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

FY2020 Annual Report Summary

NTT DATA INSTITUTE OF MANAGEMENT CONSULTING, Inc.

April 2021

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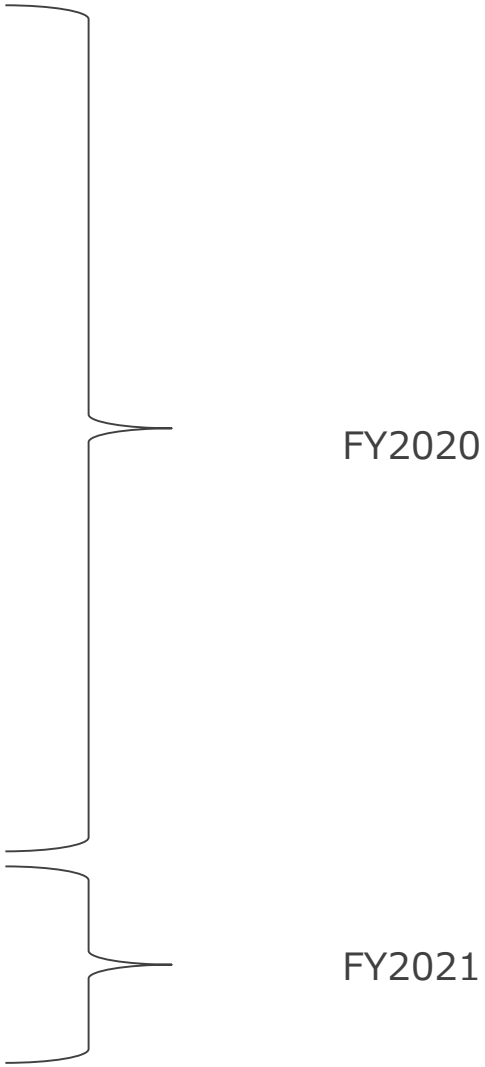


1.Project outline

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

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	

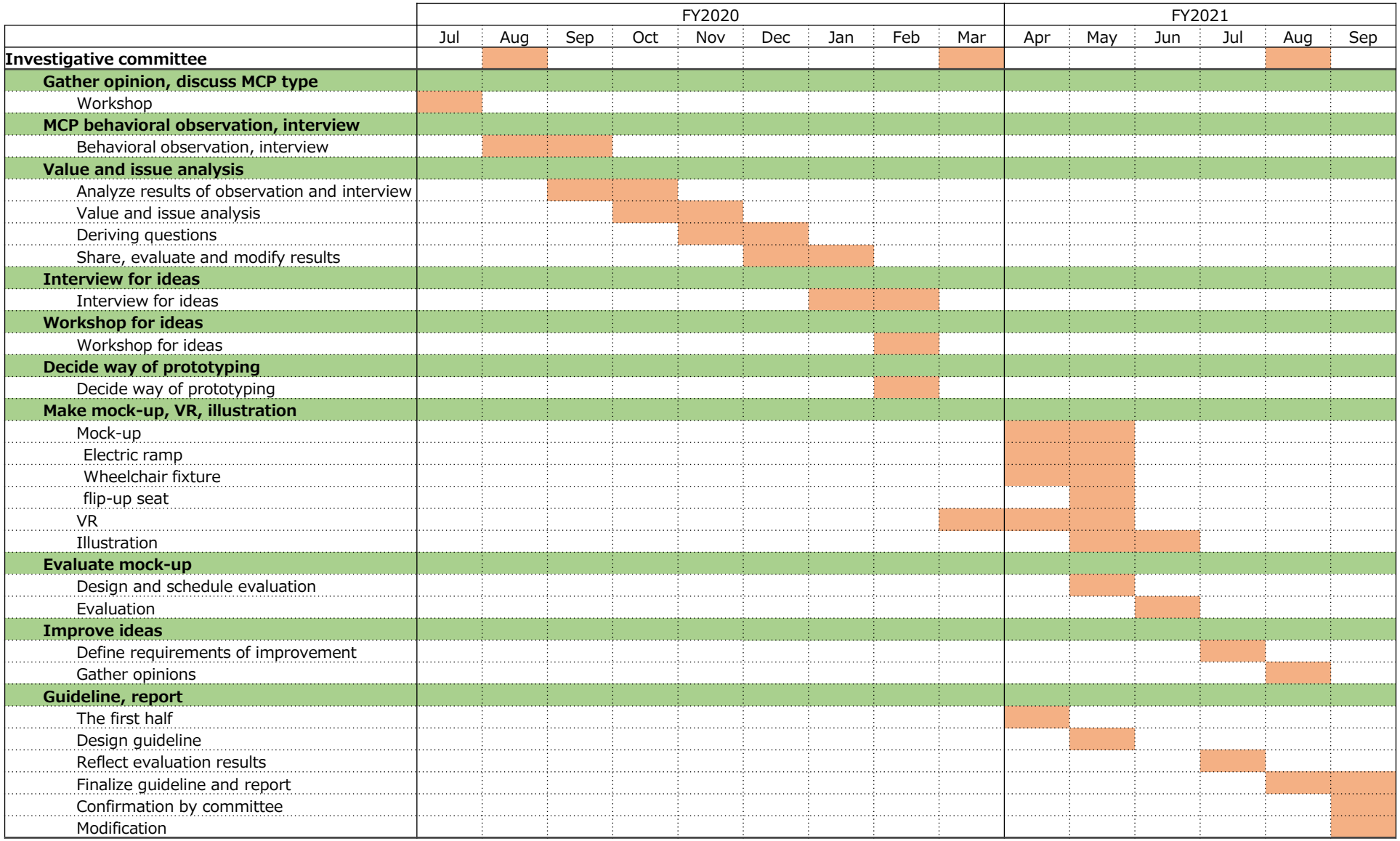
3.Premises

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.)

4.Schedule

We will proceed this study 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
Kasuhiro 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. Organizing issues and discussing ideas

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

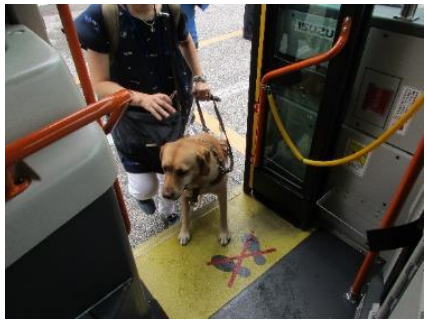
In the behavioral observation, we used an actual bus to recreate the situation of bus use. We were able to obtain opinions on the problems people have when using the bus and the physical and psychological reasons for them.

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

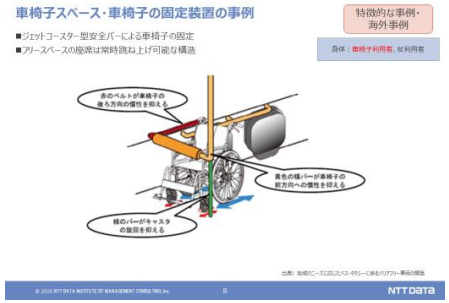
In the interviews with MCP, we asked them to bring their own tools and applications that they normally use. We also asked them to refer to case studies in Japan and abroad. By doing so, we were able to get their opinions on actual usage scenarios and advanced layouts that they do not normally use.

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)

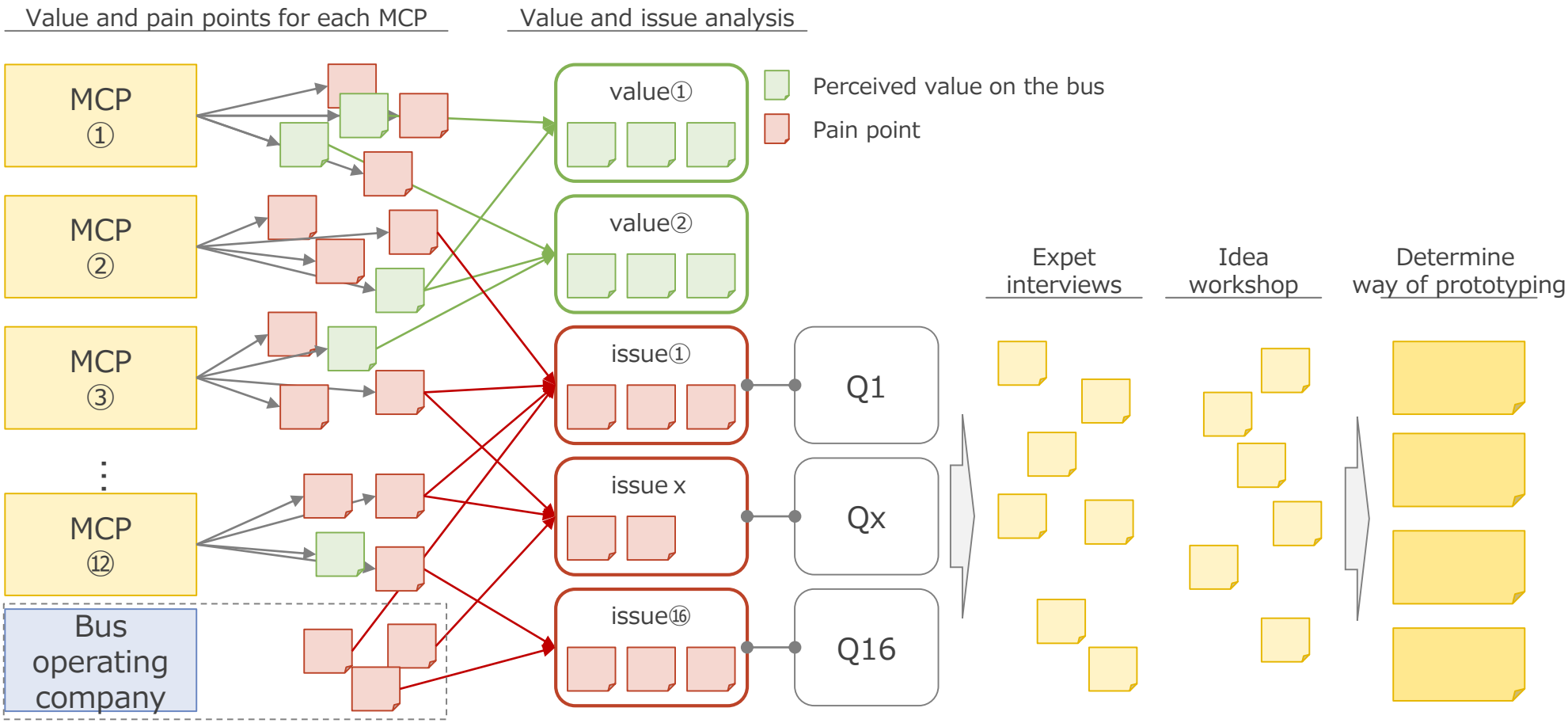
- Resistance to priority seating due to mixed feelings
- White cane user and cane/brace user feel that there are people who need priority seating more than they do.
- Deaf people and people with mental disabilities find it difficult to use priority seating because their disabilities are difficult to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



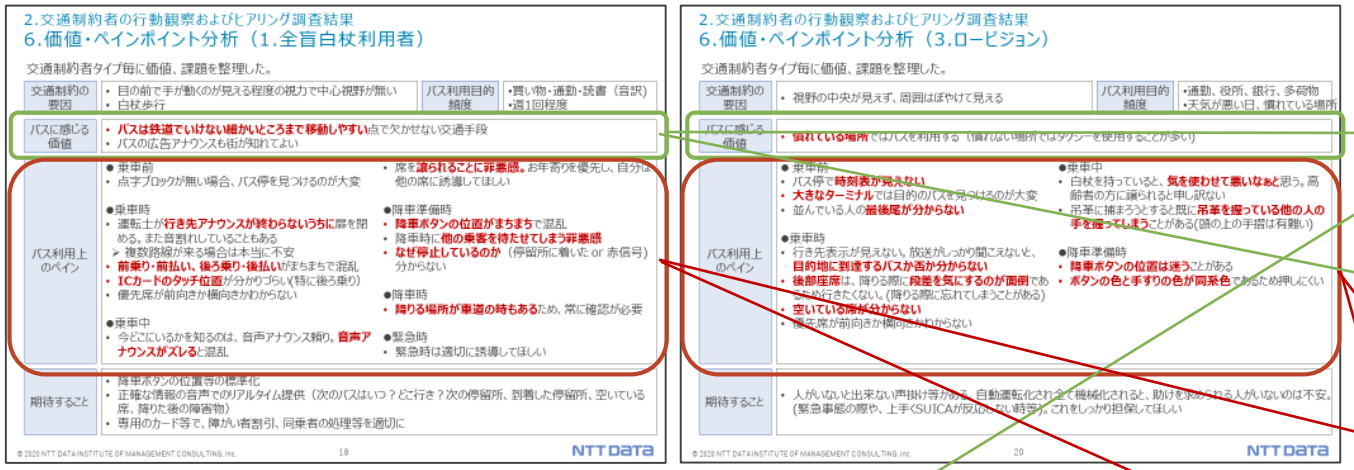
2. Organizing issues and discussing ideas

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 people with transportation constraints 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 traffic constrained people 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 traffic constrained people to use the back seat? How can we make it easier for transportation constrained people 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 traffic constrained people 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.

Location	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 traffic constrained people get off.
App	Navigation apps	We experimented with an app for traffic constrained people 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 people with traffic constraints, 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	

外部ICT(アプリ等)のみで実現

変更箇所	layout improvement	Provision of information	Institutional and cultural modifications
Building the app		Learning information, learning videos of traffic constrained people, 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 people with transportation constraints 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.

aws 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: ier-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

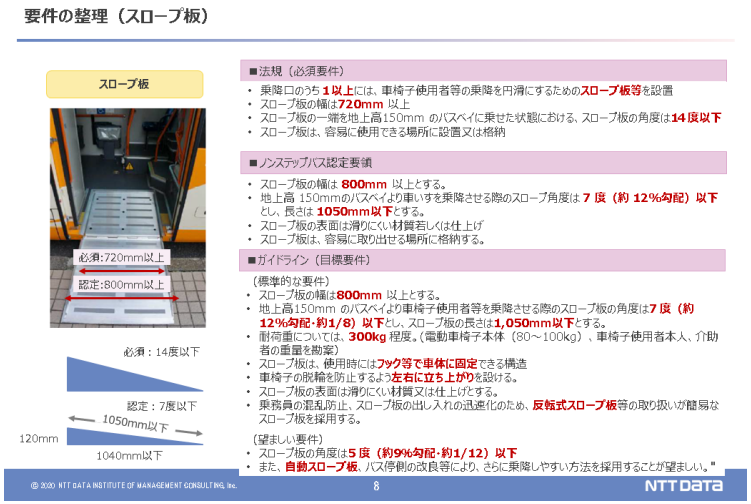
2. Organizing issues and discussing ideas
8. Research of relevant laws and standards

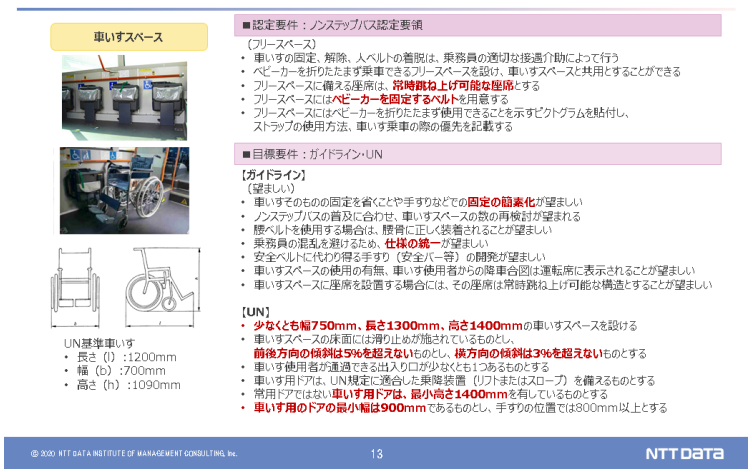
Relevant regulations and standards were organized by bus part.

■ 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.