2nd phase of Cross-ministerial Strategic Innovation Promotion Program (SIP) /Automated Driving for Universal Services / Fundamental Research for Automated Buses Friendly to Mobility-Constrained People

FY2021 Annual Report Summary

NTT DATA INSTITUTE OF MANAGEMENT CONSULTING, Inc.

September 2021

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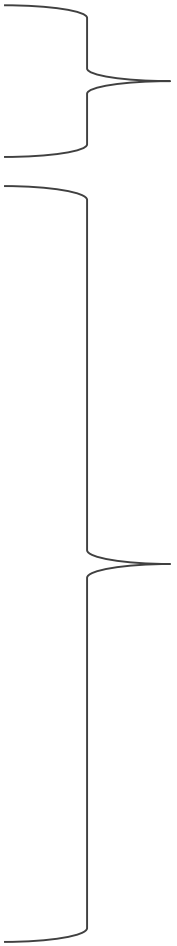


FY2020

FY2021

1. Project outline

1.Background and objective

The 2nd phase of SIP includes research on transportation services with automated buses that can be used independently and safely by mobility-constrained people (MCP). The purpose of this research is to propose draft guidelines including a bus interior layout design, which can be used safely by MCP.

Background
• In the 1st phase of the SIP, automatic bus arrival and departure control and acceleration/ deceleration smoothing control were developed. • In the 2nd phase of SIP, we will conduct surveys and verification experiments to **clarify the requirements for the application and social implementation of automated bus transportation services that can be used independently and safely by MCP**, such as wheelchair users, people with visual or hearing disabilities, and those who use baby carriages.

Objective
• In this research, we will: ➢ conduct research and analysis of the needs of MCP and domestic and international trends ➢ **propose design guidelines, including interior layout design** for buses that can be used safely by MCP

＊The investigative committee decided to call it "Design Implementation Requirements and Considerations (Design Requirements and Considerations) based on the fundamental research for automated buses friendly to mobility-constrained people".

2.Project overview

We will organize the values and issues that MCP perceive in buses and examine ideas. We evaluate ideas with mock-ups and virtual reality (VR), improve ideas and draft a guideline.

#	Title	Summary	What we do	Schedule
1	Value and issue analysis	Organize values and issues of using buses perceived by multiple MCP	・Workshop for opinions ・Behavioral observation and interviews with MCP ・Organize values and issues ・Survey on laws, regulations and standards ・Layout case study	FY2020
2	Discussing ideas	Consider ideas for improving the issues while maintaining the values perceived by MCP	・Expert interviews ・Workshop for ideas	
3	Evaluating ideas	Formulate derived ideas and get feedback from MCP	・Evaluation with mock-up ・Evaluation with VR ・Evaluation with illustration	FY2021
4	Improving ideas	Organize the idea improvement policy based on the feedbacks and obtain feedbacks from MCP again	・Organize the idea improvement policy ・Interviews with MCP	
5	Drafting guideline	Draft guideline based on ideas and feedbacks	・Draft guideline	

3.Premises

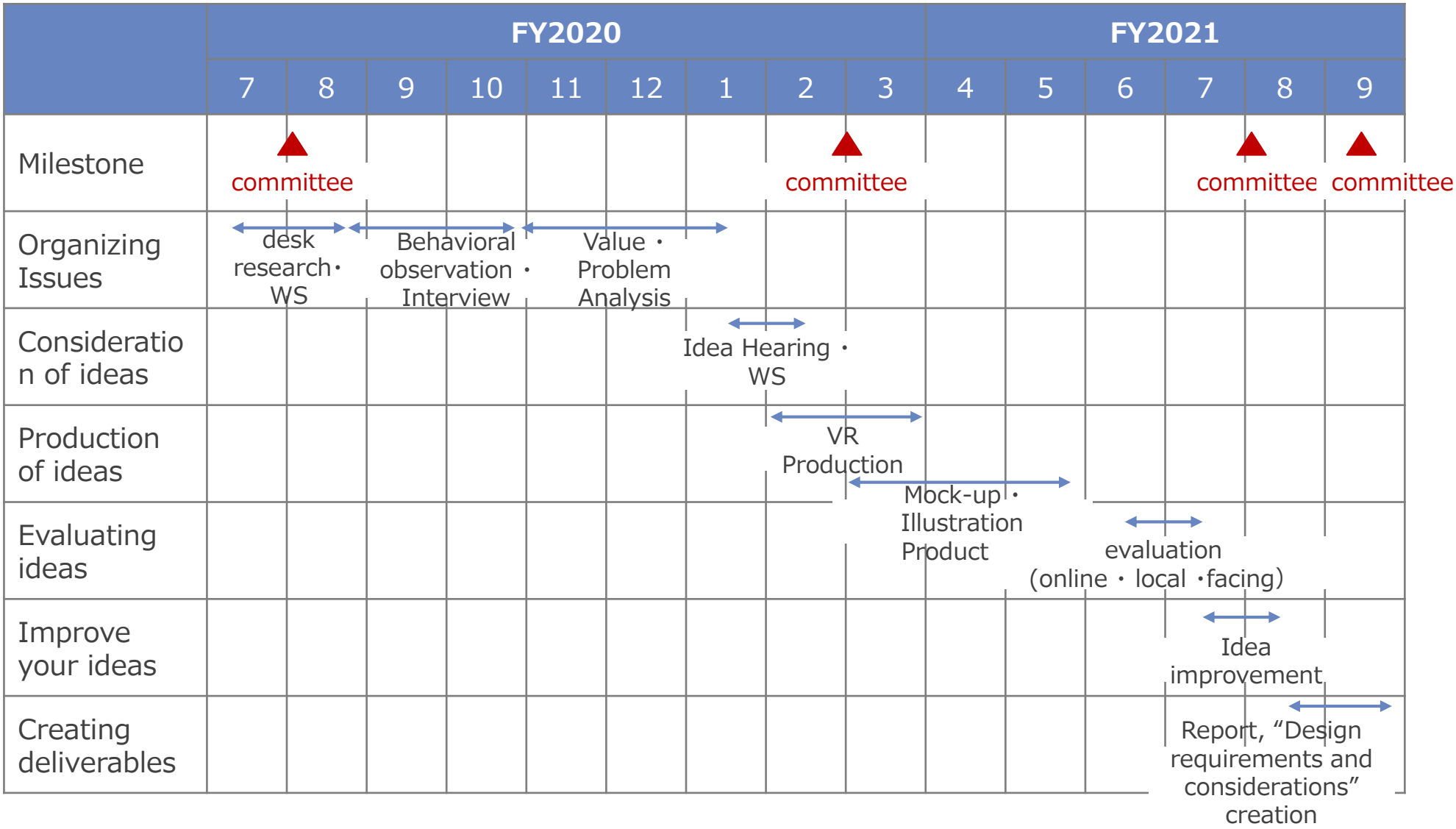
In this survey, we assume that MCP who are still using the bus are the users. The automatic driving level is Lv3, and the bus is a fixed-route buses. The guidelines include a bus design layout plan and a service plan for passengers at the bus company.

User image	• MCP who still use buses (people with disabilities, elderly, baby carriage users) Especially, • Those who are currently able to carry out their daily activities and short-distance transportation by themselves or with the help of escorts, but have concerns about using buses • Those who are able to use buses with escorts, but are not able to do so because of anxiety about using buses. • Healthy elderly people will increase in the future (those who can move around but cannot drive, etc.)
Assumed automated driving level*	• Lv3 ➢ System does most of the accelerating, braking, steering, etc. ➢ Drivers need to stay in the driver's seat in case of emergency, but it will be possible to operate the navigation system, etc. while driving.
Assumed buses	• Fixed route-buses (Not the small ones currently used in demonstration experiments, but the large ones that we see on our routes every day.)

*Previously, various organizations have conducted surveys and research on solving the problems of MCP. In this survey, while taking these efforts into account, we will also consider the solution of problems faced by drivers as an important perspective, with an eye to the future of automated driving.

4.Project Schedule

This study will proceed according to the following schedule.



5. Investigative committee

In this study, an investigative committee is established to give opinions and advice from expert viewpoints.

■ Member of investigative committee

Name	Organization
Tadashi Aisaka	Japan Federation of the Visually Impaired
Hirofumi Asaka	National Federation of Organization for the Disabled Persons
Kazuhiro Ariyama	Japanese Federation of the Deaf
Shungo Okano	Japan Automobile Manufacturers Association, Inc.
◎Masayuki Kawamoto	i-mobility platform, inc.
Kiyokuni Goshima	The Association for Technical Aids (ATA)
Hiroshi Tanaka	Nihon Bus Association
Shinichi Watanabe	Yokohama rehabilitation center

◎Chairman

2. Organize issues and discuss ideas

1. What we did in FY2020 - Value and issue analysis (1/2)

In the last fiscal year, we organized the types of MCP to be surveyed, and through behavioral observation and interviews, we derived the values and issues for MCP when they use buses.

1. Organize MCP types

- **The 12 types of MCP to be surveyed were determined** through workshops attended by MCP and opinions obtained from experts.

Visual
1. White cane
2. Guide dog
3. Low-vision

Hearing
4. Deaf
5. Hard-of-hearing

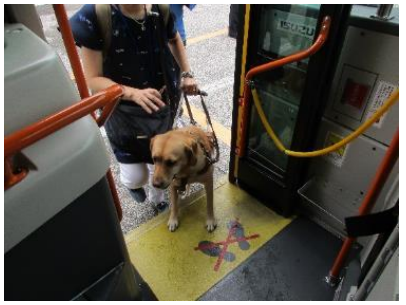
Physical
6. Power wheelchair user
7. Cane & brace user
8. Physically handicapped (upper limb)

Mental
9. Mental disability

Others
10. Stroller user
11. Elderly

2. Behavior observation

- Conducted behavioral observation **using an actual bus**
- The participants were asked to say out loud what they feel in their hearts, although they usually do not say it out loud.

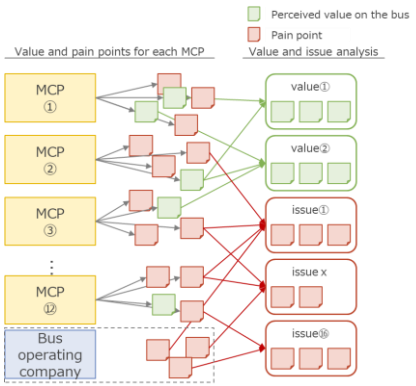


3. Interview

- Asked broad questions about what they felt during the behavioral observation, good points of using the bus, inconvenient points, tools they use, etc.
- Present bus floor plans and examples of bus layouts in Japan and overseas to gather opinions.

4. Value and issue analysis

- **Organized values and pain points** for each traffic constraint type
- **Derived 2 values and 16 issues** from the values and pain points for each type of MCP.



2. Organizing issues and discussing ideas

1. What we did in FY2020 - Value and issue analysis (2/2)

While MCP consider buses to be "a valuable part of their daily lives" and "a door to the world that expands the scope of their activities," they feel various troubles from before boarding to after getting off the bus, and are concerned about "not being able to ask for help when in trouble" if the buses are automated. Bus operators would like to improve the efficiency of loading and unloading ramps and securing wheelchairs, and reduce the number of accidents involving falls on board.

■What is the value of using buses for MCP?

a valuable link in daily life

a door to the world that expands the range of activities

■What problems do MCP have using the bus?

#	Task Title	#	Task Title
1	I can't get to the bus I want to take.	9	I don't know where I am or what I'm doing.
2	Fee payment method unknown	10	Difficulty in hearing announcements inside and outside the vehicle
3	Difficulty in grasping space	11	Stroller space
4	Fixing the wheelchair requires time and psychological burden.	12	Guilt, reticence, and relationships with other passengers
5	Burden on the body when getting on and off	13	Difficulty in pressing the get-off button
6	Rear bumps are inconvenient.	14	Impatience to get off the train
7	Anxiety about horizontal shaking	15	Anxiety about drop-off location
8	Communication with the driver	16	Anxiety about health problems

■What are your concerns about automated driving?

- If the driver were to disappear, **there would be no one to ask for help** when you want to confirm your destination, when you want to know where you are driving, when you pay your fare electronically and an error occurs, when you feel sick, or when a disaster such as an earthquake occurs.

■What do you think bus companies need to solve in order to better serve MCP?

- The **work involved in loading and unloading ramps and securing wheelchairs** when wheelchair users get on and off the bus is **very important for wheelchair users to get on and off the bus safely**, but because of the impact on the on-time operation of the bus and health, bus operators **want to perform this work more efficiently while maintaining safety**.
- Even though drivers make on-board announcements to warn passengers about **rising while driving**, MCP are **in a hurry to get off the bus**, and this is partly due to the fact that the drivers' anxiety about **accidents involving falling on the bus** has not been reduced.

2. Organizing issues and discussing ideas
1. What we did in FY2020 – Idea hearing, Consideration of ideas (1/2)

Based on the derived values and issues, hearings on ideas to solve the issues and a workshop to discuss the ideas were held, and detailed discussions were conducted on the derived ideas. In addition, research on related laws and standards was conducted.

value①

a valuable link in daily life

value②

a door to the world that expands the range of activities

#	Task Title
1	I can't get to the bus I want to take.
2	Fee payment method unknown
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14	Impatience to get off the train
15	Anxiety about drop-off location
16	Anxiety about health problems

5.1 Idea hearing

- Hearing from experts about ideas to solve problems.

Locationc	Idea title/type
slope	Automatic Slope
Wheelchair fixation	Automation of wheelchair fixation
folding (collapsible) chair	Folding chair like a movie theater
receipt of freight	Improve efficiency of fare collection Simplify the fare box Improved convenience of payment
IC card	Use of IC cards
glass window	In-car display using window glass
Light to teach space	A light that shows where the traffic constrained person is getting on and off the bus.
Handrail outside bus	Handrails that only come out when getting in and out
Tacit knowledge practice system for drivers	Driver Support System
App	Navigation apps An app to keep track of bus stop locations Matching Apps Notification to the driver Automatic Slope Reservation App An app that allows you to experience the layout of a car

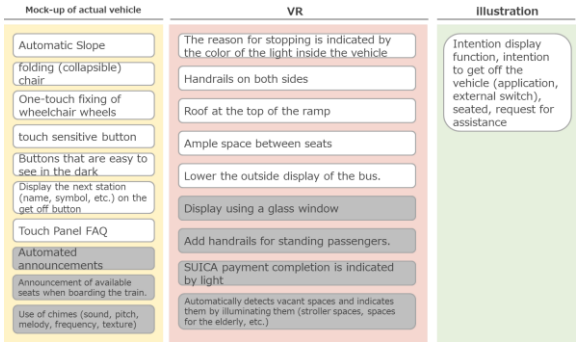
5.2 Idea review WS

- Identify ideas that can be realized by changing only buses, ideas that can be realized by buses and external ICT, ideas that can be realized by external ICT, etc.

Changes	layout improvement	Provision of information	Institutional and cultural modifications
Entire bus	Full flat (EV)	The reason for stopping is indicated by the color of the light inside the vehicle.	Automatic driving and driver assistance technologies (anti-rolling)
entrance and exit	Increase the number of entrances and exits (front, middle, and rear)		
slope	Automatic Slope		Even able-bodied people basically use the ramp
	Handrails on both sides		
	Roof at the top of the ramp		
Fare box and IC reader	Elimination of belt conveyor type fare boxes Minimize the number of fare boxes by separating the money changer, etc.	SUICA payment completion is indicated by light	
space	Backrest for standing passengers	Automatically detects vacant spaces and indicates them by illuminating them (stroller spaces, spaces for the elderly, etc.)	thoughtful seat
	small piece of furniture upon which one can sit and relax		

6. Consideration of ideas

- Of the ideas identified, select those to be evaluated using **actual vehicle mock-ups, VR, and illustrations**.
- Examine and concretize the ideas in detail according to the evaluation method.



7. Survey of relevant laws, regulations and standards

- Research and organize current laws and regulations (ministerial ordinances), certification procedures, guidelines, etc., to understand the constraints on the consideration of ideas.

1. What we did in FY2020 – Idea hearing, Consideration of ideas (2/2)

Mock-up of actual vehicle

- Automatic Slope
- folding (collapsible) chair
- One-touch fixing of wheelchair wheels
- touch sensitive button
- Buttons that are easy to see in the dark
- Display the next station (name, symbol, etc.) on the get off button
- Touch Panel FAQ
- Automated announcements
- Announcement of available seats when boarding the train.
- Use of chimes (sound, pitch, melody, frequency, texture)

VR

- The reason for stopping is indicated by the color of the light inside the vehicle
- Handrails on both sides
- Roof at the top of the ramp
- Ample space between seats
- Lower the outside display of the bus.
- Display using a glass window
- Add handrails for standing passengers.
- SUICA payment completion is indicated by light
- Automatically detects vacant spaces and indicates them by illuminating them (stroller spaces, spaces for the elderly, etc.)

illustration

- Intention display function, intention to get off the vehicle (application, external switch), seated, request for assistance

3. Evaluating ideas
(The following are implemented in FY2021)

2.Conducting evaluation meetings

An evaluation session was held at the Japan Automobile Research Institute using mock-ups, VR, and illustrations.

On-site evaluation (Japan Automobile Research Institute)

Date and time		June 30, 2021, 10:00-17:00
Participant	Evaluator	・Physical disability/electric wheelchair user (1), cane/short leg braces user (1), caregiver (1) Stroller users (2) ・Hearing impaired / Deaf (2), caregiver (1) ・Visually impaired/ White cane user (1 person), Low vision (1 person)
	adviser	・i-mobility platform inc.（1） ・Yokohama City Comprehensive Rehabilitation Center（1）
	observer	・Cabinet Office (4) ・New Energy and Industrial Technology Development Organization (1) ・Japan Automobile Research Institute (1) ・Japan Automobile Manufacturers Association (6) ・Japan Auto Body Industries Association (3) ・Tokyu Techno Systems Corporation (1)
Evaluation details		①Mock-up experience: Experience the parts installed on the bus (flip-up seat, wheelchair one-touch fixing device, electric boarding/exiting ramp) and ask for opinions. ② VR experience: Put on the VR goggles and see the layout of the bus recreated in the VR and ask for opinions. ③ Interview: See the bus layout ideas expressed in illustrations and ask for opinions along with other ideas. For those who have difficulty in presenting visual information, we will explain the details orally.

2.Conducting evaluation meetings

Online and in-person evaluations were conducted. Mock-ups, VR videos, and illustrations were used to get feedback.

Online Evaluation

Date and time	June23,2021 10:30-11:30	June23,2021 14:00-15:00	June 25, 2021 10:30-11:30	June 28, 2021 10:30-11:30
Participant	Hearing impaired/deaf	Mental disability/mentally challenged	People with intellectual /developmental disabilities	Visually impaired / guide dog users
Evaluation details	Interview While showing illustrations, mock-ups, VR videos, etc. that reflect the idea, ask for opinions about the idea. ※For those who have difficulty in presenting visual information, explain the details orally.			

Face-to-face evaluation (NTT DATA Institute of Management Consulting, Inc.)

Date and time	July 6, 2021 10:30-11:30
Participant	Physical disabilities/upper limb disabilities
Evaluation details	①VR Experience Put on the VR goggles, see the bus layout idea reproduced on the VR, and ask your opinion. ②Interview Ask for opinions on the ideas while showing illustrations and videos of mock-ups that reflect the ideas.

3. Scenes of the evaluation meeting

During the on-site evaluation, the participants experienced mock-ups, VR, and illustrations, and were asked for their opinions.

3.Evaluating ideas
4.Evaluation results obtained (1/2)

#	Evaluated ideas	General comment
1	Automatic slope	There were many positive comments about automatic ramps from electric wheelchair users, stroller users, and those who feel burdened by steps when getting on and off. However, **there were also requests for improvements to prevent users from slipping and falling, and for devices that would allow visually impaired people to recognize the presence of automatic ramps** (sound signals, social awareness).
2	Folding chair	Electric wheelchair users and stroller users gave positive comments on **the ease of folding** and **the space available.** On the other hand, white cane users and guide dog users commented **that they could not find a seat** when the chair was folded, upper limb users and users of canes and short leg braces were **burdened by having to lower the seat by themselves**, and some people with intellectual/developmental disabilities expressed the opinion that consideration should be given to **those who play with the ability to raise and lower the seat**.
3	One-touch fixing of wheelchair	Power wheelchair users and experts gave positive comments on the idea of adding guide lines and **making it easier to secure the wheelchair.** However, it was pointed out that the current fixation system creates **uneven surfaces on the floor**, which may cause **tripping hazards**, especially for users of canes, short leg braces, and the visually impaired, and may even cause **the cane to get caught in the floor**.
4	Touch-type buttons	There were positive comments from people with upper limb disabilities and experts that it was easy to push. However, **there were concerns about malfunctions** and requests for improvements in **the installation position to accommodate left and right upper limb disabilities.**
5	Easy-to-see button and next station (name, symbol, etc.) display even in the dark	As a positive point, people with low vision said that **the LCD screen is easier to read** than the current get-off button. The hearing impaired and other MCP also commented that the easy-to-understand information on **the next stop would help them prepare before getting off the bus and give them a sense of security.** There were several requests for improvement, such as the need to know **the time until the next stop**, and **the need to show the information on a large screen or smartphone** because it was difficult to assume a safe location.
6	Touch panel FAQ	There were positive comments from the hearing impaired, mentally challenged, and intellectually/developmentally challenged about the ability to make a reservation to get off the bus, to receive information about the current location and arrival at the next bus stop, and to receive information about nearby rest facilities as a FAQ. There were several requests for improvement, such as **the size of text**, **display of ruby**, **simple operability**, and **the ability to search for information on a large screen or personal smartphone or tablet instead of a tablet**. People with low vision also said that it would be better if there was a **voice reading function.**
7	Lower the outside display on the bus.	There were several opinions that the multiple displays on the outside of the vehicle were easy to understand. In addition, some low-vision users said that **it would be easier to see the displays if they were at eye level.** On the other hand, it became clear that low-vision users **need to get closer to the bus** in order to see the displays. Furthermore, there were several requests from users of electric wheelchairs, etc., that the display should be higher **because it would be difficult to see when it is crowded if it is installed in a low position,** and that the display should be available at bus stops, etc. People with intellectual and developmental disabilities requested **the use of ruby** and a way to **indicate route names in an easy-to-understand manner.**

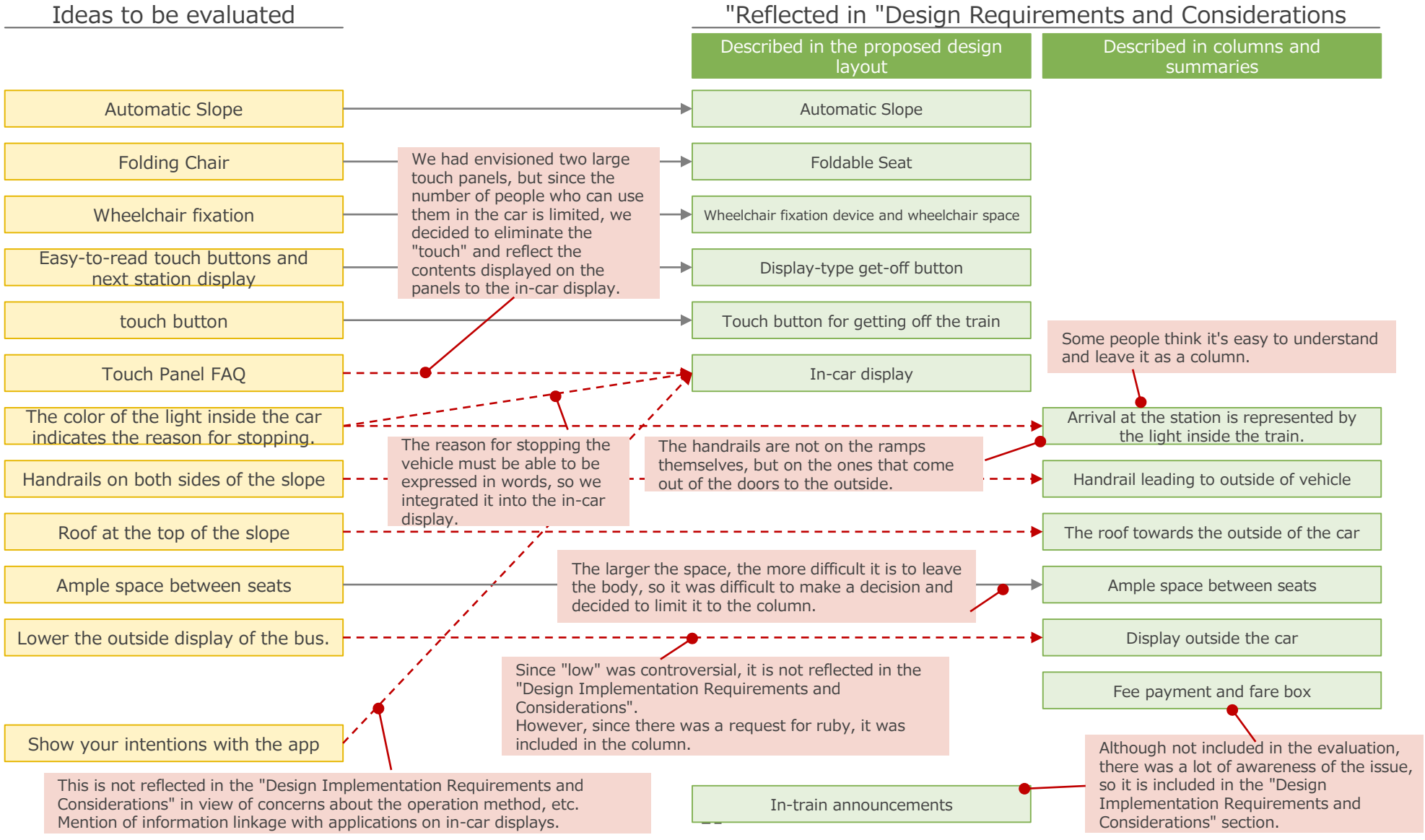
3.Evaluating ideas
4.Evaluation results obtained (2/2)

#	Evaluated ideas	General comment
8	Handrails on both sides of the automatic ramp	There were positive comments from electric wheelchair users, such **as the risk of wheelchair derailment is reduced**, and **the handrails help** the elderly. However, users of canes and short leg braces commented that **the handrails may get in the way** when walking and that they themselves do not need to use them.
9	Roof at the top of the automatic ramp	There were positive comments from electric wheelchair users and users of canes and short leg braces who were concerned about slipperiness in the rain and the need to use umbrellas. On the other hand, several people pointed out **the difficulty of stopping at bus stops** and suggested that the roofs of bus stops be made wider.
10	The reason for stopping is indicated by the color of the light in the car.	Many people with hearing disabilities and other transportation constraints expressed positive opinions about the ability to know when a bus is arriving or pausing. In terms of requests for improvement, some of the comments included **the use of different colors, the display of information in easily visible locations such as the ceiling**, and the ability to know when the bus is arriving at the bus stop. In addition, there were opinions that **text should be displayed** for people with color blindness and that **voice announcements would be good** for people with low vision.
11	Seat space	Positive comments included that the space would **make it easier** for users of canes and short leg braces **to stretch their legs**, for deaf people **to sign**, and **for stroller users to use**. However, the experts pointed out that **the space would reduce the space** for cane users and elderly people **to lean on, which may affect the safety of their movement**. In addition, electric wheelchair users expressed a desire **to sit facing forward** if possible.
12	Communication of intentions to bus drivers and other passengers using apps, etc.-1	There were several positive opinions that **informing the driver of the disability in advance would reduce the psychological burden**. On the other hand, there were several concerns about the operation of the application and requests to make it easier to use. In addition, there were opinions that **it is necessary to consider in detail how to communicate the necessary support and how to obtain effective support from the driver** after the driver is informed of the disability.
13	Using apps, etc., to communicate with bus drivers and other passengers – 2	Guide dog users, hearing-impaired people, and stroller users expressed positive opinions about the ability **to travel safely on the bus without worrying about the information at the drop-off station**. People with intellectual/developmental disabilities also appreciated the fact that **they could avoid the trouble of pressing the "get off" button when it was not necessary**. As for requests for improvement, there were opinions that the operation of the application needs to be made **more widely known, that information needs to be input by AI speakers, that notifications need to be made by vibration, and that there needs to be a mechanism to confirm that people who want to get off the bus** have done so.

4. Improving ideas

1. Improving ideas and how to reflect them in "Design Requirements and Considerations"

Based on the opinions obtained from the evaluation, ideas for improvement were discussed and reflected in the design layout plan or column and summary of "Design Requirements and Points to Consider".

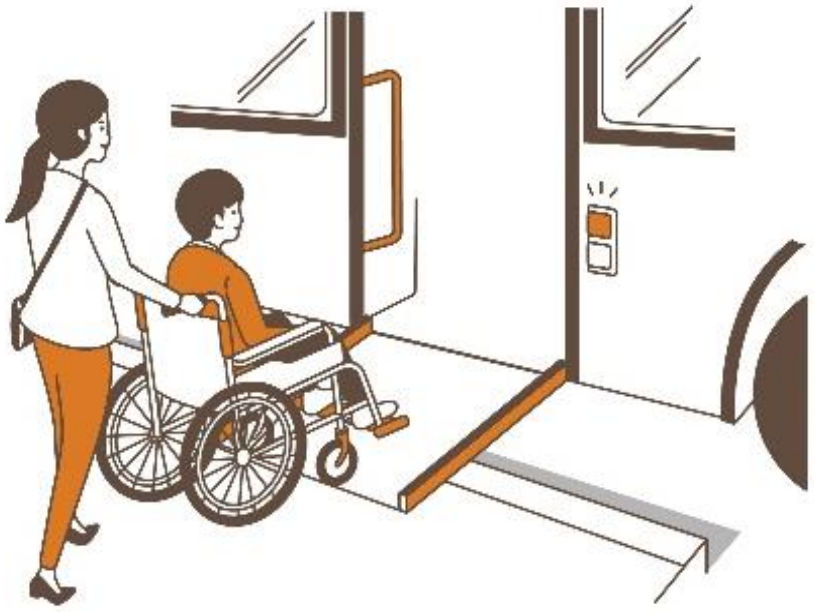


2.Create design requirements and considerations ①Automatic Slope

Summary	When wheelchair users get on and off the bus, the driver has to manually move the ramp in and out, which takes a lot of time and affects the ease of use for wheelchair users and the regular operation of the bus. This increases the workload of the driver. In response to the need to reduce the workload of drivers, we will solve these problems by developing an **automatic slope that can be loaded and unloaded at the touch of a button**.

MCP Problems	・ It takes a long time for the driver to set up the ramp when getting on and off the train, **which makes me feel sorry for the other passengers**. It also makes me hesitant to get on the train because it takes so long (electric wheelchair user). ・ When getting on and off the bus, **it is difficult to get up and down when there is a distance between the ground and the floor of the bus** (users of canes and short leg braces)
Driver Problems	・ It takes time to temporarily leave the driver's seat for loading and unloading the ramp, **which can interfere with on-time operation**. ・ When getting in and out of a wheelchair, the driver cannot leave his seat to collect the fare, **making either the wheelchair user or the passenger wait**.

Design implementation image



Design requirements (example)

- **Provide unevenness on the slope surface that does not interfere with walking.**
  - To help the visually impaired recognize the boundary between the vehicle and the slope.
- Provide **a system that alerts people with visual or hearing disabilities with sound or light** when the ramp is being used.
  - To allow visually and hearing impaired people inside and outside the vehicle to recognize that the slope is in operation.
- The slope of the ramp shall be designed to be equal to or more gentle than the existing standard of 7 degrees with the lowest 15 cm of height out to the sidewalk.
  - Because some wheelchair assistants feel that the existing standard of 7 degrees is too steep.

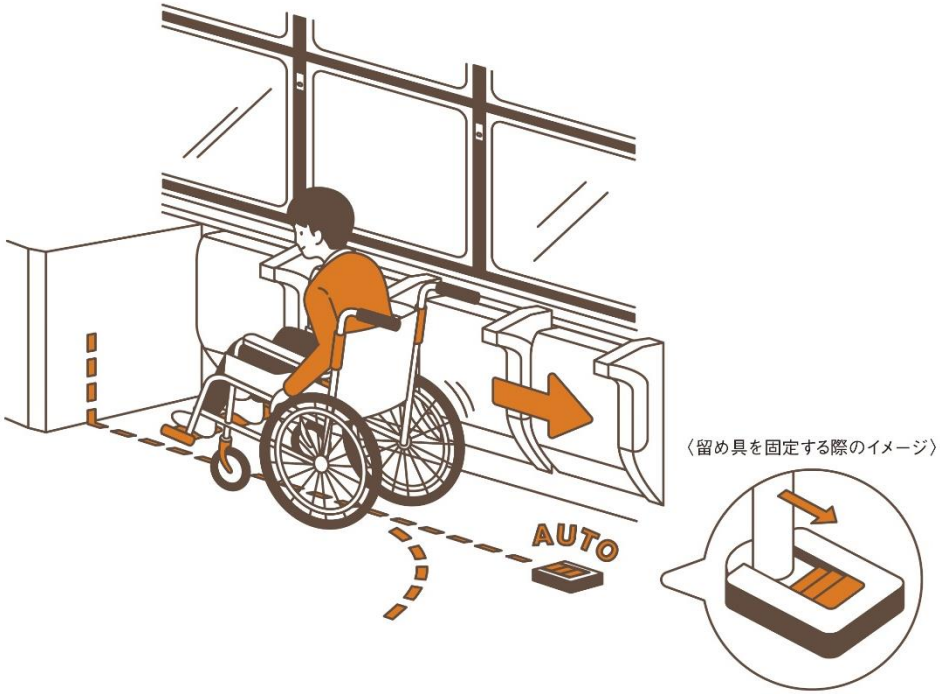
Considerations (example)

- Visually impaired people are concerned about tripping over ramps and not knowing the boundary between the ramp and the interior of the vehicle. In order to prevent confusion among the visually impaired, the presence or absence of an automatic ramp and the shape of the ramp should be indicated **by the sound of the ramp moving** and the **unevenness of the surface of the ramp**. Efforts should also be made to inform society about the installation of automatic ramps.
- In addition to the bus layout, **bus stops need to be improved**, such as those without sidewalks or with sloped roads for drainage, etc.

2.Create design requirements and considerations ②Wheelchair fixation device and wheelchair space

Summary	Currently, in order to secure a wheelchair, the driver must leave the driver's seat, get out of the seat, and secure the wheelchair to the floor with a three-point belt, which is time-consuming. This affects the ease of use of the bus for wheelchair users and the regular operation of the bus. We will solve this problem by introducing **a wheelchair fixation device that can easily fix wheelchairs**. In this fixture, **the wheelchair is attached to the fixture on the floor of the bus and the wheelchair is attached to the fixture**. (It is desirable to install this device in combination with the foldable seat, as described below.
MCP Problems	· I **sometimes feel sorry for other passengers** when it takes a long time to fix my wheelchair. (Electric wheelchair user)
Driver Problems	· It takes time to secure the wheelchair, **which leads to delays in the bus service**. · Many wheelchair users do not want to wear fixed belts, but only the side belts need to be attached for safety reasons. **It is a psychological burden for the driver to install such belts against their wishes.**

Design implementation image



Design requirements (example)

- **Put guide lines on the floor.**
  - To allow wheelchair users to move their wheelchairs without hesitation to the fixture.
- Place **the seat of the foldable seat (open), described below, on top of the anchorage device**.
  - This is to prevent passengers from tripping over the fixture.
- The fixation device should **have a lid that can be easily opened and closed**. The lid should be able to slide open and close easily (e.g., when the lid is pushed by a clamp attached to the wheelchair).
  - The fixation device should have a lid that can be easily opened and closed. The lid should be able to slide open and close easily (e.g., when the lid is pushed by a clamp attached to the wheelchair).

Considerations (example)

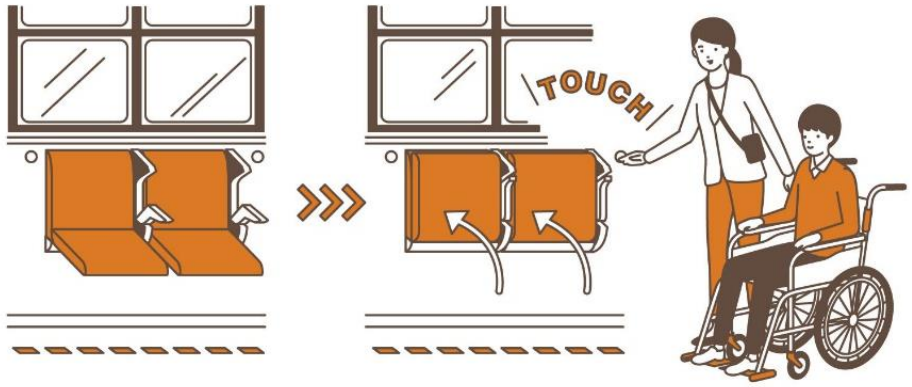
- In order to fix a wheelchair to a wheelchair fixture, the wheelchair must be equipped with a clamp to be inserted into the fixture. The technology and structure to attach the clamp to the wheelchair is needed so that the clamp can be attached to any wheelchair in Japan without damaging the wheelchair.

2.Create design requirements and considerations ③Foldable Seat

Summary	Existing folding seats require the driver to leave his seat to fold the seat, which is one of the reasons why it takes a long time to secure a wheelchair. By **making it possible for passengers to fold their seats by simply pushing a button** without the driver having to leave his or her seat, we can reduce the time and effort required for folding, and make buses more accessible to wheelchair users, baby carriage users, and others who need a certain amount of space.

MCP Problems	· **It takes time to fix the wheelchair** (electric wheelchair users) · **Fixing the wheelchair next to the current folding seat makes the aisle narrower** (power wheelchair user)
Driver Problems	· When wheelchairs are fixed, it takes time to fold the seats, which leads to **delays in the bus service**.

Design implementation image



Design requirements (example)

- **Normally, the seat shall be in the open (seat down) position.**
  - This is because it is difficult for a white cane user to recognize the existence of a seat when the foldable seat is closed, since the user uses the white cane to grasp the position and availability of the seat.
- **The seat shall be easily folded by the passenger**, such as by a touch button.
- **The orientation of the foldable seat should be sideways in the direction of travel**.
  - If the wheelchair is placed facing forward in the direction of travel, the backrest will not provide the space necessary to secure the wheelchair.
- **No ceiling-to-floor vertical grip bars** should be installed near folding seats.
  - Because it interferes with the flow line needed to secure the wheelchair.

Considerations (example)

- Since there is a risk of being tripped over or stepped on by lower limb orthoses when cane and short leg orthosis users sit in sideways-facing seats, it is recommended **that forward-facing seats** be installed near wheelchair spaces.

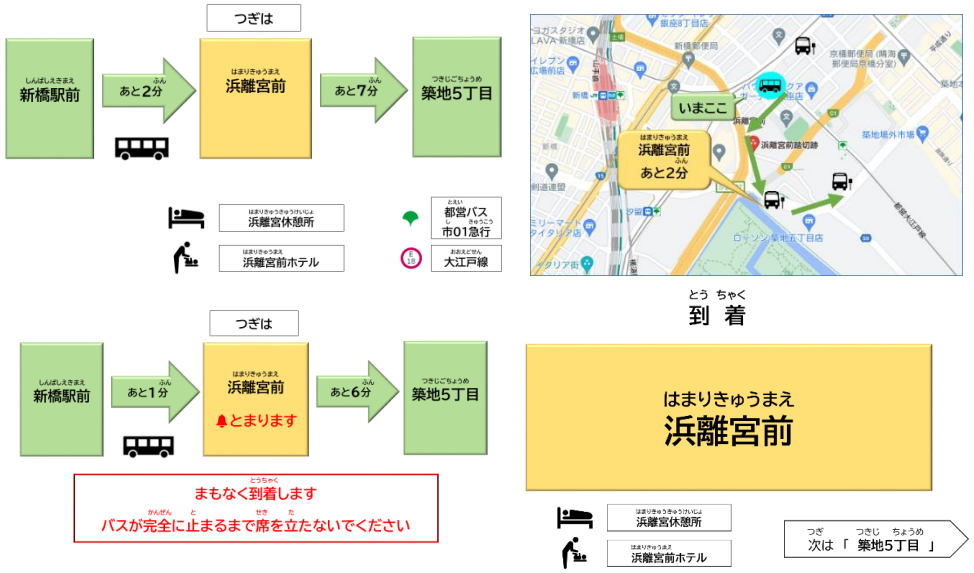
2.Create design requirements and considerations ④ Contents of the display in the car

Summary

When a person with transportation constraints who takes a long time to get off the bus gets on an unfamiliar bus, **if they do not know where they are or how long it will take them to get to their destination**, they cannot prepare to get off the bus with enough time to spare and **become impatient when they arrive at their destination stop**. Also, if you don't know at which stop you can get off to take a rest when you feel sick, you may feel uneasy about using the bus. The solution to these problems is to **provide detailed information on the on-board display**.

MCP Problems	・ **Not knowing the time and distance to the next stop** and not being prepared to get off (Deaf and hard-of-hearing people) ・ **I don't know if the reason for stopping is because I arrived at the stop or because of a red light** (Deaf person). ・ I **sometimes feel rushed because I have to fix my orthosis** even before the bus stops (user of cane and short leg orthosis) ・ When I feel sick, I get off the bus to rest because **it is seen as bad manners to lie down and rest in the bus** (mentally disabled person)
Driver Problems	・ While driving, it is **dangerous to be distracted** and unable to concentrate on driving when passengers talk to you when inquiring about the destination of the bus.

Design implementation image



Source: Tokyo Metropolitan Government Bureau of Transportation website, Google Maps

Design requirements (example)

- Displays **the location of the bus** while it is running and **the arrival time** to the next stop.
- When the bus is approaching a stop, it will display information about its **imminent arrival**.
  - ➢ To allow MCP to prepare for drop-off in plenty of time.
- **Show where you can take a break near the stop.**
  - ➢ To be able to cope with sudden illness or the need to take care of an infant during the ride.
- The display shows the **bus route and transfer information to other buses**.
  - ➢ To reduce the number of inquiries to the driver about the bus's route and destination.

Considerations (example)

- While it is good to be able to get a variety of information, there is a concern that **if the display is overloaded with information, it may become difficult to see**. Also, depending on the location of the display and how crowded the bus is, some passengers may not be able to see the display. In order to solve these problems, it is necessary to consider the use of passenger apps to provide information.

2.Create design requirements and considerations ⑤ In-train announcements

Summary	When a person with transportation constraints who takes a long time to get off the bus gets on an unfamiliar bus, **if they do not know where they are or how long it will take them to get to their destination**, they cannot prepare to get off the bus with enough time to spare and **become impatient when they arrive at their destination stop**. Also, if you don't know at which stop you can get off to take a rest when you feel sick, you may feel uneasy about using the bus. We will solve this problem by **providing easy-to-understand in-train announcements before and upon arrival at the stop**.

MCP Problems	・ It is confusing to know **where you are when the voice and display are different** (stroller user) ・ It is **difficult to hear the announcements** (elderly). ・ Sometimes I **feel rushed because I have to fix my orthosis** before the bus stops (user of a cane or short leg brace) ・ **I don't know if the reason for stopping is because the bus has arrived at the stop or because of a red light** (white cane user)
Driver Problems	・ Making announcements while driving, or being spoken to by passengers who did not hear the announcement, can **make it difficult to concentrate on driving**.

Design requirements (example)

- **Make an announcement shortly before arrival that you will be arriving shortly.**
  - To allow MCP to prepare for drop-off in plenty of time.
- Upon arrival at the stop, **announce the arrival**.
  - To enable traffic constrainers to distinguish between a stop at which the intended stop has been reached and a stop at a traffic light or traffic jam.
  - To clearly communicate to passengers that they have arrived at the desired stop.
- The announcements are basically **automated**.
  - To allow the driver to concentrate on driving.
- **An automated voice in English will also be used.**
  - This is so that passengers who do not understand Japanese can use the bus without any burden.

Considerations (example)

- For the mentally challenged, the fact that the automated voice is too mechanical, too fast, and too loud is a psychological burden. Announcements need to be made at a **slower speed, closer to a human voice, and at an appropriate volume**.

2.Create design requirements and considerations ⑥ Touch button for getting off the bus

Summary	For people with upper limb disabilities who find it difficult to put pressure on their fingers or move their arms finely, **the existing get-off button may be difficult to press because it is small and needs to be pushed in**. To solve this problem, **the buttons can be made touch-type so that they can be pressed without effort**.

MCP Problems	· **It is sometimes difficult for me to press the "get off" button due to lack of strength in my fingers. (People with upper limb disabilities)**
Driver Problems	· Sometimes passengers cannot press the button before they reach the bus stop where they want to get off, and the driver calls out to them when they have passed the bus stop. In such a case, the driver brakes suddenly, which is dangerous.

Design implementation image

Design requirements (example)

- The shape of the button shall be **rectangular**.
  - ➢ To make it easier for people who cannot move their fingers well to press with their palms.
- Buttons should be **placed in front of the seat or on both the left and right sides**.
  - ➢ To make it easy to use for both those who can only move their right arm and those who can only move their left arm.
- The height of the button should be **slightly higher than the navel**.
  - ➢ To allow people who have difficulty raising their arms to reach them.
- The **color of the button should be easy to see in contrast to the background color**, such as yellow.
  - ➢ To make it easier for the visually impaired to locate the buttons.
- The touch surface should have a slightly concave shape to **prevent malfunction**.
- The touch screen should be designed so that **it does not malfunction** when it is touched by something other than the human body, such as a capacitive touch switch.
- The size of the button should be about **the size of the palm of the hand (about 20 cm x 5 cm).**
  - ➢ If the button is too large, it is more likely to be accidentally touched.

2.Create design requirements and considerations ⑦ Display-type get-off button

Summary	Depending on how crowded the bus is or where they are riding, they **may not be able to see the sign for the next stop or the situation outside, making it difficult to know where they are**. In addition, some visually impaired people face the problem of **not being able to see the get off button in the evening due to the light,** making it difficult to press. To solve these problems, a **bright display** is attached to the existing get-off button to **show the next stop**, making the button itself easier to see.

MCP Problems	· **It is difficult to see the display** when sitting in the back (Deaf people). · **The color of the get-off button is the same as the color of the handrails, making it difficult to press**. Especially in the evening, it becomes **even more difficult to see due to the light of the setting sun** (Low vision)
Driver Problems	· Sometimes passengers cannot press the button before they reach the bus stop where they want to get off, and the driver calls out to them when they have passed the bus stop. In such a case, the driver brakes suddenly, which is dangerous.

Design implementation image

Design requirements (example)

- **The overall shape of the button is generally inherited from the existing shape.**
  - If the shape is complicated or very different from existing buttons, it will cause confusion until people get used to it.
- **Attach a display to the button to show the next stop**.
- Use a backlight to **brighten the display**.
  - To make it easier to see the buttons even when the sun shines directly on them or when it is dark inside the car.

Considerations (example)

- While it is better to include information in the button display, if the existing shape is taken over, the display is small and the information that can be shown is limited. It is necessary to devise a way to **convey information about the next stop even in a small space** by using **symbols and numbers**, etc., just like the current Tokyo Metro station displays.
- When the display is exposed to direct sunlight, it is difficult to see unless the display is brightened considerably, but strong light is a psychological burden for the mentally disabled. It is necessary to implement a display **with a light intensity that is both easy to see and reassuring**.

5. Summary and proposal

1.Summary

<Preparation of this journal>

- While assuming that it will be easier for MCP to use buses, the report also takes care to make it easier for people without constraints to use buses and to reduce the problems faced by bus operators who are facing a shortage of manpower and aging drivers.
- It is hoped that the proposed bus layout presented in this magazine will be continuously improved by collecting the opinions of more transportation constrained people in the future.

5.Summary and recommendations

1. Summary

＜Value and problems in bus use for people with transportation constraints＞

- Value: Buses are an essential means of transportation for daily life, such as shopping, commuting, going to the hospital, going to school, etc." "Buses can easily take you to places you have never been before and make you feel like you are traveling" were some of the comments, and **buses are** one of **the essential social infrastructures for people with transportation constraints.**

- problem ：

  ＜Problems that apply to the current bus＞

  - Before boarding the bus ：
    - ✓ **Difficult to get information about the bus you want to take,** such as route and arrival time.
  - When boarding and while boarding :
    - ✓ I'm confused by the lack of standardized rules for front and back riding.
    - ✓ Feeling the strain of getting on and off the steps between the sidewalk and the bus
    - ✓ **It takes time and psychological burden to get in and out of the ramp and to open and close the seat** when riding in a wheelchair.
    - ✓ There is no space to ride with the stroller open.
    - ✓ I can't get good information from announcements or on-board displays.
  - When getting off ：
    - ✓ Concern about the environment around the bus stop (distance to the sidewalk when getting off the road, presence of obstacles, etc.)
    - ✓ Many people with disabilities want people around them to understand that they have a disability, but they also don't want people to know that they have a disability.

  ＜Anxiety about automated driving＞

  - If the driver were to disappear, **there would be no one to ask for help** when you want to confirm your destination, when you want to know where you are driving, when you pay your fare electronically and an error occurs, when you feel sick, or when a disaster such as an earthquake occurs. I wonder

5.Summary and recommendations

1. Summary

＜Problems of bus operators＞

- As problems related to traffic constrained persons, **the drivers consider the passenger service other than driving and the accidental fall in the car due to standing up before stopping** to be major problems.

- About non-driving services
  - **Focus on operations related to loading and unloading ramps and securing wheelchairs when wheelchair users get on and off the ramps.**
    - ✓ Boarding: The driver leaves the driver's seat, manually brings out the ramp, and pushes the wheelchair from behind to support the passenger.
    - ✓ After boarding: folding the folding seat in the wheelchair space, securing the wheelchair in the wheelchair fixture, then manually folding the ramp and returning to the driver's seat.
    - ✓ On disembarkation: The same process is performed in reverse order.

    ※It takes a lot of energy and time, especially for heavy wheelchairs.

    ⇒**Although this is a very important task** for wheelchair users to get on and off the bus safely, **drivers would like to perform this task more efficiently and easily while maintaining safety due to the impact on the on-time operation of the bus and their health.**

- Accidental falls in vehicles due to standing up before stopping
  - Although standing up is not limited to traffic-constrained people, accidents involving falls in vehicles caused by standing up are common among traffic-constrained people, especially among the elderly.
  - Even if the driver **makes an announcement in the car to alert** the driver to stand up, the driver's anxiety about falling over in the car is not reduced, **partly because the traffic constrained person is in a hurry and anxious to get off the train.**

5.Summary and recommendations

1. Summary

＜Design layout of a traffic constraint-friendly self-driving bus＞

- In order to promote the social implementation of mobility services using automated buses, it is necessary **to solve both the problems of bus users, including those with transportation constraints, and the problems of bus drivers.**
  - **Automatic ramps** to reduce the physical burden of traffic constrained people when getting on and off buses and to safely guide drivers to wheelchairs.
  - **Foldable seats** intended to provide space for wheelchair users and stroller users while maintaining the number of seats.
  - **A wheelchair fixation device** that makes fixing a wheelchair quick and easy

- Those who rely on **limited visual and audio information** and those who have difficulty understanding complex information mentioned several problems **related to information**, such as difficulty in obtaining information on bus destinations and arrival times at the next stop.
  - Use of **in-house displays** to show estimated arrival times
  - **Automation of voice announcements**

- In the course of our research, we found that **some layout plans that solve the problems of some traffic constrained people are difficult to use because they are obstacles for other traffic constrained people.** We have tried to **improve such conflicting layouts**, and for example, we have added the following suggestions to the layout plan for wheelchair fixation devices
  - Provide a lid on the securing device to prevent the cane from entering the groove.
  - To avoid tripping over the protruding parts of the anchoring device, use the foldable seat in the open position so that the anchoring device is hidden under the seat.

5.Summary and recommendations

2. proposal

＜Toward the realization of design layouts for automated buses＞

- In addition to the improvement of the layout, we believe that three other initiatives are important.
  - ① **Public awareness of the improvements** to ensure that transportation constrained people are aware of the facilities and functions of the improved bus layout and can use it safely.
    - For example, blind people will not be able to understand and use the structure and functions of the improved bus unless they have the opportunity to actually touch the new bus equipment. Therefore, for those who need practice **to get used to the new layout or those who have difficulty understanding the new layout only through actual experience,** efforts should be made to inform them carefully by providing them **with opportunities to actually touch the buses.**

  ① This means **better equipment** to assist the disabled, bus stops, and other peripheral facilities to enable people with transportation constraints to ride the bus safely and independently.
    - When wheelchair fixation devices are introduced to buses, **it is assumed that the wheelchairs must be equipped with fasteners** in order to utilize them, but at present there are no wheelchairs with corresponding fasteners, so **the wheelchairs** need to **be improved.**
    - **At some bus stops, the height of the sidewalk is different at each bus stop,** and the structure of the bus stop makes it difficult to bring the middle door of the bus close to the sidewalk. **This means that even if automatic ramps are implemented on buses, the number of situations where they can be used effectively will be limited.** There were also other problems such as difficulty in seeing the timetable at bus stops. In order to solve the problems of transportation constrained people, it is necessary to improve the surrounding facilities.
  - ② **Clarifying the cost-benefit ratio** for bus operators to introduce traffic-constrained people-friendly self-driving buses
    - While the proposed design layout presented in "Design Requirements and Points to Consider" is friendly to people with transportation constraints, implementing all of them in buses **would increase the price of buses, and bus operators are expected to hesitate and not purchase them.** It is necessary to clearly show how much the workload of drivers will be reduced by improving the bus layout, and how much revenue can be expected by increasing the number of bus users, so that **bus operators, including those in urban as well as rural areas,** can introduce traffic constraint-friendly automated buses on a sustainable basis.

Reference Material

2. Organizing issues and discussing ideas

1. Organizing mobility-constrained people (MCP) types

Through a workshop attended with MCP, 9 types of MCP were determined. 3more types were added based on the opinions of experts, making a total of 12 types for the survey.

Workshop

photos

Questions and opinions (excerpt)

- **How will automated buses change your mobility? How do you think it will change the lives of MCP?**
  - The less brakes you have, the safer you can sit.
  - Hearing-impaired people currently have to endure the communication. ex) when they want to know the destination of a bus they are not used to riding.
  - The use of buses will increase if the ride quality (shaking) and steps in buses are improved.
  - When they don't know where the bus is going or how to pay the fare, the driver help them.
- **In your experience, what are the different types of disabilities that cause different problems?**
  - visual impairment : full(white cane, guide dog, etc.), partly(narrow-vision, Difficulty in adapting to light and dark, etc.)
  - Hearing : deaf, blind-and-deaf, etc.
  - Physical disability : upper/lower limbs, wheelchair, with/without caregiver, etc.

Determined MCP type

#	MCP type	Disability type	Reason
1	Full-blind, white cane	Visual	WS
2	Full-blind, guide dog		WS
3	Low-vision		WS
4	Deaf	Hearing	WS
5	Hard-of-hearing		WS
6	Power wheelchair user	Physical	WS
7	Cane and brace user		WS
8	Physically handicapped (upper limb)*	added 3 types	Expert
9	Mental disability	Mental	Expert
10	Intellectual and developmental disability	Intellectual developmental	Expert
11	Stroller user	–	WS
12	Elderly	–	Expert

*With regard to upper limb disabilities, no clear issues regarding bus use were obtained from the interviewees. However, since challenges can be expected depending on the disability status, we have organized them based on our findings.

2. Behavioral observation

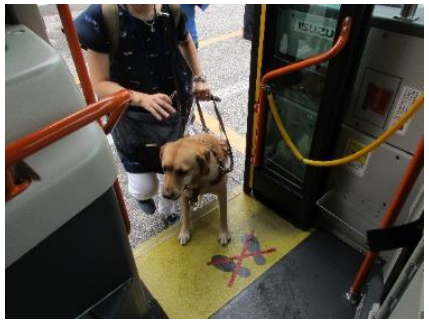
In the behavioral observation, we used an actual bus to recreate the situation of bus use. We were able to obtain opinions on the problems people have when using the bus and the physical and psychological reasons for them.

Contents of behavioral observation

What we did

- Used actual buses to recreate normal usage conditions
- Observed the driver when the driver needs assistance
- Organized the results of the survey by phase of use (getting to the bus stop, getting on the bus, getting a ticket, etc.) and by flow line in the car.

Photos



What we found(example)

- Unaware of the existence of support facilities or that they are inadequate
- The priority seats were equipped with belts to secure strollers, but stroller user was unaware of their existence.
- The guide dog was trying to get into the space under the seat, but it couldn't fit and was sticking out into the aisle. Owner didn't even notice it.
- Guide dog owner hit his/her face on the handrails and change rails.

- Imagine a bus layout based on their own experience.
- Front/back riding varied depending on the subject.
- White cane user was aware that priority seating is sideways, and were surprised that the bus they used was forward-facing.

- Choose a location that is easy to get off
- Most subjects choose to be near the drop-off door.
- Deaf people who have no problem with steps in the aisle should choose the front-most seat in the back, where they can easily see the stop sign at the front of the bus.
- Low vision people who do not know which seats are available should stand in an open space near the door for getting off the train.

3.Interviews with MCP

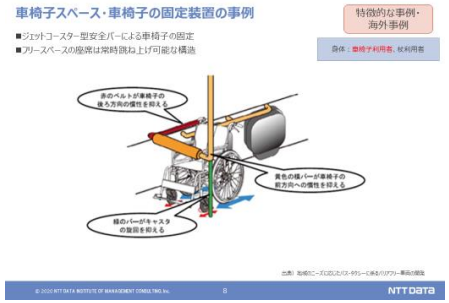
In the interviews with MCP, we asked them to bring their own tools and applications that they normally use. We also asked them to refer to case studies in Japan and abroad. By doing so, we were able to get their opinions on actual usage scenarios and advanced layouts that they do not normally use.

Contents of interview

What we did

- We asked MCP to bring their personal belongings and apps that they normally use, and devised a way to get a detailed understanding of the context of bus use and issues.
- MCP reviewed materials on bus layout examples from Japan and overseas, and gave thier opinions on layouts and ideas that are not normally used.

Photos



What we found(example)

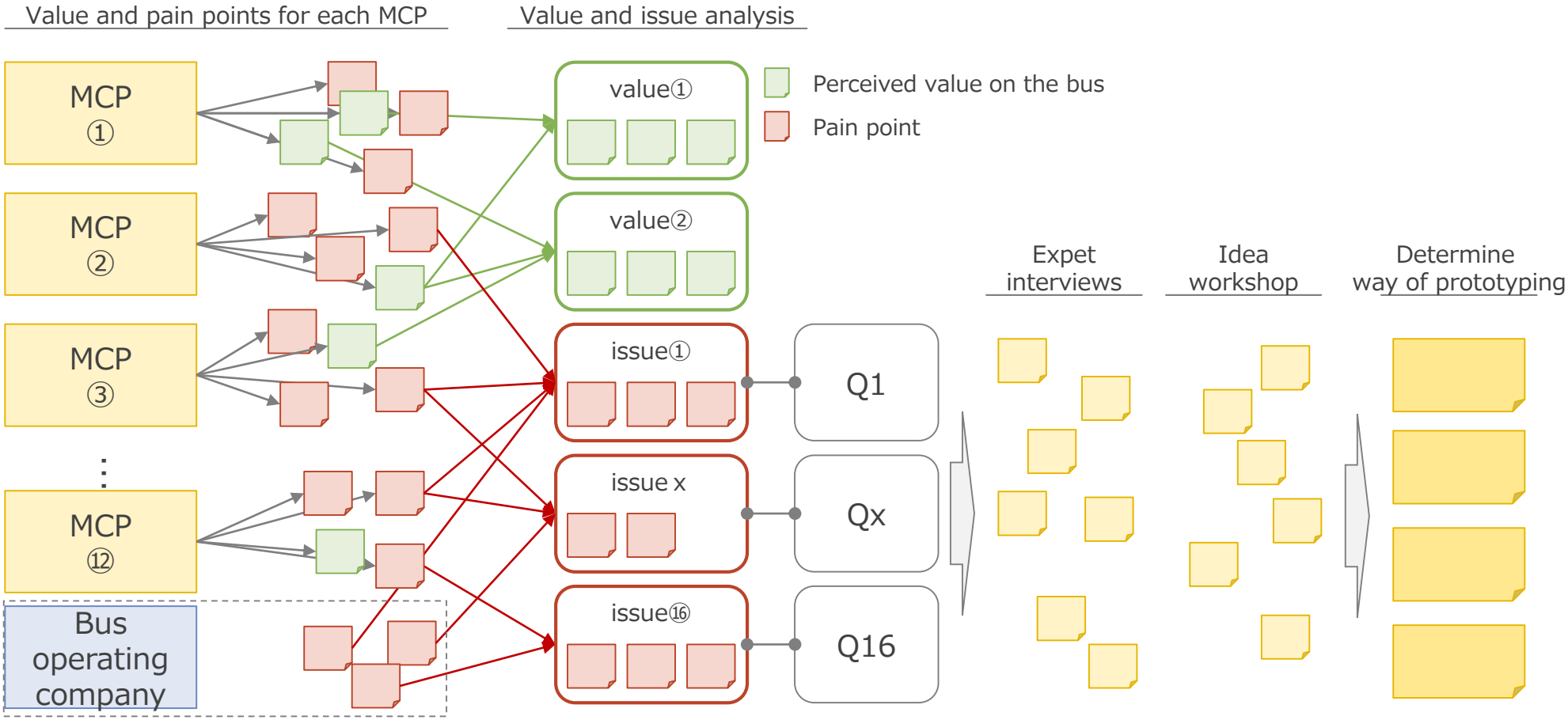
- Resistance to priority seating due to mixed feelings
- White cane user and cane/brace user feel that there are people who need priority seating more than they do.
- Deaf people and people with mental disabilities find it difficult to use priority seating because their disabilities are difficult to see from the outside.

- Expectations and concerns about service automation
- People with mental disabilities will feel safer as services are automated and variability is eliminated.
- Many subjects want a flexible response by the driver in case of emergency.

- High acceptance of new technologies (e.g., smartphones)
- low vision and hearing impaired people utilized apps that provide functions appropriate for different disabilities.
- Among the hearing impaired, those who cannot hear are more familiar with the app.

4. Value and issue analysis - Analysis method

We identified the values and pain points of each MCP, grouped similar contents, and derived 2 values and 16 issues. Questions on how to solve the issues were formulated and used as input for idea consideration.



2. Organizing issues and discussing ideas

4. Value and issue analysis - Organize values and pains for each MCP and overall values and issues

The values and pain points of MCP were identified after organizing the values and pain points in bus use for each MCP as follows.

Value and pain points for MCP

Values and issues

2. Organizing issues and discussing ideas

4. Value and issue analysis - Summary of value

By grouping the values of bus use organized by each MCP type, two values were derived: "a valuable link in daily life" and "a door to the world that expands the range of activities".

#	MCP type	Perceived value on the bus
1	Full-blind, white cane	• Buses are an indispensable means of transportation **because they can easily take you to places that cannot be reached by train.** • Advertising announcements on buses are also a good way to get to know the city.
2	Full-blind, guide dog	• **Time of relief, and it's connected to those feelings.** • Use the bus if it is available at the time you want to use it and where you want to go.
3	Low-vision	• Use buses **in places you are familiar with** (often use cabs in unfamiliar places)
4	Deaf	• **Very important in daily life**. It's convenient that various buses come to the bus stop you get on. • **It feels familiar.** I'm used to it, so I feel safer on the bus if I'm in a familiar place.
5	Hard-of-hearing	• (N/A)
6	Power wheelchair	• **Easy to travel with** • The distance between stops is close, making it **suitable for short-distance travel.**
7	Cane and brace user	• The bus stop is close to my house, so **I just use it for convenience**.
8	Physically handicapped (upper limb)	• It's hard for me to walk and I can't drive, so it's **an important means of transportation for me when I'm alone (plus my kids)**.
9	Mental disability	• To use as a means of access to the train station because my house is far from the station. • Also, depending on your destination, **it may be more convenient to take the bus**.
10	Intellectual & developmental disability	• The means of transportation you usually use. Based on this training, you will be able to use other means of transportation **and expand your range of activities**.
11	Stroller user	• It's convenient to get from the front of my house to my destination **with hardly any walking**. • **Strollers can't use the escalator** and sometimes have to take a long way, so the bus is convenient.
12	Elderly	• **Transportation necessary for daily activities** such as visiting family members in the facility or going to the hospital

value①

a valuable link in daily life

value②

a door to the world that expands the range of activities

4. Value and issue analysis - Derivation of issues and questions

A total of 16 issues were derived from the grouping of pain points organized by MCP.

#	Task Title	問
1	I can't get to the bus I want to take.	What kind of information should be provided to MCP so that they can easily reach the bus they want to take? How to ride without getting lost which to ride front or back ?
2	Fee payment method unknown	How can we streamline the process of paying fees and checking disability certificates?
3	Difficulty in grasping space	How can we tell MCP where the buses are and where the seats are?
4	Fixing the wheelchair requires time and psychological burden.	What is the best way to secure a wheelchair that is not time-consuming and stressful for the person and other passengers?
5	Burden on the body when getting on and off	How can I get on and off the bus without straining my body?
6	Rear bumps are inconvenient.	How can we make it easier for MCP to use the back seat? How can we make it easier for MCP to use the back seat, and make it easier for them not to have to?
7	Anxiety about horizontal shaking	How can we get rid of our fear of lateral movement?
8	Communication with the driver	How can we better communicate with the driver? Or, can we get the information we need without communicating with the driver?
9	I don't know where I am or what I'm doing.	How can we find out where the bus is?
10	Difficulty in hearing announcements inside and outside the vehicle	How can we best convey the information conveyed in the announcement?
11	Stroller space	What would an obvious stroller space look like without undue concern for other passengers?
12	Guilt, reticence, and relationships with other passengers	How can we remove our guilt and reservation about other passengers? Will other passengers notice?
13	Difficulty in pressing the get-off button	What would a get off button look like that was easy for anyone to understand and press?
14	Impatience to get off the train	How can MCP get off the bus without feeling rushed?
15	Anxiety about drop-off location	How can we ensure safety and security when getting off the train?
16	Anxiety about health problems	How can I get rid of my anxiety about my health condition?

5. Idea Hearing

In the idea hearing, we received ideas for situations such as ramps, wheelchair fixation, folding chairs, and fare collection.

Locationc	Idea title/type	Idea Details
slope	Automatic Slope	Automatic stairs and ramps to connect bus stops and buses
Wheelchair fixation	Automation of wheelchair fixation	The seat automatically lifts up and the wheelchair fixture comes out of the floor
folding (collapsible) chair	Folding chair like a movie theater	Considering the needs of the elderly for seating, free space is difficult. Chairs that snap together like in a movie theater are better.
receipt of freight	Improve efficiency of fare collection	It would be nice to be able to pay the fare away from the driver's seat
	Simplify the fare box	The fare box makes it impossible for wheelchair users to ride from the front. Why don't we eliminate the seats immediately in front of the front door? This would eliminate the need to change direction
	Improved convenience of payment	It would be nice to be able to get off at the door you get on. This won't happen until the fare collection issue is resolved.
IC card	Use of IC cards	IC cards can be set up to offer a discount if the passenger rides within a certain period of time after getting off the card.
glass window	In-car display using window glass	Information such as the current location and destination is displayed on the glass window, and information can be obtained in the car no matter where you sit.
Light to teach space	A light that shows where the traffic constrained person is getting on and off the bus.	Lights (LED) that show the position of disabled passengers, priority spaces, and seat positions. Lights that can flexibly change their space and position according to the passenger's behavioral style.
Handrail outside bus	Handrails that only come out when getting in and out	The elderly sometimes get off the bus backwards while holding on to the handrails inside the bus. It would be better if there were handrails that smoothly connect the bus stop to the bus.
Tacit knowledge practice system for drivers	Driver Support System	A system that can replace the work and tacit knowledge that drivers used to have to respond flexibly by judging the surrounding situation, such as where MCP get off.
App	Navigation apps	We experimented with an app for MCP in another SIP project last year. (https://www.sip-adus.go.jp/file/showcase2019/SIP_zone2-6_s.pdf)
	An app to keep track of bus stop locations	A system that shows the location of bus stops for the visually impaired
	Matching Apps	An app that matches people who need help with people who can help them.
	Notification to the driver	The driver should be able to recognize that you are sick when you press the get off button.
	Automatic Slope Reservation App	An app that allows you to reserve an automatic ramp in advance before boarding the bus
	An app that allows you to experience the layout of a car	Since information that can be prepared in advance is important for MCP, it would be good to have something (such as an app) that can simulate the layout of the vehicle.

2. Organizing issues and discussing ideas

5. Idea Workshop (1/2)

The idea workshop identified ideas that could be realized by changing only the bus, ideas that could be realized with the bus and external ICT, ideas that could be realized with external ICT, etc. Achieved by changing only the bus

Changes	layout improvement	Provision of information	Institutional and cultural modifications
Entire bus	Full flat (EV)	The reason for stopping is indicated by the color of the light inside the vehicle.	Automatic driving and driver assistance technologies (anti-rolling)
entrance and exit	Increase the number of entrances and exits (front, middle, and rear)		
slope	Automatic Slope		Even able-bodied people basically use the ramp
	Handrails on both sides		
	Roof at the top of the ramp		
Fare box and IC reader	Elimination of belt conveyor type fare boxes Minimize the number of fare boxes by separating the money changer, etc.	SUICA payment completion is indicated by light	
space	Backrest for standing passengers	Automatically detects vacant spaces and indicates them by illuminating them (stroller spaces, spaces for the elderly, etc.)	thoughtful seat
	small piece of furniture upon which one can sit and relax		
Chair	folding (collapsible) chair	A system that detects when a traffic constrained person leaves his seat before getting off and alerts the driver.	
	Ample space between seats		
	Chairs that are easy for wheelchair users to transfer		
	Seating zoning (priority)		
Wheelchair fixture	One-touch fixing of wheelchair wheels		
handrail	Cushioned handrails		
	Handrail to hold a stroller		
	Add handrails for standing passengers		
Get off button	touch sensitive button	Display the next station (name, symbol, etc.) on the get off button.	
	Buttons that are easy to see in the dark		
windowpane		Display using a glass window	
Panels and boards		Touch Panel FAQ	
		Panel board to inform passengers of available seats when they board the train	
Sound and announcements		Automated announcements	
		Use of chimes (sound, pitch, melody, frequency, texture)	
		Provide information on the environment around the bus stop through announcements	
		Announcement of available seats when boarding the train	
Outside the car said		Lower the outside display of the bus	

2. Organizing issues and discussing ideas

5. Idea Workshop (2/2)

The idea workshop identified ideas that could be realized by changing only the bus, ideas that could be realized with the bus and external ICT, ideas that could be realized with external ICT, etc.

Bus x external ICT (applications, etc.)

Changes	layout improvement	Provision of information	Institutional and cultural modifications
IoT for Buses		Operation information, bus location, destination, front/back boarding, payment method, current location, arrival time	
		In-train information, in-train seat availability, internal layout	
		Intention display function, intention to get off the vehicle (application, external switch), seated, request for assistance	

Only with external ICT (e.g., applications)

変更箇所	layout improvement	Provision of information	Institutional and cultural modifications
Building the app		Learning information, learning videos of MCP, simulated internal layout	
		Bus stop information and environment around the bus stop (availability of space to rest, etc.)	

2. Organizing issues and discussing ideas

6. Selecting ideas

Of the ideas we identified, we selected ideas to be evaluated using actual vehicle mock-ups, VR, and illustrations

Mock-up of actual vehicle

- Automatic Slope
- folding (collapsible) chair
- One-touch fixing of wheelchair wheels
- touch sensitive button
- Buttons that are easy to see in the dark
- Display the next station (name, symbol, etc.) on the get off button
- Touch Panel FAQ
- Automated announcements
- Announcement of available seats when boarding the train.
- Use of chimes (sound, pitch, melody, frequency, texture)

VR

- The reason for stopping is indicated by the color of the light inside the vehicle
- Handrails on both sides
- Roof at the top of the ramp
- Ample space between seats
- Lower the outside display of the bus.
- Display using a glass window
- Add handrails for standing passengers.
- SUICA payment completion is indicated by light
- Automatically detects vacant spaces and indicates them by illuminating them (stroller spaces, spaces for the elderly, etc.)

illustration

- Intention display function, intention to get off the vehicle (application, external switch), seated, request for assistance

2. Organizing issues and discussing ideas

7. Research of relevant laws and standards

As a basic research for the formulation of the draft guideline, existing laws, regulations and standards related to the use of buses by MCP were surveyed. Based on the laws and regulations (ministerial ordinances), certification guidelines, guidelines and UN, and national projects and reports, the information was organized into essential requirements, certification requirements, target requirements, issues, policies and goals, and discussions.

Objective	Research existing relevant laws, regulations, and standards to understand the assumptions that should be considered when developing draft guidelines.

Current requirements for bus layout and services to be organized in this project, etc.

Laws and Regulations (Provincial Orders)

- H30: Standards for Facilitating Mobility, etc. (Revised)

➡Necessary

Recognition gist

- H27: Non-step Bus Certification Guidelines (Revised)

➡Recognized elements

Guidelines・UN

- H30: Guidelines for Public Transport Operators
- H31: Barrier-free Maintenance Guidelines(Vehicles)
- H31: Barrier-Free Maintenance Guidelines (Passenger Facilities)
- H30: UN Regulation No.107

➡Objective Elements

National projects and reports

SIP

- H26～H30: SIP Ph.1 Next-generation urban transportation system Positive arrival control related
- H26～H27: SIP Ph.1 Reduce boarding and alighting time for public transportation
- H30: SIP Ph.1 Data collection and storage (bus field)
- H30: SIP Ph.1 Demonstration experiment in Okinawa Prefecture
- H30: SIP Ph.2 Automated Driving in Rural Areas

Other

- H23: Study group on the development of barrier-free vehicles for buses and cabs to meet local needs

➡Topics

➡Policy and Goals

➡consideration

2. Organizing issues and discussing ideas

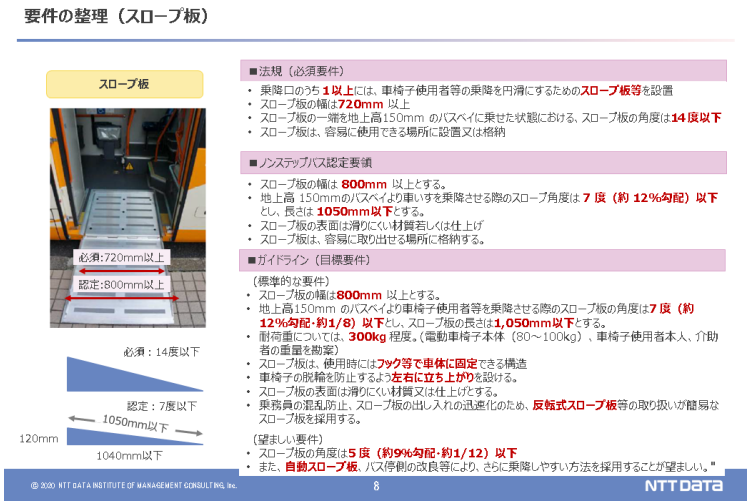
8. Research of relevant laws and standards

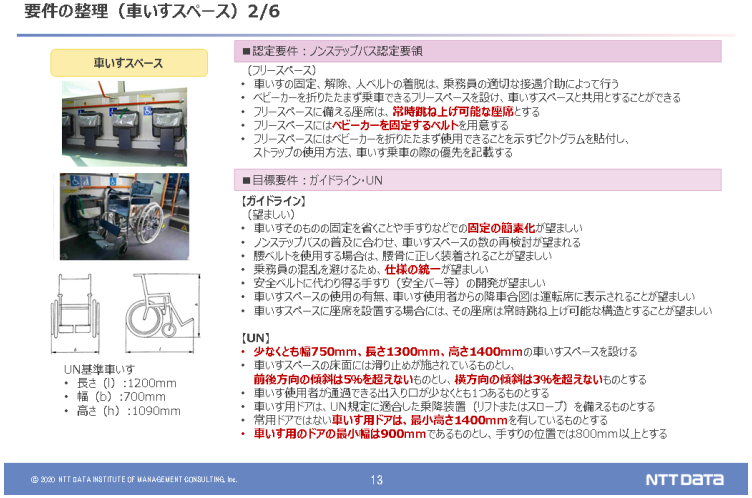
Relevant regulations and standards were organized by bus part.

■ items to be sorted

- entrance and exit
- Priority Seats
- Slope board
- Rear section difference
- Interior color
- place where one puts the money required to ride public transportation
- Wheelchair space
- Outside the car said
- Inside the car said
- Outbound Release
- in-car announcement
- handrail
- Communication Equipment
- Get-off button
- Aisle and floor surfaces
- Seats
- Positive arrival control
- Internal monitor
- Congestion monitoring

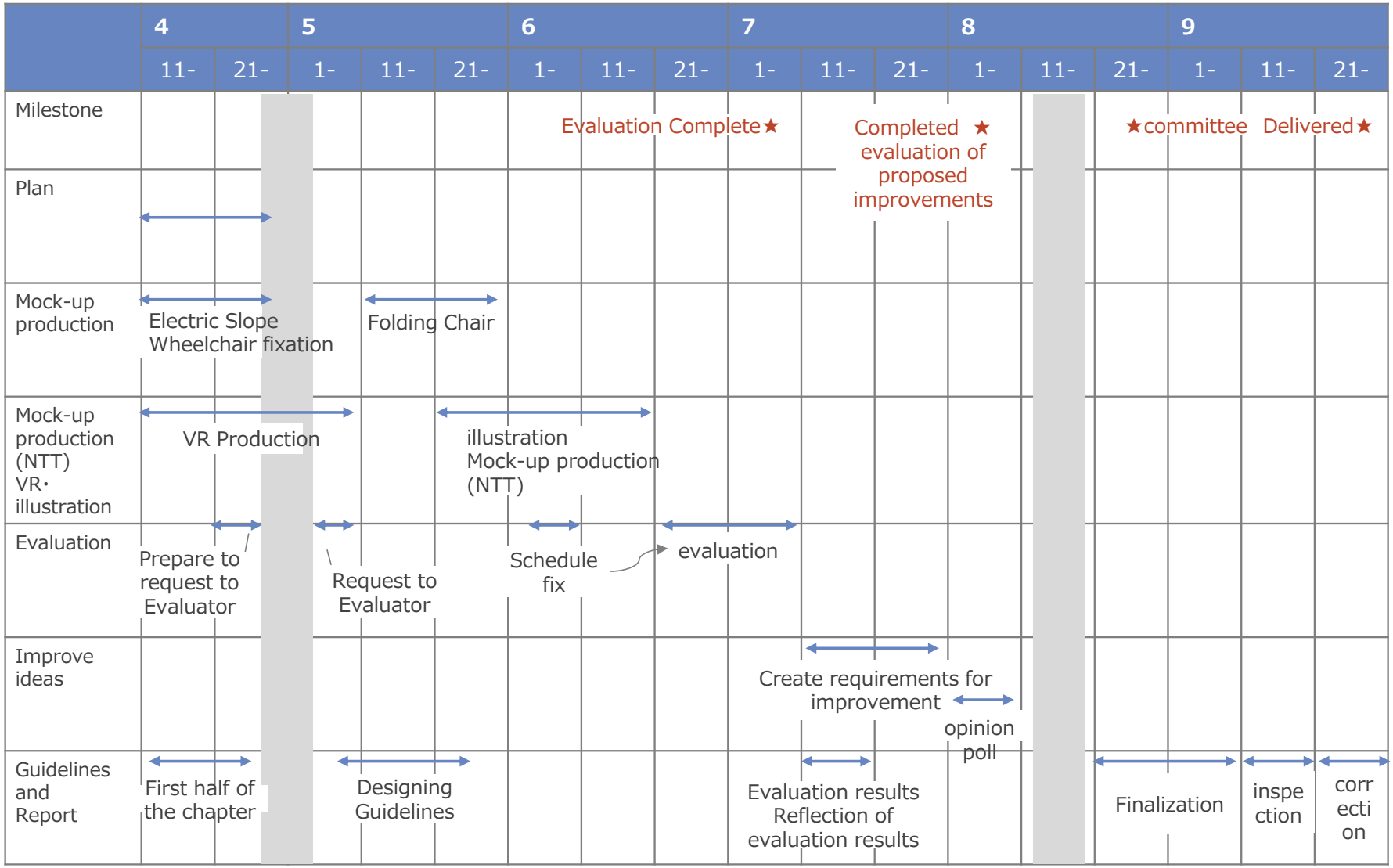
■ An example of an arrangement result





Future Schedule

We will now proceed according to the following schedule.



1. Producing ideas for issues

As an idea to relieve the guilt of other passengers, impatience to get off the train, and anxiety about where to get off, an automatic ramp was built on a mock-up of a real train.

①Automatic Slope
Summary: A sliding ramp is automatically laid from the bus to the bus stop.

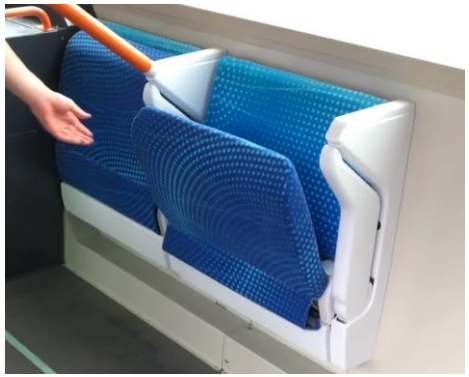
Who and what issues and pains are to be solved	**12. Guilt, reticence, and relationships with other passengers／14. Impatience to get off the bus**	
	Stroller users	• When I get off, I make sure that all the others have gotten off before I get off.
	15. Anxiety about drop-off location	
	Electric wheelchair users	• If you have to go down to the driveway, the slope of the ramp is too steep.
	Users of canes and short leg braces	• If there is a distance between the sidewalk and the roadway, if the bus is not a low-floor bus, or if the roadway is high, it is difficult to get up and down.

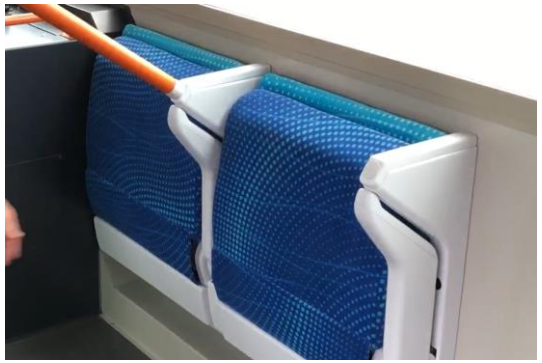
1. Producing ideas for issues

As an idea to solve the time and psychological burden of fixing a wheelchair, a folding chair was made on an actual vehicle mock-up.

②Folding Chair
Summary: A flip-up seat automatically folds up when you stand up (just like a movie theater chair).

Who and what issues and pains are to be solved	**4. Fixing the wheelchair requires time and psychological burden.**	
	Electric wheelchair users	• 80-90% of users do not like fixed belts (bus operators).
		• When getting on and off the bus through the middle door, it is always necessary to turn the wheelchair around. It takes a long time to get on and off the bus (bus operator).
	elderly person	• I hope the number of seats does not decrease from the current level. The need for seats is increasing as the population ages, and we don't want to reduce the number of seats (bus operator).





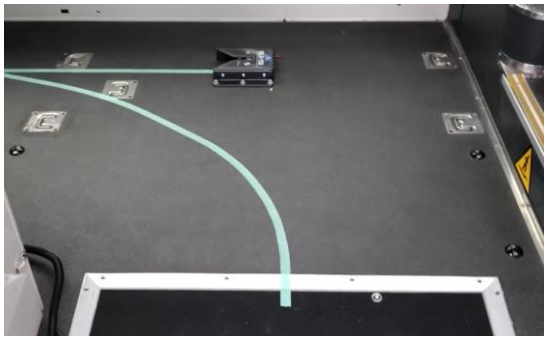
1. Producing ideas for issues

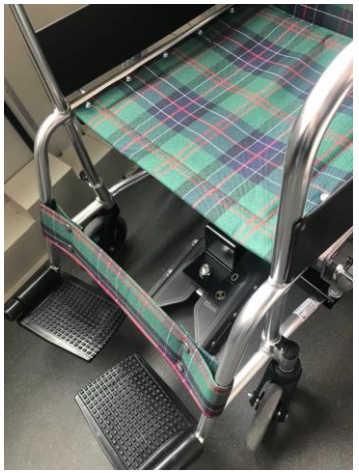
As an idea to solve the time and psychological burden required to secure a wheelchair, a device that can secure a wheelchair with a single touch was created on a mock-up of an actual vehicle.

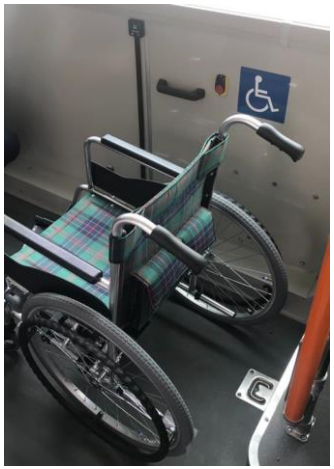
③One-touch fixing of wheelchair

Summary: The wheelchair can be fixed with a single touch, reducing the time required for fixing and the psychological burden associated with it. Special hardware is also attached to the wheelchair side.

Who and what issues and pains are to be solved	**4. Time and mind to fix the wheelchair**	
	Electric wheelchair users	• 80-90% of users do not like fixed belts (bus operators).
		• When getting on and off the bus through the middle door, it is always necessary to turn the wheelchair around. It takes a long time to get on and off the bus (bus operator).







1. Producing ideas for issues

As an idea to solve the difficulty of pressing the get-off button, we made a mock-up of the actual train with a touch button that is easy to see even in the dark and indicates the next station.

④Easy-to-see touch buttons even in the dark, and display of next station (name, symbol, etc.)
Summary: The name and symbol of the next stop will be displayed on the touch panel for easy communication, and the display color will be adjusted according to the weather and time of day to make it easier for the visually impaired to see.

Who and what issues and pains are to be solved	**13. Difficulty in pressing the get-off button due to its inconsistent location and confusing color.**	
	low vision	• The color of the button and the color of the railing are the same color, making it difficult to press.
	physically handicapped person	• Difficulty in pressing the get-off button due to lack of strength in fingers

1. Producing ideas for issues

As an idea to solve the difficulty of pressing the get-off button, a touch-type button was made on the mock-up of the actual vehicle.

⑤touch sensitive button
Summary: Install a touch-switch alighting button so that it can be pressed without effort.

Who and what issues and pains are to be solved	**13. Difficulty in pressing the get-off button due to its inconsistent location and confusing color.**	
	low vision	• The color of the button and the color of the railing are the same color, making it difficult to press.
	physically handicapped person	• Difficulty in pressing the get-off button due to lack of strength in fingers.

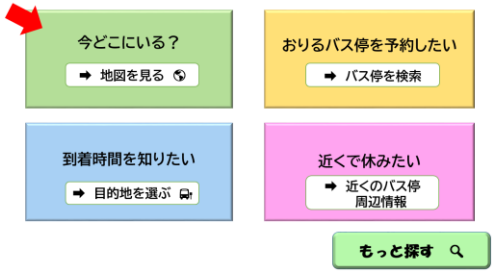
1. Producing ideas for issues

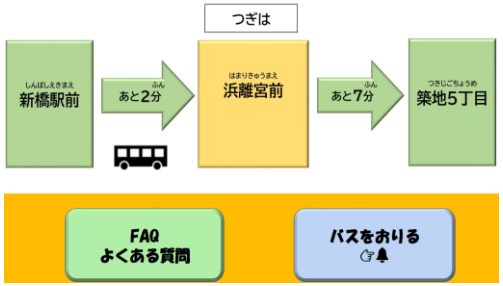
As an idea to solve the problem of not being able to find the current location and the difficulty of pressing the get-off button, a touch panel FAQ was created on the actual vehicle mock-up.

⑥Touch Panel FAQ

Summary: You can check the remaining time required to reach the intermediate stations, the location of bus stops where you can take a break, etc. on the touch panel.

Who and what issues and pains are to be solved		
	9. I don't know where I am or what I'm doing.	
	low vision	• If you sit in the back seat OR if the text is small, it is difficult to see the display
	13. Difficulty in pressing the get-off button	
	physically handicapped person	• Difficulty in pressing the get-off button due to lack of strength in fingers



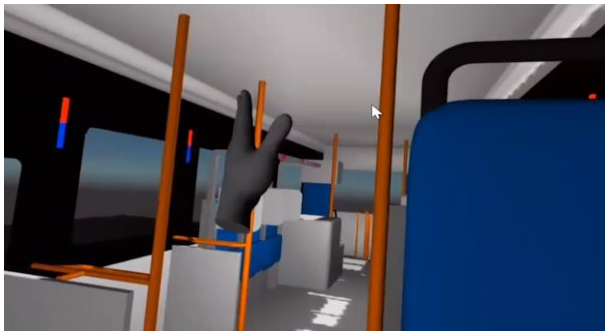


1. Producing ideas for issues

In order to solve the problem of not knowing where you are and not being able to hear the announcements, we came up with the idea of displaying the reason for stopping by the color of the light inside the car, and made it in VR.

⑦ The reason for stopping is indicated by the color of the light inside the vehicle.
Summary: The color of the light inside the bus changes according to the reason for stopping, such as pausing at a red light or arriving at a bus stop.

Who and what issues and pains are to be solved	**9. I don't know where I am or what I'm doing.**	
	Stroller users	• Confusion about where you are now when the audio and display are not the same
	deaf person	• I don't know why I'm stopped (I'm at a stop sign or a red light).
	10. Difficulty in hearing announcements inside and outside the vehicle	
	elderly person	• I can't hear the destination announcement. Difficult to hear

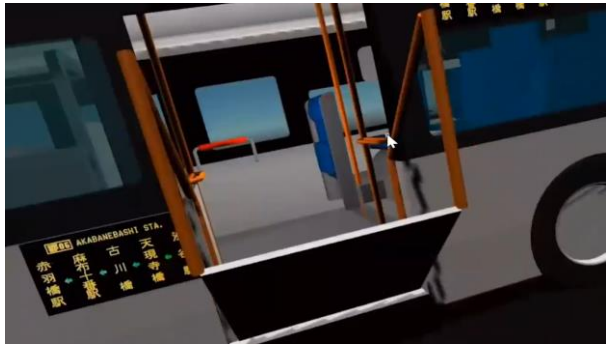


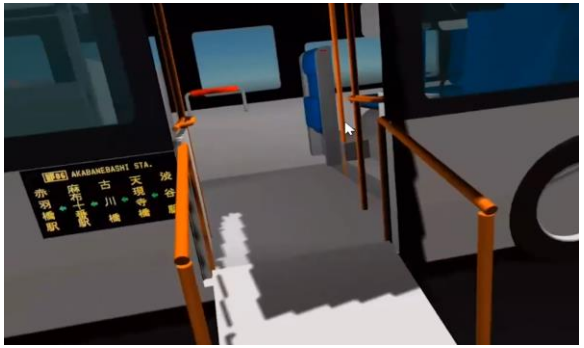
1.Producing ideas for issues

As an idea to solve the problem of physical strain when getting in and out of the car, we created handrails on both sides of the automatic ramp in VR.

⑧Handrails on both sides of the automatic slope
Summary: The handrails that used to be folded on both sides appear automatically at the same time as the automatic ramp.

Who and what issues and pains are to be solved	**5. Burden on the body when getting on and off**	
	Cane and lower limb orthosis users Elderly people	• If the handrails at the entrance/exit are too high, it is difficult to use force to get in and out of the car.
		• The step at the entrance/exit is unstable unless you have something to hold onto in front of you.
		• If the railing at the entrance/exit is vertical, it will be slippery.
		• It takes a long time to get down from the handrail next to the door because you can't get a good grip on it.
		• If there is a distance between the sidewalk and the roadway, if the bus is not a low-floor bus, or if the roadway is high, it is difficult to get up and down.



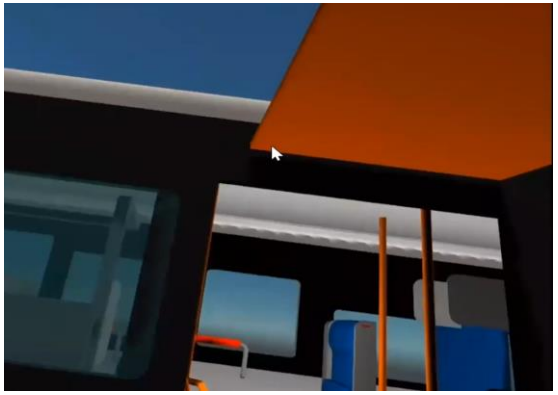


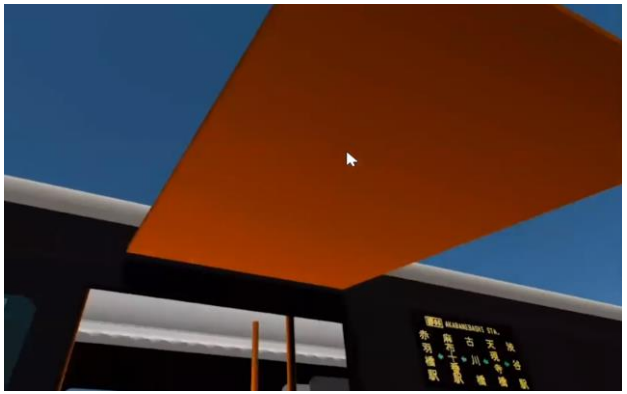
1.Producing ideas for issues

As an idea to solve the slippage of the ramp in rainy weather, a roof for the top of the automatic ramp was fabricated on the VR.

⑨Roof at the top of the automatic ramp
Description: A rain awning automatically appears from the roof of the bus at the same time as the automatic ramp.

Who and what issues and pains are to be solved	**Pain not grouped into any of the issues.**	
	Electric wheelchair users	• The slope is slippery in the rain.



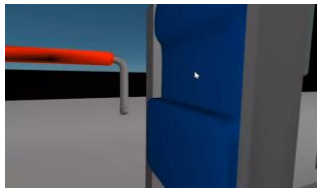


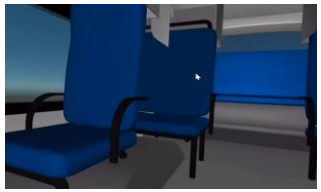
1.Producing ideas for issues

As an idea to solve the difficulty of finding baby stroller space and using priority seats, we created a layout in VR with a spacious seat interval.

⑩Ample space between seats
Summary: Increase the distance between the seat and the seat in front of it, and make the seat a space where MCP can easily enter and sit.

Who and what issues and pains are to be solved	**11. The use of a stroller makes the passengers around you feel uncomfortable. It's hard to tell if there is a stroller space.**	
	Stroller users	• We have a stroller, so I feel bad if we can't sit down right away and leave right away.
		• Stroller users are asked to use the fastening belts provided in the seats, but basically they are asked to fasten the strollers themselves. There are many cases where the bus driver refuses to provide assistance. (Bus operator)
	12. They feel guilty about delaying the bus service because of them, or asking other passengers to move. The atmosphere is not conducive to sitting in priority seats.	
	Users of canes and short leg braces	• Sometimes I get impatient because I need to fix my brace even before the bus stops.



1.Producing ideas for issues

As an idea to solve the difficulty of listening to announcements, we created a low-positioned exterior display in VR and on a mock-up of the actual vehicle.

⑪**Lower the outside display of the bus.**
Abstract: Information about bus stops and other locations is displayed at a low position outside the bus so that wheelchair users can get information even if they cannot hear the announcements.

Who and what issues and pains are to be solved	**10. It is difficult to hear the announcements inside and outside the train, making it difficult to obtain necessary information. In some cases, the announcements become a psychological burden.**	
	elderly person	• Sometimes you have to ask the driver to find out where the bus is going.
	person who uses a white cane guide dog user low vision elderly person	• I can't hear the destination announcement.

3. Evaluating ideas

1.Producing ideas for issues

As an idea to solve the feeling of guilt for other passengers, the difficulty of pressing the "get off" button, and the anxiety of being sick, I devised and illustrated a way to express my intentions to the driver using the app.

⑫Using apps and other means to communicate with bus drivers and other passengers-1

Summary: By operating their own app before boarding the bus, they can inform the driver of their disability and support needs.

Who and what issues and pains are to be solved	**12. They feel guilty about delaying the bus service because of them, or asking other passengers to move. The atmosphere is not conducive to sitting in priority seats.**	
	low vision	• I get impatient when other passengers line up behind me.
	Users of canes and short leg braces	• I don't want to sit on the window side of a two-seater seat.
	mentally-handicapped person	• Not being able to say "I'm getting off" when a bus that is not usually crowded gets crowded
	13. Difficulty in pressing the get-off button due to its inconsistent location and confusing color.	
	person who uses a white cane low vision	• Confusion over the location of the get off button.
	physically handicapped person	• Difficulty in pressing the get-off button due to lack of strength in fingers
	16. There is a financial and psychological burden to take a rest if you feel sick while riding the bus. Therefore, I feel uneasy about using the bus.	
	mentally challenged person	• If you feel sick, you want to lie down, but it will be treated as bad manners, so get off the bus and rest.

3. Evaluating ideas

1.Producing ideas for issues

As an idea to solve the feeling of guilt for other passengers, the difficulty of pressing the "get off" button, and the anxiety of being sick, I devised and illustrated a way to express my intentions to the driver using the app.

⑬Using apps and other means to communicate with bus drivers and other passengers-2
Summary: By operating your own app, you can let people know the station you want to get off at before or during the bus ride.

Who and what issues and pains are to be solved	**12. They feel guilty about delaying the bus service because of them, or asking other passengers to move. The atmosphere is not conducive to sitting in priority seats.**	
	low vision	• I get impatient when other passengers line up behind me.
	Users of canes and short leg braces	• I don't want to sit on the window side of a two-seater seat.
	mentally-handicapped person	• Not being able to say "I'm getting off" when a bus that is not usually crowded gets crowded
	13. Difficulty in pressing the get-off button due to its inconsistent location and confusing color.	
	person who uses a white cane low vision	• Confusion over the location of the get off button.
	physically handicapped person	• Difficulty in pressing the get-off button due to lack of strength in fingers
	16. There is a financial and psychological burden to take a rest if you feel sick while riding the bus. Therefore, I feel uneasy about using the bus.	
	mentally challenged person	• If you feel sick, you want to lie down, but it will be treated as bad manners, so get off the bus and rest.

3.Evaluation results ①Automatic slope

General comment

There were many positive comments about automatic ramps from electric wheelchair users, stroller users, and those who feel burdened by steps when getting on and off. However, **there were also requests for improvements to prevent users from slipping and falling, and for devices that would allow visually impaired people to recognize the presence of automatic ramps** (sound signals, social awareness).

Good point

- **There is no problem getting in and out of the wheelchair.** I have no problem getting in and out of the wheelchair, as long as the angle is the same as during the evaluation meeting (4 degrees). (Electric wheelchair user)
- I can get in and out of the chair without any problems, **except for the slippery part**. It is helpful that I don't have to go down the steps. (Cane and short leg brace user)
- Very good. There is no problem for those who have no physical disabilities at all, but there are many people with intellectual/developmental disabilities who also have mild physical disabilities. (People with intellectual and developmental disabilities)
- **There is no need to fold the stroller when boarding** the bus, so I don't think it would bother other passengers. It is easy to get in and out of the car without having to lift it. (Stroller user)
- I think it will eliminate the physical burden of steps. It's good because my feet don't go up. (Elderly people)
- Since 70% of visually impaired people are over 65 years old, it is effective for people with weak legs and feet. (White cane users)

Requests for improvement

- **I don't know the boundary between inside and outside the car, or how high or wide I can walk**. I've never used a slope before, so I can't imagine it as a physical sensation. (Guide dog users, white cane users)
- **I'd like to see information on when the slope will appear.** It's dangerous when it comes out suddenly. (Deaf people, guide dog users, low vision users)
- (Deaf people, guide dog users, low vision) There are places where the road is sloped due to rain drainage. Some bus stops do not have sidewalks. (Deaf, guide dog user, low vision) Some bus stops don't have sidewalks, in which case **the slope becomes too steep and scary.** (Electric wheelchair user, upper limb disabled person)
- I feel safer with someone beside me, so it should be wider. Rubber canes are slippery when it rains, (Users of canes and short leg bracesso **the floor needs to be made of a non-slip material.**)
- It would be very useful if people could recognize that the slope of an automatically driven bus is also automatic. (People with intellectual and developmental disabilities)
- The driver needs to calculate and stop the bus so that it doesn't hit the bus stop. (Stroller users)
- It is necessary to prevent wheelchairs from falling out of their wheels. (Experts)

Other

- I think most people with visual disabilities only have trouble with their eyes and not their legs, so I think it's too polite. I don't feel the need for this. (Low vision)

3.Evaluation results ②Folding chair

General comment

Electric wheelchair users and stroller users gave positive comments on **the ease of folding** and **the space available.** On the other hand, white cane users and guide dog users commented **that they could not find a seat** when the chair was folded, upper limb users and users of canes and short leg braces were **burdened by having to lower the seat by themselves**, and some people with intellectual/developmental disabilities expressed the opinion that consideration should be given to **those who play with the ability to raise and lower the seat**.

Good point

- It is difficult for **a dog to get under a chair when it is facing forward**, but it is very helpful when it is facing sideways. (Guide dog user)
- If it takes less time to get in and out of the chair compared to the current manual flip-up chair, it will be less stressful for passengers. (Electric wheelchair user)
- I think the location is safe because it is near the driver and he can see the mirrors. (People with upper limb disabilities)
- Even when the baby is sleeping, **I can put the stroller in the car while the baby is sleeping** without folding it. (Stroller user)

Requests for improvement

- **When the handrail is folded, it is difficult to find with a white cane because of its high position.** It is better to lower the vertical handrail to the feet. (White cane user)
- I don't think dogs will recognize it as a chair if it is attached to the wall. I think dogs will recognize it as a chair if it is taught to them. (Guide dog users)
- (Guide dog users) I am not sure if I can use this chair or not, so I would like it to be folded with the touch of a button, while **the seat is usually in the down position.** (Deaf people)
- It is easier to sit when the chair is down than when it is folded. **I'm worried about stepping on my feet when I'm on my side.**(Cane and short legged orthosis users)
- If I don't put my luggage on the chair, I can't fold it down. (Cane and short legged orthosis users) I can't put my luggage on the chair unless I put it down. It would be better if the chair could be automatically folded down with a foot pedal. (People with upper limb disabilities)
- As a special case, there is a person who likes a flip-up chair. **The movement is interesting, so some people turn it into a chair and put it back without even sitting down.** This needs to be taken into consideration. (People with intellectual/developmental disabilities)
- **It is difficult for people with upper limb disabilities to sit on a folding chair while holding it down.** It would be effective if it is possible to turn on the switch or apply a little force to lower the seat and then let go of the chair. I feel more comfortable when I can sit while holding the handrail. (Specialist)

Other

- None

3.Evaluation result ③One-touch fixing of wheelchair

general comment	Power wheelchair users and experts gave positive comments on the idea of adding guide lines and **making it easier to secure the wheelchair.** However, it was pointed out that the current fixation system creates **uneven surfaces on the floor**, which may cause **tripping hazards**, especially for users of canes, short leg braces, and the visually impaired, and may even cause **the cane to get caught in the floor**.

Good point

- I think the problem of it taking time to fix the wheelchair will be somewhat improved. (Electric wheelchair user)
- The guide line of the wheelchair is good. **It is easy to operate backward if there is a guide.** (Specialist)
- I think it will make it easier for the driver. I think it will be easier for the driver.

Requests for improvement

- I can't see behind me when I'm fixing the back, and it's difficult for me to do it alone. It would be good if **there was something to look behind or something to aim at.** It would be good to have a guide line. (Power wheelchair user, expert)
- The color of the fixture is similar to that of the floor, so it is difficult to see. (Low vision)
- It's a little obtrusive. **I can't help tripping over it without being told.** (Low vision, stroller users, cane/short leg braces users, white cane users)

Other

- None

3.Evaluation results ④Touch-type buttons

general comment

There were positive comments from people with upper limb disabilities and experts that it was easy to push. However, **there were concerns about malfunctions** and requests for improvements in **the installation position to accommodate left and right upper limb disabilities.**

Good point

- Easy to push. (Electric wheelchair user)
- I think it's good. The shape and size are good. The shape and size are good, and the height is good (relative to the button on the back of the driver's seat). (Persons with upper limb disabilities)
- The position and visibility are both good. (Specialist)

Requests for improvement

- **I'm worried that it might malfunction.** (Power wheelchair users, professionals, upper limb disabled)
- **There is a fear of being hit by luggage.** Pressing and holding is too hard. Touch is better. The yellow color is easier to see. It would be better if **it were placed directly in front of the device.** If you have a left hand disability, it's hard to put it on the left side. It would be better **to have them on both sides.** (People with upper limb disabilities)
- It needs to be in a position where it is difficult for other people to touch it.

Other

- It will be good for people who have difficulty with their fingers. (Stroller user)
- It didn't feel right. (Low vision)

3. Evaluation result ⑤Easy-to-see button and next station (name, symbol, etc.) display even in the dark

general comment

As a positive point, people with low vision said that **the LCD screen is easier to read** than the current get-off button. The hearing impaired and other MCP also commented that the easy-to-understand information on **the next stop would help them prepare before getting off the bus and give them a sense of security.** There were several requests for improvement, such as the need to know **the time until the next stop**, and **the need to show the information on a large screen or smartphone** because it was difficult to assume a safe location.

Good point

- It was easier to understand that the back of the camera was illuminated by the LCD compared to a regular button. (Low vision)
- Easy to see and understand. It would be helpful to have a variety of information. (Hearing impaired, mentally challenged)
- There is no need to rush to get out of the way. Even if I don't know the train line, I can know where I am getting off, which makes me feel safer. When I go somewhere for the first time, I feel nervous if I don't know where I am going, but I can ride without worry. (Users of canes, short leg braces, and upper limb disabilities)
- The touch panel seems to be easy to use for people who are not good at operating smartphones. (Persons with mental disabilities)
- Very good. It is basically difficult to understand information on buses. I think it's a useful idea for people who don't have transportation limitations. (Stroller user)

Requests for improvement

- Vertical orientation is better for the screen. Especially **when it is mounted on a railing, it will get in the way if it is mounted horizontally in a place where the width is narrow.** The screen should also be oriented vertically. I would like to see the station you are going to on the top and the station you have passed on the bottom. (Deaf people)
- It would be nice **to have the current location of the bus and the time until the next stop.** (Hearing impaired, mentally challenged)
- It would be better if the screen is placed at the top so that all passengers can see it. It would be better to have large screens in various places so that people would be interested in touching and pulling them. (People with upper limb disabilities, people with intellectual/developmental disabilities)
- **It is better to use a normal button for getting off the train.** (Persons with upper limb disabilities)
- It is easy to see, but **it is difficult to locate it safely.** Why not send the information to your personal smartphone?(Experts)

Other

- If it's a bus that I ride every day, it doesn't have to be special. (Electric wheelchair user)

3.Evaluation results ⑥Touch panel FAQ

general comment

There were positive comments from the hearing impaired, mentally challenged, and intellectually/developmentally challenged about the ability to make a reservation to get off the bus, to receive information about the current location and arrival at the next bus stop, and to receive information about nearby rest facilities as a FAQ. There were several requests for improvement, such as **the size of text**, **display of ruby**, **simple operability**, and **the ability to search for information on a large screen or personal smartphone or tablet instead of a tablet**. People with low vision also said that it would be better if there was a **voice reading function.**

Good point

- Information is easy to come by. "I feel anxious about where I am. I feel anxious when I don't know where I am, and I feel impatient when I don't know where my next stop is. (Hearing impaired)
- I've never been able to make a reservation to get off the train. It would be helpful. The function that displays nearby rest areas is useful when I suddenly need to use the restroom. (Hard of hearing)
- It would be very nice to have this much. (People with mental disabilities)

Other

- Even now, I don't have that much trouble with the bus (cane and short leg brace user)

Requests for improvement

- Apple's Maps has **a feature that reads out the stations and things nearby**. It should be similar to that. (Low vision)
- It's difficult to operate for first-time users. It's better to make it so that the user can understand how to use it by looking at it. The ruby should be a little larger. It would be better to make **the characters larger in the display only, without making it too complicated.** (Hearing impaired, upper limb disabled)
- **People in wheelchairs cannot see if someone is standing in front of them.** It is a problem where to install them. It is better to make it large and put it on a high place where it can be seen. It would be better if the map was displayed on a large screen, and the name of the station and the time between stations were displayed below the map. It would be good to add a button for getting off there (for professionals, people with upper limb disabilities, people with intellectual/developmental disabilities).
- **It would be good to be able to use a touch panel to convey information to the driver** in the event of a disaster or other unexpected situation (deaf people).
- **I don't know information on traffic jams and delays due to accidents,** etc., so I think it would be useful for drivers to have this information. I think it would be useful for the driver to have this information.
- It would be better if changes in weather and traffic conditions were also reflected. I think the order of priority should be **bus reservations, arrival time, where I am, and where I want to rest**. (Persons with mental disabilities)
- It is better **to download the information to a tablet** held by the person (mild) or the accompanying person (moderate to severe). I think it is better to fly to a smartphone. (Persons with intellectual/developmental disabilities, specialists)

3. Evaluation results ⑦Lower the outside display on the bus.

general comment

There were several opinions that the multiple displays on the outside of the vehicle were easy to understand. In addition, some low-vision users said that **it would be easier to see the displays if they were at eye level.** On the other hand, it became clear that low-vision users **need to get closer to the bus** in order to see the displays. Furthermore, there were several requests from users of electric wheelchairs, etc., that the display should be higher **because it would be difficult to see when it is crowded if it is installed in a low position,** and that the display should be available at bus stops, etc. People with intellectual and developmental disabilities requested **the use of ruby** and a way to **indicate route names in an easy-to-understand manner.**

Good point

- **It's at eye level and easy to see when you get close.** (Low vision)
- Colors are easy to see. (Users of canes and short leg braces)
- It is easy to see if it is placed in various positions. It is easy to see when getting on and off the bus. It is easy to see from a distance.
- (Deaf people, electric wheelchair users, baby carriage users)
- (Deaf, electric wheelchair users, baby carriage users) If it is a large bus terminal, buses come in from various directions. (Deaf people, electric wheelchair users, baby carriage users) (Experts)
- It would be easier to understand if they were next to the doors. **It would be better to have them in front of you when you get on the bus.** (Cane/short-legged orthopedic users)

Requests for improvement

- **I can't see unless I get close.** I'm concerned about whether it's safe (or even dangerous) to get close. It would be better if the back of the screen was brightened with a backlight or something. I can't see the text if it's streaming. (Low vision)
- The appropriate place varies from person to person. The appropriate place varies from person to person, even among wheelchair users. If it is too low, it will be difficult to see when there are many visitors, so **higher is better than lower**. (Electric wheelchair users, baby carriage users)
- **If it is installed on the bus, it will not be visible when it is crowded**, so it would be better if it is possible to find out which bus to take at the bus stop or elsewhere. (Stroller user, expert)
- **Ruby is a must on the outside of the bus**. Some people don't understand kanji. For people with intellectual/developmental disabilities and autism, **it is useful to symbolize** bus stops with hiragana (route name) + numbers. In fact, hiragana and numbers are better, but alphabetical names are also easy to remember. (People with intellectual and developmental disabilities)

Other

- I have never felt any inconvenience with the current bus because I check with the driver. (Electric wheelchair users)
- I don't have any problems with the current display outside the bus. (Persons with intellectual/developmental disabilities, persons with mental disabilities)

3.Evaluation results ⑧Handrails on both sides of the automatic ramp

general comment

There were positive comments from electric wheelchair users, such **as the risk of wheelchair derailment is reduced**, and **the handrails help** the elderly. However, users of canes and short leg braces commented that **the handrails may get in the way** when walking and that they themselves do not need to use them.

Good point

- **It reduces the risk of falling off a wheel.** Depending on the condition of the sidewalk, the slope may be too steep, but the handrails are useful for supporting the body (electric wheelchair user).
- I can't think of any bad points. It is easy for any person to get in and out of the car. (Stroller user)
- It is helpful for the elderly. (Elderly person)

Requests for improvement

- **Some people swing their legs outward** (sideways) when they walk. For those people, **the handrails may be a hindrance**. However, the length of the railing is short, so it does not seem to be a problem. (Users of canes and short leg braces)

Other

- I don't think I need to use the handrails. I don't need to use handrails.

3. Evaluation results ⑨Roof at the top of the automatic ramp

general comment

There were positive comments from electric wheelchair users and users of canes and short leg braces who were concerned about slipperiness in the rain and the need to use umbrellas. On the other hand, several people pointed out **the difficulty of stopping at bus stops** and suggested that the roofs of bus stops be made wider.

Good point

- Absolutely good for getting on and off in the rain (electric wheelchair user)
- Very helpful. Without a roof, I have to hold an umbrella until just before getting on the bus. If there is a roof, I can put my umbrella away early and feel safe. (Users of canes and short leg braces)
- If it doesn't rain too hard, the slope will be protected (stroller user)

Requests for improvement

- If it is not covered to the bus stop, it will get wet. If the bus entrance were wider and had a roof, it might be more convenient. **It is necessary to accommodate both front and rear riders.** (People with upper limb disabilities)
- It would be better to enlarge the roof of the bus stop. (Persons with upper limb disabilities)
- **It is necessary to stop so as not to bump into the bus stop.** (Stroller users)

Other

- I don't care if it's there. It would be better if the bus stop was not destroyed. (Expert)
- In the first place, I don't go out much on rainy days. I have a cover for my stroller, but when I need to go out, I use an umbrella. However, this is a very rare case. (Stroller user)

3. Evaluation results ⑩The reason for stopping is indicated by the color of the light in the car.

general comment

Many people with hearing disabilities and other transportation constraints expressed positive opinions about the ability to know when a bus is arriving or pausing. In terms of requests for improvement, some of the comments included **the use of different colors, the display of information in easily visible locations such as the ceiling**, and the ability to know when the bus is arriving at the bus stop. In addition, there were opinions that **text should be displayed** for people with color blindness and that **voice announcements would be good** for people with low vision.

Good point

- I think the shape, location, and number are good. (Deaf people)
- **I don't understand emergency braking** in particular**, so it would be easier to understand if there were lights.** It is easy to see because it is divided into two parts. (Deaf people, users of canes and short leg braces)
- When a bus stops, it is difficult to tell whether it stopped at a traffic light or a bus stop. (Hearing-impaired person)
- Very good idea. If people could practice getting out of their seats when the light turns blue, and **make it a pattern, it would increase safety**. (People with intellectual and developmental disabilities)
- Very good. It will be easy to understand not only for the hearing impaired but also for those who wear earphones. It will help to relieve the anxiety of people with hearing disabilities. (Stroller user, expert)

Other

- I don't really feel the need to stop at traffic lights because I can identify them by the sound of the engine, etc. I'm stopped at a traffic light. The road is congested. It would be better to say, "We will stop at the next stop sign. (Low vision)

Requests for improvement

- It would be good to have three colors: red, blue, and yellow. I think there are international standards for the use of colors, such as ISO, and it would be better to conform to them. The use of blue when the bus stops is different from the image. **It would be better to consider the color.** (Deaf people)
- If you are sitting sideways, it will be difficult to see if someone is standing in front of you. It would be easier to see if it is mounted on the ceiling. (Deaf and hard-of-hearing people)
- (Deaf, hard-of-hearing) It would be easier to understand if **the light blinks when approaching a bus stop and stays on when the bus stops.** (Deaf and hard-of-hearing people) I feel uncomfortable when the red light flashes every time I brake. (Deaf, hard-of-hearing, short-legged) It would be easier to understand if the light flashed when the bus stopped and stayed on when it stopped. (Hearing-impaired, cane/short-legged orthopedic users)
- It is not necessary to know that the bus is stopped at a place other than a bus stop. It would be enough if the light glowed when the bus arrived. **The fact that the light is on inside the bus is noisy to some people.** (mentally challenged person)
- It would be good **if the letters "brake" and "bus stop" could be displayed together,** since some people have color blindness. It is more important to know where the train is stopping than whether or not the brakes have been applied. (People with intellectual/developmental disabilities)

3. Evaluation results ⑪Seat space

general comment	Positive comments included that the space would **make it easier** for users of canes and short leg braces **to stretch their legs**, for deaf people **to sign**, and **for stroller users to use**. However, the experts pointed out that **the space would reduce the space** for cane users and elderly people **to lean on, which may affect the safety of their movement**. In addition, electric wheelchair users expressed a desire **to sit facing forward** if possible.

Good point

- **I need more space when using sign language**, so it would be nice if there was more room. It would be nice if my elbows didn't hit other people. (Deaf people)
- I don't need to bend my legs. (Deaf people) I don't need to bend my legs. I don't have a problem if my legs are under the seat in front of me. (Cane/short-legged orthosis users)
- It is good to be able to stretch my legs. (Persons with upper limb disabilities)
- I appreciate that there is space. Since the chair can be folded, there may be people who will give it to me as a stroller space. (Baby carriage users)

Requests for improvement

- In fact, instead of facing the aisle, **it is better to face forward if possible**. You can see the scenery outside. Also, the location of the bus stop varies from station to station, so if I face sideways, I can't see where the bus stop is at intersections. (Electric wheelchair user)
- How to place the handrails for standing up is an issue. **The narrower the seat, the more I can stand on my feet and lean over, so I don't fall.** If the seats are made wider, there is no choice but to use handrails for safety. I think it would be better if there is enough room for the legs to stick out a little. (Expert)

Other

- none

3. Evaluation results ⑫Communication of intentions to bus drivers and other passengers using apps, etc.-1

general comment

There were several positive opinions that **informing the driver of the disability in advance would reduce the psychological burden**. On the other hand, there were several concerns about the operation of the application and requests to make it easier to use. In addition, there were opinions that **it is necessary to consider in detail how to communicate the necessary support and how to obtain effective support from the driver** after the driver is informed of the disability.

Good point

- It's very good **because it saves me from having to prepare myself for the ride**, worrying that I might startle the driver or other passengers, having to explain what I want help with, and worrying about interfering with the operation. It reduces my anxiety before boarding. (Guide dog users)
- I would like to have it. It is a good idea to know what kind of person has contacted you (for example, "from a hearing-impaired person"). (Hearing-impaired people)
- Convenient if I think about only myself. (Power wheelchair user)
- I understand that **if the crew knows the information in advance, they can prepare for the trip**. I think it is wonderful to be able to prepare myself. (Upper limb disabled person)
- **There are people who are not good at communicating their disabilities**, so lowering the threshold is commendable. (Persons with mental disabilities)
- People with severe disabilities or behavioral disorders are accompanied by a caregiver**. It would be effective if the caregiver could convey information to the driver.** (Persons with intellectual/developmental disabilities) Persons with moderate to severe disabilities who are able to board the bus by themselves would benefit from being able to communicate their behavioral characteristics in advance. (People with intellectual/developmental disabilities)

Other

- none

Requests for improvement

- It would be nice if the app could be preloaded with the information, "I have a white cane. I want to sit in a seat. Or just press the send button. (White cane user)
- **It's good if only the driver can see the information, but I don't want other people to see it.** I don't like to be seen by others. It's stressful to input information in a loud voice on a bus street, such as "I have a guide dog and I'm wearing a certain color. (Guide dog user)
- Even if I inform the driver in advance about my hearing disability, it is difficult to communicate with the driver of the bus that comes, so **it would be good if the app could tell me which bus I should take.** (Deaf people)
- It is necessary to think about specific communication. For example**, written communication, voice recognition and texting.** Remote sign language interpretation technology would be nice to have on board.(Deaf people)
- I need to be taught how to use it. **It is troublesome to go through trial and error by myself**. (Users of canes and short leg braces)
- (Cane and short legged orthosis users) It is an issue whether the users are familiar with how to use them. (Persons with upper limb disabilities)
- **It is difficult to provide effective support if the driver does not understand** to what extent the disability should be categorized and displayed. It is necessary to study the communication gap in detail. (Persons with mental disabilities)
- **The application should be easy** to operate. If a person always takes the same bus at the same time, such as for commuting, the app should be able to tell whether the person has arrived at the bus stop with the touch of a button. For people with intellectual/developmental disabilities or autism, **it may be difficult to communicate verbally**. It would be good to have icons for common problems. (People with intellectual and developmental disabilities)

3. Evaluation results ⑬Using apps, etc., to communicate with bus drivers and other passengers - 2

general comment

Guide dog users, hearing-impaired people, and stroller users expressed positive opinions about the ability **to travel safely on the bus without worrying about the information at the drop-off station**. People with intellectual/developmental disabilities also appreciated the fact that **they could avoid the trouble of pressing the "get off" button when it was not necessary**. As for requests for improvement, there were opinions that the operation of the application needs to be made **more widely known, that information needs to be input by AI speakers, that notifications need to be made by vibration, and that there needs to be a mechanism to confirm that people who want to get off the bus** have done so.

Good point

- **You can eliminate the anxiety of wondering if you will be able to get off the bus** because you missed the announcement. I get really nervous when I go to a new place for the first time. With this, it will be a fun trip. (Guide dog user)
- It would be convenient to have it on my personal app. It is convenient to be able to make reservations**. In the case of hearing aids, there are cases where it is difficult to hear the voice in the car.** It is very helpful to be able to make reservations in advance. (Hearing-impaired person)
- The buttons are shaped in such a way as to arouse the desire to push them, and **there are problems with people pushing them to get off when they are not getting off**. If you use the bus regularly and know which bus stop you will get off at, the reservation system is effective. (People with intellectual/developmental disabilities)
- Very good. If people know in advance that they are going to get off the bus, they will not be forced to get on the back seat **and it will take time for them to get off the bus and the bus will depart.** This is useful when you need to take care of your child just before getting off the bus. (Stroller user)

Requests for improvement

- I need to be taught how to operate it. (Users of canes and short leg braces)
- I can't operate my phone when I'm standing, and not everyone has a phone, so I prefer AI speakers. (White cane user)
- It would be nice to be able to make reservations both on the bus and outside in advance. It would be good to have more flexibility in changing plans. I'm not good at operating a smartphone, **so it's easier to press a button.** (Guide dog user)
- Even if I tell the driver where I'm getting off in advance, I don't understand even if the driver calls out to me when I don't realize where I'm getting off. **It would be better to have the driver tell me where to get off by vibrating** my phone, etc., rather than telling the driver. (Deaf people)
- There is a time lag before the driver receives the message. **Right before the station you want to get off at, the bus button may be faster**. It is a matter of personal judgment. (Hearing-impaired people)
- **It is necessary to know who pushed the button in which seat**. If it is necessary to input various information into the app in advance, it will be difficult. (People with intellectual/developmental disabilities)
- It is necessary to consider how to deal with multiple people getting off. **We don't know if the person really got off,** such as the hearing impaired.(Experts)

Other

- You may not need it. It's not that I don't know which bus stop to get off at. (Deaf people)
- I tell the driver when I get on the train which station I am getting off at. (Deaf person) I tell the driver when I get on the bus, and the driver listens to me. I think the current situation is fine. (Electric wheelchair users)

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