controlling the number of visitors inside the venue. Further, for companies and individuals who might hesitate to visit the venue, we created a website with 3D virtual venue walkthrough. All wall graphics, texts, videos displayed in the venue were accessible online. Online guided tours were also available on the web as "virtual guided tour", which enabled online visitors to watch the venue and to communicate with exhibitors on the venue through a web meeting system. (Fig.12)

On the website, we applied various measures to encourage

online participation, making TV show-style video with hosts walking through and showing the venue, and adapting live streaming camera moving around the venue in regular basis to transmit online atmosphere of the actual venue. These measures against COVID-19 pandemic are considered as effective even after the pandemic for remote participation.

Fig.12: Scene of guided tour

A total of 1,097 people participated to the event at the venue and online. As getting media coverage, articles on the event were published by Response., cliccar, carview!, Nikkan Kogyo Shimbun, NEXT MOBILITY, Yahoo! News, and others. Also visit by researchers and SIP-adus related persons encouraged mutual communication among them as did so exchange of exhibitors.

We are preparing "Final results presentation event", as of the timing of writing of this article, to hold in around March 2023 as the end of the second phase of SIP-adus. This must be a culmination of SIP-adus activities, as we keep this in mind to plan the event. A book as a collection of overall SIP-adus activities, in progress as of this timing, will be also published and distributed at the event venue.

An objective of publication of the book is to review SIP-adus activities as a project which have led its roll and purpose to achievements in reality, then to clarify what derived the achievements, which would broadly help people who want to innovate to find a hint. Another is to structuralize whole of the project as a successful case of effective collaboration among industry, academia and government or ministries and agencies by strong will of "individuals" who aim to achieve something.

We have selected and structuralized topics among events of SIP-adus and its related industries in and outside of Japan from pre-starting of SIP-adus to FY 2022, then interviewed key persons who led major topics in ministries and agencies, companies or universities. Based of this, we are going to make a story to be remained in telling how the ideological backbone of the program have been developed over the period of two phases of SIP-adus.

3 Conclusion

Many citizens had viewed or taken part to the events described above, of which the articles were published by many medias. We can say that this contributed to foster public acceptance of automated driving to a certain extent. On the other hand, fostering public acceptance can be completed not only by SIP-adus activities, but also by continuous effort to be proceeded by researchers and experts for the future as their issue. Relationship between our-own lifestyle and mobility must be always thought by each of us as citizens to take actions, considering how automated driving can contribute and give impact to this relationship. Based on these reflections, we are going to enumerate what should be put importance even after the program to foster public acceptance as we found through the SIP-adus activities.

3.1. Expand accessibility by utilizing digital media

SIP-café, which was inaugurated with a concept of information transmission essential to foster public acceptance, contributed to enhance communication on automated driving offering space to collect, transmit and amass information, as we recognize. On this website, we effectively transmitted information in taking advantage of digital media, which enabled us to make articles public in short-time after getting information with many photos or link to videos.

Further, because of COVID-19 pandemic not only in Japan but also outside Japan since around spring 2020, we needed to shift to online activities building even in this project utilizing digital media. For example, communication events such as "Citizen Dialogue", "Automated driving LIVE News", and webinars, or exhibitions for result presentation events, these events were carried out using digital distribution system or on hybrid meeting style of in-person and remote attendees. Digital media enabled us to provide event experiences for remote attendees which are not so far from those in real venue. Like this, acquiring new contact point to participants as "remote viewing", we were able to provide an entrance to automated driving for people who had difficulties to attend to in-person event as we've done. This can be said one of contributions toward fostering public acceptance.

3.2. Deliberations as "one team" - the entire community uniting as one

What we found through activities mentioned above such as "Memoirs of Automated Driving Trials" and "Citizen Dialogue/ Regional Automated Driving Summit", that a key is "one team" of whole local stake holders, while citizens understand mobility issues in their town as their own problem, they cooperate with

local government and business operators to talk about and discuss together how mobility in their own town should be, then through implementation of such services, all participants continuously take part to improvement of this in checking operation. In contrast to ready-made or government-made mobility service provided to citizens, what we discovered was "best practice" with co-realization of ideal mobility to improve quality of life in community, with more engaged citizens as a result of construction and continuous use of a system in which citizens can voice their opinion about local mobility services as involved member. Technological development and institutional framework are indispensable to realize social implementation of automated driving, but as mentioned above, frank communication among citizens, local government and business operators must be sustained as system to make sustainable local mobility service more realistic.

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4) Research for Automated Driving Bus Friendly to Persons with Disabilities or Reduced Mobility and Orientation

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(Abstract) Our aim is to realize a "Cohesive Society" in which people with disabilities, who until now have not necessarily been able to fully participate, can actively participate and contribute to society. In the 1990s, Low-floor busses appeared on the market, and measures such as electric ramps for wheelchair access have been studied. In the near future, automated driving is expected to reduce traffic accidents and ease traffic congestion. Even in a world where automated buses are widely used, however, it is necessary to aim for automated buses that can be used by people with disabilities or reduced mobility and orientation including elderlies, rather than simply leaving them behind. We therefore conducted a research to identify design requirements and considerations in order to achieve such automated buses. The research was conducted basically with participation of people with such reduced mobility, including behavioral observation of participants and bus drivers when they have troubles and a review meeting after making and testing mockups. As a result, as recognized problems, something related to getting in and off the bus, locking the wheel chair, among others are reported. For these, we clarified requirements and considerations necessary to implement and put into practical use devices such as automatic ramp, wheelchair locking devices, and others

Keywords: Automated driving buses friendly to road users with limited mobility, inclusive society, people with disabilities, barrier-free, participation of users

1 Study Overview

1.1. Background and objectives

Buses are an important means of transportation for people with limited mobility, such as people with disabilities, the elderly, and people using baby strollers (hereinafter referred to as "road users with limited mobility"). In the early 1990s, buses equipped with wheelchair lifts were studied,[1] and in the late 1990s, low-floor busses were introduced by various manufacturers. At that time, low-floor busses were a fully-flat type with no steps inside at all, and some were equipped with an electric ramp for wheelchairs, but their high price and small number of seats prevented their wide acceptance.[2]

In response, the Ministry of Land, Infrastructure, Transport and Tourism established standard specifications[3] and a certification system[4] for low-floor busses, with the aim of reducing their manufacturing costs and promoting their safety and convenience. The standard specifications have continued to be revised to make buses more friendly to road users with limited mobility.[5]

In regard to the SIP-adus (Cross-ministerial Strategic Innovation Promotion Program (SIP) Automated Driving for Universal Services), it is also stated that one goal is to realize a society in which mobility of road users with limited mobility is ensured and all people have a higher quality of life.

Therefore, after researching and analyzing the needs of road users with limited mobility as well as domestic and international trends, we conducted a study with the aim of formulating implementation requirements and considerations concerning the interior layout of automated buses which road users with limited mobility can use more freely.

1.2. Research methodology

Through interviews with and behavioral observations of road users with limited mobility, we collected and organized the value of using buses and the problems with using buses for each type of road users with limited mobility. Based on the results, ideas for bus layout were discussed in expert interviews and workshops. Some of the ideas were then developed into a bus mockup, virtual reality (VR), and illustrations, and a review meeting was held (Fig.1), so that road users with limited mobility and experts can test these ideas.

Based on the feedback obtained thought the review meeting, a report "design requirements and considerations" was compiled. A study committee consisted of road users of limited mobilities and experts from bus and other related industry groups was established to provide advice on the overall study. This report describes the requirements for each design, the

Fig.1: A review meeting
(Left: VR evaluation (cane and short leg orthosis user);
right: mock-up evaluation (low vision)

feedback obtained from bus operators and participants to the research, and the specific requirements and considerations based on said feedback.

2 Summary of problems

Based on the interviews and behavioral observations of the road users with limited mobility and experts as mentioned above, we extracted the problems for each type of mobility limitation when road users with limited mobility take a bus and those for bus operators. The details are shown in Table 1.

During the interviews, we asked not only about the problems faced when using the bus, but also about the value of using the bus for road users with limited mobility. We found that using the bus has two primary values: as a valuable means to get around during daily life, and as a gateway to the world to expand their range of activities. The following is a partial list of ideas brushed up after obtained through the review meeting, out of all ideas discussed based on the above mentioned problems and values.

3 Design requirements and considerations

3.1. Automatic ramps

3.1.1. Overview

When wheelchair users get on and off the bus, the driver has to manually move the ramp in and out, which takes time. The installation of an automatic ramp that can be moved in and out at the touch of a button (Fig.2) would solve these problems.

Table 1: Road users with limited mobility and bus drivers' problems when using buses (extract)

Classification		Description of problems when using buses
Physically handicapped person	Electric wheelchair users	・Wheelchair users feel bad for other passengers when the driver takes time to set up a ramp and to secure the wheelchair for their getting on and off the bus, so they hesitated to do so. ・Securing a wheelchair next to the current folding seats narrows the aisle. ・Scared of sudden stops and centrifugal forces when taking a curve.
	Users with canes and short leg orthosis	・Difficulties getting on and off the bus when there is a gap between the ground and the floor of the bus. ・Sometimes feels rushed because they have to secure their brace before the bus even stops. ・Narrow space in front of the seat does not allow legs to stretch out to unfasten the brace.
	Upper limb disability users	・Sometimes difficult to press the stop button because their fingers aren't strong enough. ・Hard to hold on to the railing when they also have luggage. ・Difficult to prepare fare payments etc. without sitting down.
Visually impaired users	Blind white cane users	・Difficult to find a bus stop if there are no braille blocks. ・Unsure if the reason for the bus stopping is because of arrival at a bus stop or just due to a red light. ・Confusion due to different buses, such as forward doors, rear doors, pre-payment, post-payment, etc.
	Blind guide dog users	・Hard to find a seat when it's crowded. Feel bad about asking others to give up their seats. ・Don't know where to stand without disturbing other passengers. ・Not knowing where the stop button etc. is located, having to grope around for the location.
	Low vision users	・Unable to see which seats are available. ・Especially in the evening, it is difficult to press the stop button because of the similar colors of the button and the handrail. ・Unable to tell if this is a bus to desired destination.
Hearing-impaired users	Deaf users	・Unsure if the reason for the bus stopping is because of arrival at a bus stop or just due to a red light. ・Rely on displays for information, but it's hard to see when sitting toward the back. ・Unable to hear sounds, so unable to tell if IC card payment has succeeded.
	Hard-of-hearing users	・Unable to prepare for alighting without knowing the time and distance to the next bus stop. ・Hard to hear announcements. ・Difficult to get information to understand an emergency situation.
Intellectual/developmental disability users		・Don't know what to do when the display and the actual bus stops are out of sync. ・Confused by and unable to cope with changes in boarding methods, such as different doorway locations. ・No ruby characters provided for kanji characters, so stop signs, etc. are unreadable.
Mentally challenged users		・If they feel sick, it is considered bad manners to lie down and rest in the bus, so they get off the bus to rest, but don't know where they can rest. ・Announcements are psychologically taxing, with fast voices, mechanical noises, and loud noises.
Elderly users		・Hard to hear announcements. ・Difficult to get on and off the bus when there are steps. Also, the swaying of the bus makes them feel unsteady. ・Can panic because it takes a long time to get off the bus. Standing up before the bus stops leads to accidents involving falling over.
Baby stroller users		・Unaware of a dedicated space for strollers. Never seen anyone using it. ・Can panic because they cannot sit down or get off quickly enough due to carrying the stroller or dealing with their child. Feel apologetic to the people around them.
Bus drivers		・Many accidents involve passengers standing up and falling before arriving at the bus stop, making the driver feel uneasy during driving. ・Panic because it takes so much time to fold the seats, secure wheelchairs, and deploy the ramp. Many people are reluctant to use wheelchair safety belts, which is dangerous. ・Announcements and responses to passenger inquiries can be made while the bus is stopped, allowing the driver to concentrate on driving.

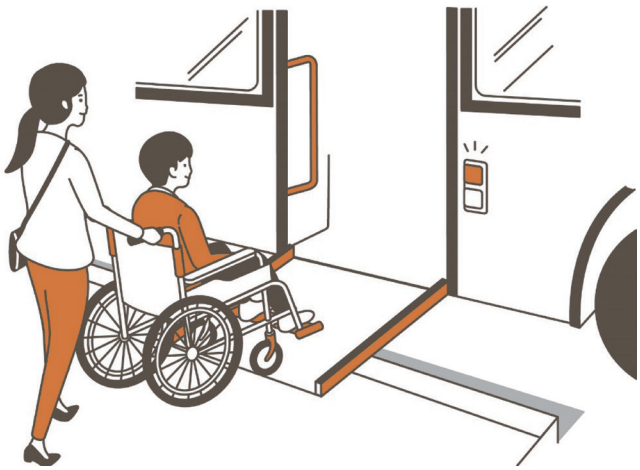

Fig.2: Image of automatic ramp

3.1.2. Feedback obtained from bus operators and research participants, etc.

While some people said that the reduction of time required for deployment of the ramp was an advantage, others said that the slope of the ramp could be concern and that visual and auditory information was necessary when deploying the equipment.

3.1.3. Examples of specific requirements

(1) Make the slope more gradual

This is because someone on the bus, not bus conductor, possibly need to support the wheel chair users when bus is automated without any conductors in the future.

(2) Automatic ramp deployment/retraction with sound and lights

This is especially required for the visually or hearing impaired, who may not otherwise know whether the automatic ramp is completely deployed or not yet.

(3) Slope formed with a single board

If the automatic ramp is stacked in two layers, wheelchairs may get stuck on the step in the middle of the ramp.

(4) Add roughness on the slope surface to an extent that will not interfere with walking

For the visually impaired, getting on and off the bus by means of a ramp, instead of the present situation of getting on and off by means of steps, would otherwise make it difficult for them to distinguish the boundary between the inside and the outside of the bus.

3.1.4. Considerations

(1) Operational industry guidelines for automatic ramp use need to be created

In order to use automatic ramps safely, it is necessary to establish operational industry guidelines for whether automatic ramps should be deployed for all passengers or only for specific passengers. Since the automatic ramp is effective not only for wheelchair users but also for the elderly, and because it may cause confusion when a driver or a system has to make a decision each time whether or not to extend the automatic ramp, it is desirable to extend the ramp for all passengers.

(2) Improvements to bus stops (boarding and alighting areas)

The standards for facilitating mobility require that bus stop areas are designed to allow wheelchair users to smoothly board and alight from the buses that stop adjacent to the areasIn reality, however, physical constraints result in bus stops without sidewalks or on sloping roads due to drainage ditches. In order for the use of automatic ramps to spread, it is necessary to improve bus stops so that automatic ramps can land on stable ground.

3.2. Simple folding seats

3.2.1. Overview

When wheelchair users get on and off the bus, the driver needs to fold the foldable seats, which takes up additional time. Because of the time required, some wheelchair users have commented that they feel apologetic toward the other passengers and the driver. Both the drivers and the wheelchair users feel the need for improvements.

The simplicity of the folding seats (Fig.3) creates space within the bus, making it easier for wheelchairs and strollers to get on and off.

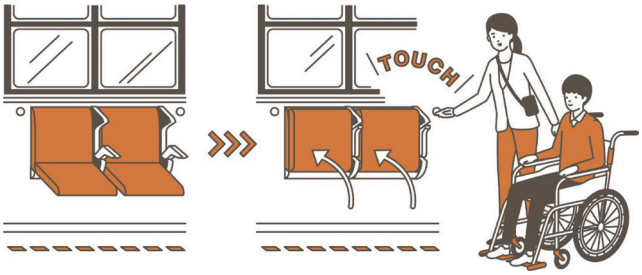

Fig.3: Image of a simple folding seat

3.2.2. Feedback obtained from operators, concerned parties, etc.

While some commented that these seats provide both space and seating as required and are easy for wheelchairs and stroller users to use, some of the participants commented that it was difficult to find a seat for a person with white cane, and difficult to sit on a folding seat while holding it down with their hands.

3.2.3. Examples of specific requirements

(1) Foldable seats should be sideways to the direction of travel

If the folding seat is oriented in the direction of travel, the seat cannot be folded to provide more space due to the position of the backrest.

(2) When not in use, the seat surface is in a lowered position.

A visually impaired person using a white cane judges whether a seat is available by the feel of the cane in their hand. Guide dogs are trained to place their head on an available seat. Therefore, when a passenger is not using a folding seat, the seat should be lowered.

(3) Open and close at the touch of a button

If the chair is heavy or requires a lot of force to close, it may be perceived as a chore to fold it up and utilize the space.

3.2.4. Considerations

(1) Minimize risk of accidents like finger entrapment

In the past, the driver folded the seat, checking carefully to perform the operation safely. In the proposed system, the passengers fold the seat for themselves by pressing a button. The new design must therefore prevent passengers from getting their fingers caught in the seat or otherwise injuring themselves.

(2) Loss of handrails

While the folding seat provides more space, it also requires fewer vertical grip bars, leaving fewer places for standing passengers to hold onto. Efforts to alleviate congestion and the installation of suspension straps and ceiling handrails are required.

(3) Safety Considerations

If a person with a cane or short leg orthosis sits on a sideways-facing seat, other passengers may trip over them, causing injury to themselves or other passengers. It is necessary to consider the safety of other passengers as well, such as by making announcements in the car to warn them.

3.3. Wheelchair locking devices

3.3.1. Overview

When a wheelchair user gets on the bus, the driver needs to secure the wheelchair to the floor with a three-point belt after the aforementioned ramp is deployed and retracted and the seat folded away, which is all very time-consuming.

A wheelchair locking device (Fig.4), which is easy to both secure and release, will be installed on the floor of the bus. It can be released by pressing a button mounted on the wall next to the device.

3.3.2. Feedback obtained from operators, research participants, etc.

Operators expressed hope that the time required to secure a wheelchair could be shortened and the burden on the operator to secure the wheelchair reduced. Users commented that they wanted floor makings to lead them to the correct position, that they stumbled over devices installed on the floor, and that their canes got caught on them.

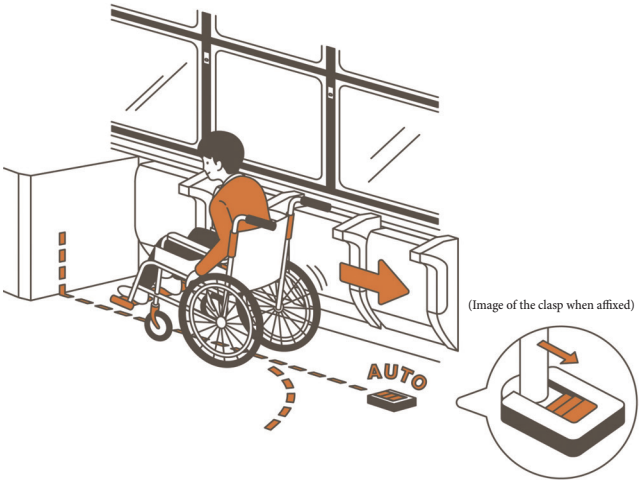

Fig.4: Image of wheelchair securing device

3.3.3. Examples of specific requirements

(1) Add floor guides for wheelchair users

Floor markings would make it easier for wheelchair users to secure their wheelchairs.

(2) Securing device installed with a lid under the folding seat

This will mitigate the risks that white canes used by the visually impaired or canes used by the elderly may get caught in the wheelchair locking device, or other passengers tripping over it.

3.3.4. Considerations

(1) Installation of fasteners on the wheelchair

In order to use such a wheelchair locking device, a clamp must be installed on the wheelchair. In a society where such wheelchair locking devices are installed on buses, it will be necessary to design a system and specifications for both the wheelchair and the locking device so that the device can be attached regardless of the type of wheelchair.

3.4. Content of on-board display

3.4.1. Overview

When road users with limited mobility who need a long time to get off the bus take an unfamiliar bus route, they are unable to prepare for getting off the bus with sufficient time to spare because they do not know where they are or how soon they will arrive at their destination, and they can panic when they arrive at their destination bus stop. People with mental disabilities and who are prone to changes in their physical condition can feel anxious about using the bus because they do not know at which bus stop they can get off to rest if they feel unwell during the bus ride. Stroller users feel inconvenienced by the lack of information around bus stops because they need to take care of their infants. This system solves these problems by displaying detailed information on the on-board display. (Fig.5)

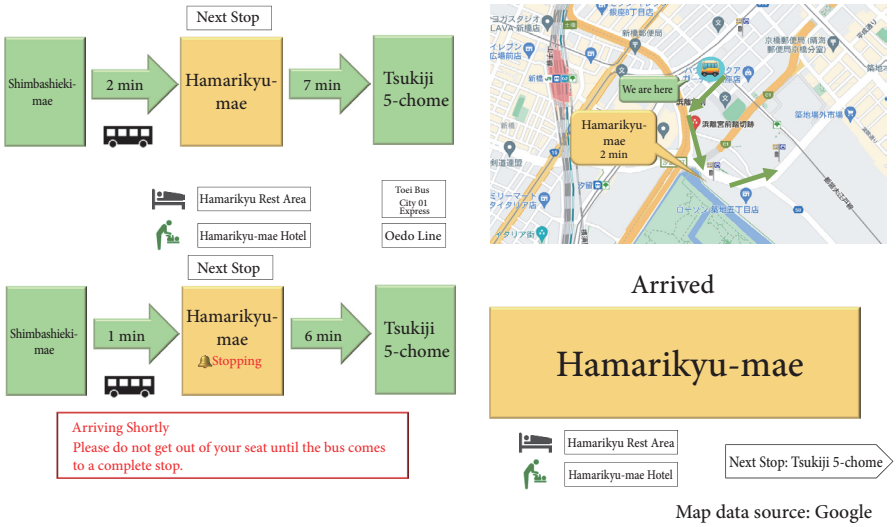

Fig.5: Image of the content displayed on the on-board display

3.4.2. Feedback obtained from operators, research participants, etc.

Operators commented that they could concentrate on driving because they would need to respond to fewer inquiries. While participants commented that it relieved their anxiety about their current location and the next stop, others said that it would be better to obtain information from tablets or other devices.

3.4.3. Considerations

(1) Selection of information to be displayed, provision of information via apps etc.

While it is good if information can be obtained via the display, too much information makes it difficult to receive each piece of information slowly and accurately, so it is necessary to consider the provision of information using apps held by the passengers.

3.5. Reason for stopping is indicated by lights inside the bus

3.5.1. Overview

Hearing-impaired persons and the elderly may not be able to understand the reason for the bus stopping, due to inability or difficulty in hearing announcements on the bus. To solve this problem, the reason for the bus stopping is indicated by the color of a light installed inside the bus. (Fig.6)

3.5.2. Feedback obtained from operators, concerned parties, etc.

Some users commented that while this does make it easier to understand the reason for stopping, and increases safety, color and brightness need to be taken into consideration.

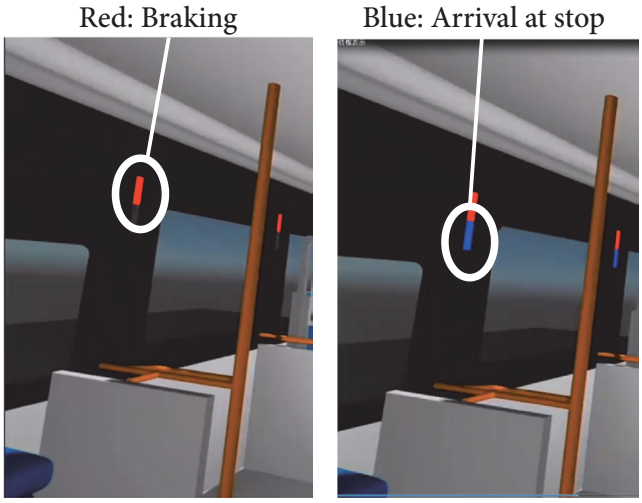

Fig.6: Image of on-board light display

4 Results and summary of the study

4.1. Design layout proposal to solve the problems of road users with limited mobility and drivers

This project focused not only on solving the problems of road users with limited mobility but also the problems of drivers.

Bus operators have been making efforts to promote buses that are easy for road users with limited mobility to use by introducing low-floor busses and continuously studying and working on improvements. For this study, we obtained feedback from road users with limited mobility on (1) automatic ramps, (2) simple folding seats, and (3) wheelchair securing devices, with the intent of allowing them smoother boarding and alighting.

In addition, bus operators and drivers make announcements to prevent accidents aboard the bus. Nevertheless, such accidents occur, especially among the elderly and road users with limited mobility, due to being in a hurry to get off the bus.

The content of onboard displays and reasons for stopping being indicated by a colored light, as described in sections 3.4 and 3.5 of this report, are considered to enhance the communication of information to road users with limited mobility, contributing to the reduction of impatience to get off the bus and the prevention of accidents involving falls inside the bus.

This project studied the design requirements and considerations assuming a situation in which automated buses will be widely used in the future and so drivers will not always be able to provide support to passengers. These requirements are applicable not only to future automated driving buses, but also to solving the problems of current scheduled buses.

4.2. Design requirements with consideration of universal design

We carefully made a design to solve an issue for a user so as not to generate another fresh issue for other users.

For example, for the visually impaired, the automatic ramp makes it difficult to see the boundary between inside and outside of the bus, the folding seats make it difficult to spot empty seats when they are closed, and the wheelchair securing device poses a risk of a cane getting caught in it. It is easy to imagine that such physical layout changes would cause inconvenience to visually impaired people who have difficulties for spatial recognition. As shown in the requirements and considerations in this study, it is necessary to design the space so that visually impaired people can use it safely; for example, by using materials and unevenness of the floor surface, alerts using sound, and the removal of exposed hazards.

4.3. Future considerations

The committee confirmed that the Japan Automobile Manufacturers Association would start measuring workability and safety using the mockups (automatic ramp, wheelchair securing device, and folding seats) created by this project, and that they would like to continue studying other ideas, incorporating new opinions based on the requirements described, with a view to proposing them to business operators.

5 Conclusion from Masayuki Kawamoto, chairperson of this study project

This study began with the question of how everyone, including road users with limited mobility, can use public transportation by themselves when public transportation becomes fully automated in the future and drivers and other crew members are no longer on board. The introduction of automated driving technology does not mean a sudden shift to fully automated driving, but a number of careful steps must be taken. It is an important point of view that the driver of public transportation, such as a bus route, should be able to concentrate on the driving itself and drive safely at the same time, while allowing road users with limited mobility to make full use of public transport without concern.

Furthermore, this survey have reaffirmed that, regardless of the introduction of automated driving, all public transportation, including existing public transportation, must provide reasonable consideration for road users with limited mobility, and that there is still much room for improvement from the current situation. Of course, various measures and the efforts of many predecessors have lowered the barriers for wheelchair users and others to use public transportation. However, while many of these measures have been hardware-based, the use of the IoT, although remarkably popular in recent years, has been slower to take root. Many bus transportation businesses are placed in a very difficult business environment, and it is difficult to introduce new equipment that requires a large investment. On the other hand, many road users with limited mobility now also have smartphones, and it is no longer so outlandish to making using such devices a prerequisite of taking the bus. Of course, there are many challenges in making such applications easy to use and understand; AI is not the simple and convenient answer to everything. What is important is to steadily identify true needs from the user's, rather than from the provider's, point of view, and to make repeated improvements from there. We hope that this survey will serve as a guidepost along the long road ahead.

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