SIP-adus
Innovation of Automated Driving for Universal Services

Plenary Session: Service and Business Implementation / FOTs ＋
Human Factors (Joint Session)

AIST's efforts toward social implementation of automated driving mobility services

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Demonstration evaluation of last mile automated driving project overview

The METI/MLIT's MaaS, Social Implementation of Advanced Automated Driving System R&D and FOT Project: FOT for Social Implementation of Terminal Transportation with Driverless Cars in Dedicated Lanes (Automated Last-Mile Driving FOT: FY2016–2020)

✓ Cover short/mid-range distances, e.g., home–nearest station with last-mile automated driving (terminal transportation system)
✓ Develop technologies, assess public acceptance and business feasibility (business model) needed for post-2020 practical application

* Conduct regional verification with the aim of reducing transportation, labor shortages, costs, etc. in depopulated areas and vulnerable people.

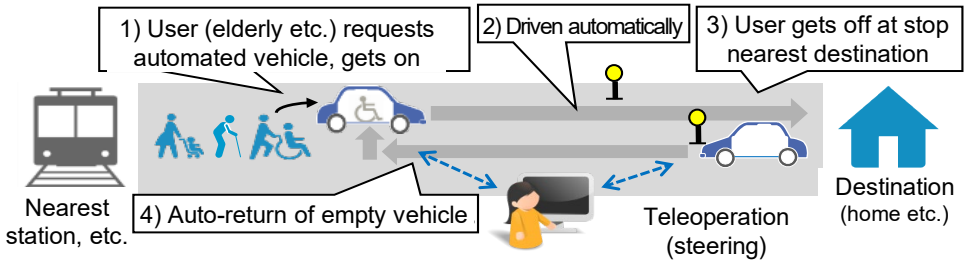
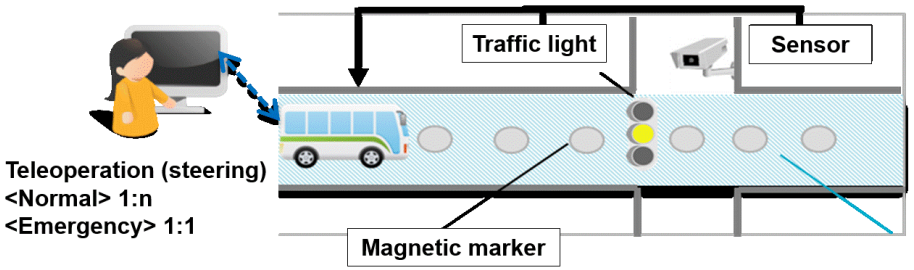


Image for Last-Mile Automated Vehicles in Operation



Operational image of dedicated space using bus

Smart E cart
(Low-speed automated driving vehicle)

Automated driving bus
(Advanced Mobility: Minibus)

At the beginning of the project, the three-year plan was aimed at regional demonstration evaluation in FY2018, but it was extended to the five-year plan with the goal of realizing unmanned automatic driving and mobile services in limited areas during FY2020 (government target).

Shift to development and demonstration of medium-sized buses with more passengers from 2019

Medium-sized automated driving bus
(Advanced mobility remodeling: 2 units)

Focus on balancing the following objectives during testing: ①Establish the technology, ②Define a business model, ③Establish a social system, ④Cultivate social acceptance

⇨ **Aim to lead the way to commercialization**

Last-mile Automated Driving FOT for Social Implementation of Mobility Services Using Automated Driving Technologies

- **Evaluated business feasibility in model areas and developed vehicle technology toward implementation of unmanned automated driving mobility services in selected areas in FY2020.**

2020 demonstration experiment area

❶ Test run in Eiheiji

❷ Test run in Chatan

■ **Trial operations for full-scale introduction**

Trial operations as part of preparations for system transfer toward commercialization in FY2020

Aim for remote monitoring and control of 3 or more carts by one operator (traffic control)

■ **Unmanned cart retrieval FOT**

FOT for unmanned cart retrieval and remote operation of 3 or more carts (labor-saving and cost reduction)

METI/MLIT Project

■ **FOT for mid-sized automated buses**

FOT using two mid-sized buses with five bus operators:

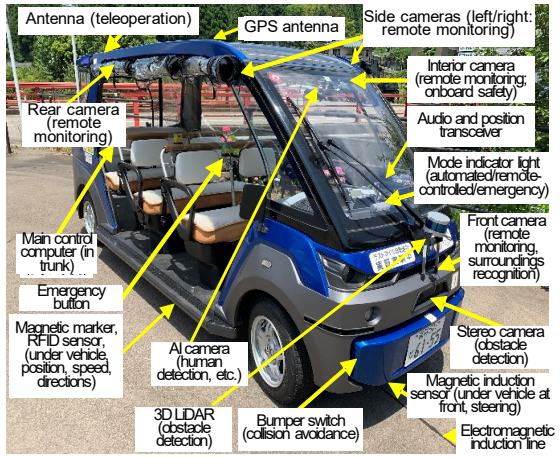
❸ Otsu City (July–Sept.), ❹ Sanda City (July–Aug.), ❺ Kitakyushu City (Oct.–Nov.), ❻ Hitachi City (Nov.–March), ❼ Yokohama City (Dec.–March)

Conduct R&D for automated driving at Level 3 or higher and for the expansion of social implementation of remotely operated mobility services as well as conduct long-term trials in preparation for system transfer

Long-Term Mobility Service Trial in Eiheiji, Fukui

Demo case

- **Dates: July 6 to Nov. 30, 2020**
- **Pilot site: "Eiheiji Mai Road" in Eiheiji, Fukui (approx. 6 km)**
- **Stakeholders include: Machizukuri ZEN Connect, AIST, Eiheiji**
- **Project Summary:**
  - **Mobility service trial with local operators toward system transfer**
  - Verify profitability, devise ways to boost demand, secure sufficient vehicle charging time
  - Evaluate safety/operability of automated cars and remote monitoring system



Yamaha Motor electric cart retrofitted by AIST

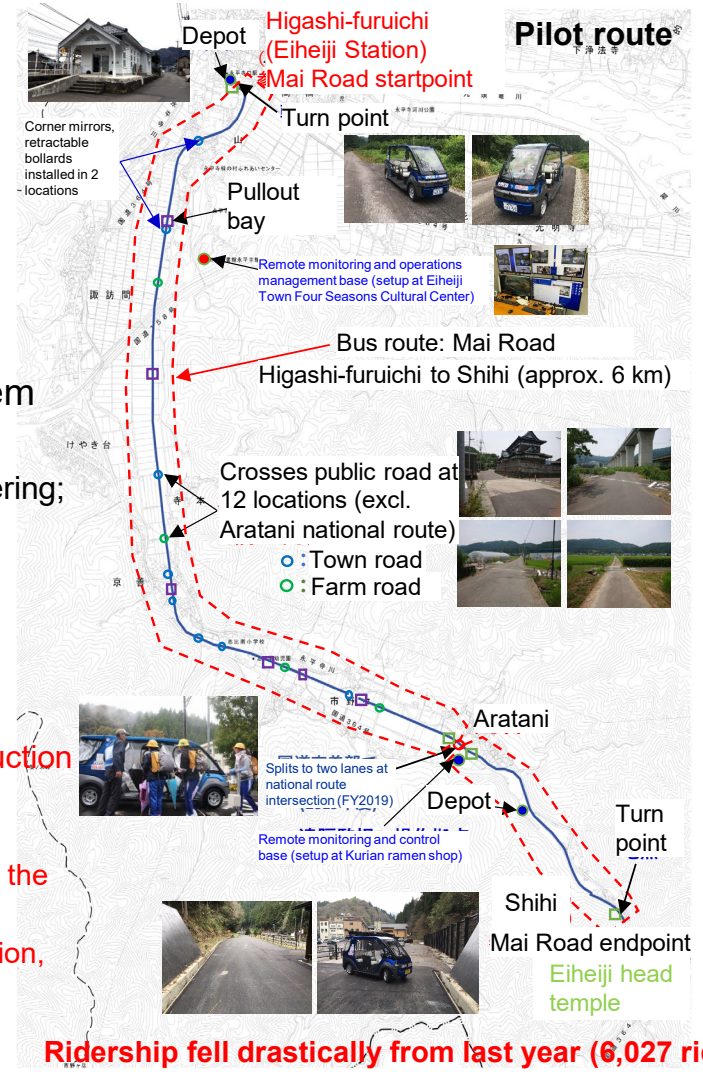
Automated Driving Functions

- Electromagnetic induction wire for automatic steering; roadside RFID for speed control and brakes
- Travel speed ≤12 km/h during automated mode, maximum speed < 20 km/h
- Obstacle detection, automatic brake control

Connected to remote monitoring system

Why use older technology (i.e., electromagnetic induction cable) for automated driving?

- ➢ High adaptability to the environment (e.g., GPS and LiDAR ineffective in the woods, camera ineffective in the snow)
- ➢ Proven record and maintainability for commercialization, cost-effectiveness considerations, etc.



- Total number of users: 1,654 (excl. project staff) over 100 days
  - Daily rider average: 16
  - Peak single-day ridership: 55 on Aug. 14, 53 on Nov. 10
  - No. of weekends/holiday operations: 32 days, Total number of riders on weekends/holidays: 686
  - Daily rider average on weekends/holidays: 21

Ridership fell drastically from last year (6,027 riders over 147 days; daily average of 41 riders) due to COVID-19, with effects including reduced advertising, passenger limits, and service frequency revisions

Unmanned Automated Driving Mobility Service Starts in Eiheiji, Fukui

- **Service start:** Dec. 22 (Tue.), 2020

*Operation ends on Dec. 25 (Fri.), 2020 and resumes on Mar. 1, 2021. (winter service suspension in Jan. and Feb.)

- **Route:**“Eiheiji Mai Road” in Eiheiji, Fukui (approx. 2 km)

*The route utilizes a 6 km dedicated bicycle/pedestrian lane (formerly a railway line), of which 2 km between Aratani and Shihi is designated for this service. A mobility service with a driver onboard will commence in March for the remaining sections of the route.

- **Main stakeholders:** **Eiheiji (commissioned to Machizukuri ZEN Connect)**
- **Fare:** Adult 100 yen/trip; child 50 yen/trip (categorized as paid passenger transportation with private vehicles)
- **Operational format:** One remote operator controls three unmanned automated carts

*Run with a safety monitor onboard at the back solely for onboard safety measures, etc.)

Launch a mobility service with a small team operating multiple vehicles to aid in eliminating driver shortages and reducing costs (produce a model achieving the government's target)

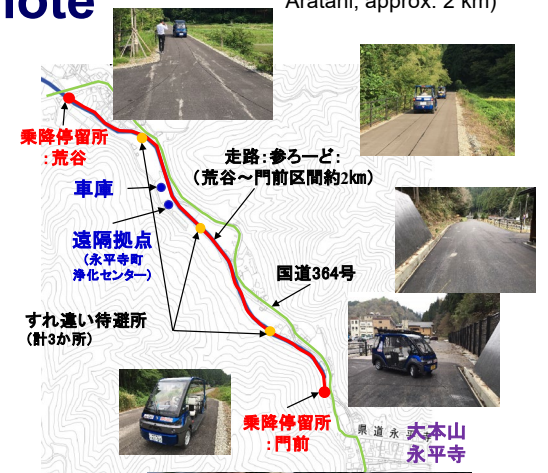
Remote monitoring and control station

One remote monitor/operator handles operation for 3 unmanned vehicles

*This operation resulted from METI/MLIT commissioning AIST for its initiative to create unmanned automated driving mobility services. This project utilized the positive takeaways from the field tests done to date.

World's First Demonstration on Public Roads: One Remote Driver Controlling Three Teleoperated Vehicles (Eiheiji)

Route: A section on Mai Road (Shihi to Aratani, approx. 2 km)



FOT for multi-vehicle operation with a small team to aid in eliminating driver shortages and reducing costs

- Standard eased for teleoperation of two automated vehicles by one driver (Chubu District Transport Bureau, MLIT: Oct. 18, 2018)
- Road usage approved for the test (Fukui Prefectural Police: Nov. 7, 2018)
- The world's first test on public roads began (from Nov. 19, 2018) *With onboard safety driver

  - Remote driver: 1 operator sits at the main controls for vehicle monitoring and control, constantly monitoring the two carts
  - Operator typically only checks for boarding and unboarding of passengers at the stop and presses the departure button

Example operator workstation (teleoperation monitor at right)

1:2

(1 remote driver operates 2 carts)

- Feb. 21, 2020: Standard eased for teleoperation of two automated vehicles by one driver → Demo test suspended to stem the spread of COVID-19
- June 23, 2020: Standard eased for teleoperation of two unmanned automated vehicles by one driver
- Aug. 12, 2020: Road usage approved following driving demo for the above test
  - Currently collecting data → Aim for further sophistication toward operation of three vehicles by one driver

*Without onboard safety driver

⇒ Standard eased for teleoperation of three automated vehicles by one driver, road usage approved

- From Dec. 22, 2020: Commercialization of teleoperation of three automated vehicles by one driver

Labor saving and cost reduction by increasing the number of unmanned carts that can be operated with fewer staff

Advance automation and sophistication

3:1

Conducted vehicle performance tests at public testing institutions (JARI), etc. for Level 3

- Conducted tests at JARI, etc. to confirm the vehicle performance inside and outside the assumed driving environment conditions (ODD) and for assumed scenarios that cause problems.⇒**Sensor systems that can judge the inside and outside of ODD are important**
- Confirmed that the vehicle is controlled safely for all test items.

Driving environment conditions(ODD)	**Main test contents (outside ODD)** ⇒Stop (MRM : Minimum Risk Maneuver)
The vehicle is on an electromagnetic induction cable and there is a magnetic field that the vehicle can detect.	Electromagnetic induction cable power loss, When deviating from the electromagnetic induction cable
It should not be bad weather due to heavy rain or snowfall, thick fog, nighttime, etc. that cannot detect pedestrians in the vicinity.	At the limit of driving in fog, rainfall and dusk
The speed should be less than about 12km / h	When speed control or RFID reading fails
The road surface should not be in an unstable state such as freezing	When the tire slips
There are no emergency vehicles on the course	When the siren sound is approaching

Vehicle control	**Main test contents (in ODD, malfunction)** ⇒Stop (control function)
When there are obstacles	Pedestrian passing or jumping out, lying down, bicycle approaching or overtaking / interrupting, obstacles (obstacle detection above the minimum ground clearance), fixed obstacles, obstacle movement
System not working, sensor not working	Confirmation of sensor power loss, sensor covered with flying objects


State of rainfall test

State of thick fog test


State of slip test (slip simulation)


State of obstacle detection / vehicle control test

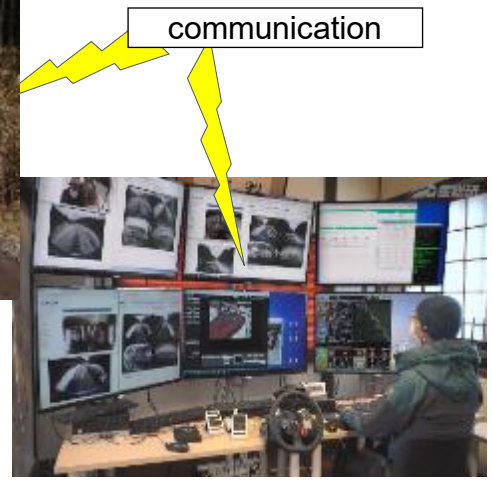

State of flying object cover mock test to LiDAR

First in Japan! Level 3 approval and operation of automated driving vehicles by remote type system

- The remote automated driving system that AIST has conducted a demonstration experiment in Eiheiji Town, Fukui Prefecture, was approved for the first time in Japan on March 5, 2021 as a remote monitoring and operation type automated driving device (level 3).
- The automated driving device mounted on the vehicle operates on an electromagnetic induction cable installed on a bicycle and a pedestrian-only road (public road), and detects and responds to pedestrians, bicycles, obstacles, etc.
- **From March 25, 2021, full-scale operation started in Japan's first vehicle equipped with an automated driving device (level 3).**

Approval of Japan's first remote monitoring / operation type automated driving device (level 3)

One remote monitoring and operation person operates three unmanned automated driving vehicles



Remote monitoring / operation room

Name : ZEN drive Pilot

Remote drivers are freed from constant peripheral monitoring of three automated driving vehicless, reducing the driving burden

Driving environment conditions

1. **Road and geographical conditions**
   (Road section)
   - Eiheiji Mai-road: The site of the abandoned Keifuku Electric Railroad Eiheiji Line
   - Part of the south side of Eiheiji Mai-road: Approximately 2km between Eiheiji Town Aratani and Shihi (Monzen)

   (Road environment)
   - Driving course using electromagnetic induction cable and RFID
2. **Environmental conditions**
   (Weather conditions)
   - It should not be bad weather, heavy fog, nighttime, etc. due to heavy rain or snowfall that cannot detect pedestrians in the vicinity.

   (Traffic situation)
   - There is no emergency vehicle on the course
3. **Driving situation**
   (Vehicle speed)
   - The driving speed of the automated driving device must less than 12 km / h.

   (Driving situation)
   - The vehicle is on an electromagnetic induction cable and there is a detectable magnetic field.
   - The road surface should not be in an unstable state such as freezing.

Configuration of automated driving devise

Vehicle position recognition

- Electromagnetic induction cable and RFID
- GPS and map

External recognition (main ones)

- Cameras
- 3D-LiDAR

Correspondence and equipment necessary for automated driving devise

- Cyber security
- Software update
- Driving status recorder
- Outward display (sticker)

Remote monitoring / operation type automated driving system

- Remote monitoring / operation device
- Inside / outside monitoring device

communication

Remote monitoring / operation room

Driver condition detection

- Condition detection for remote monitoring and operation

Although it is the realization of mobility services on public roads in the limited space of the abandoned railway site, we were able to obtain Level 3 approval for remote type automated driving that can operate multiple vehicles. In addition, the start of operation is a big step because it can show the way to future development.

Operation of unmanned automated driving mobility service by remote type automated driving system

Operation of unmanned automated driving mobility service by remote type automated driving system

Operated by a remote driver of ZEN Connect

Three vehicles passing each other at the waiting area

ZEN drive information sign

Collection of usage charges as paid passenger transportation with private vehicles

Even now, on Saturdays, Sundays, and holidays, it is operating at automated driving level 3.

Steps to technological development and commercialization in Eiheiji Town

FY2016 | FY2017 | FY2018 | FY2019 | FY2020 | FY2021

Selected as a demonstration area

October 7, 2017
Test drive event

May 2017
Test drive on the electric cart (test drive for residents)

World's first remote driver to operate two remote drivers on public roads (November 2018)

April 2018
Demonstration evaluation departure ceremony

April 25-May 25, 2019
Demonstration of maximum demand during Golden Week
(Operation of 10 units)

Promotion of use by support for returning home

June 24th-December 20th, 2019
6-month service demonstration operated by a local operator

Test operation of unmanned automated driving mobility service by Japan's first remote automated driving system started on December 22, 2020

First in Japan, Shifted to full-scale operation of remote type automated driving system (1: 3) at level 3 on March 25

Expand the area of unmanned automated driving mobility services with remote type system

Tech. dev.

Development of automated vehicles tailored to the region

February 2018
Technical verification of automated driving on snowy roads

Development of remote type automated driving system

February 2018
Standard mitigation certification

Tech. dev.

Development of long-term demonstration vehicles and systems, improvement of reliability, etc.

Development of remote automated driving system assuming multiple operations, development of passing control system

Tech. dev.

Introducing 6- and 7-seater vehicles, upgrading the system, and improving reliability and durability

Development of remote monitoring system assuming operation of up to 10 vehicles

Tech. dev.

AI-based recognition of people, etc. Advancement by introducing cameras and LiDAR

Development of a remote automated driving system in which one remote driver operates three vehicles

Level 3 ODD examination and vehicle development / performance test

Fostering regional understanding and acceptance is important

Commercialization: Maintained by local governments for the purpose of public services and regional revitalization (Mobility service + added value)

Introduction of new projects for social implementation of automated driving mobility services such as level 4

“RoAD to the L4“

Project on Research, Development, Demonstration and Deployment (RDD&D) of Autonomous Driving toward the Level 4 and its Enhanced Mobility Services.

Objective

- Create a sustainable society with mobility systems compatible with major trends in the automotive industry, such as CASE and carbon neutrality.
- Achieve demonstrations and deployments of level 4 autonomous driving mobility systems that contribute to reducing environmental burdens, solving mobility issues and increasing Japan’s economic value

Targets and KPI

①Demonstrations and diffusion of unmanned autonomous driving mobility services.

- Complete the demonstration of autonomous driving mobility services with remote monitoring (level 4) in limited areas and vehicles types by FY 2022
- Expansion of the service to more than 40 locations in diverse areas and vehicle types by FY2025,etc.

②Diffusion of new mobility services (MaaS) using IoT and AI

- Deployment of new mobility services using IoT and AI to solve social issues and vitalize local communities.

③Develop and secure human resources

- Develop and secure human resources in various field including engineers for both hardware and software, innovators who can match technological solutions with social issues, etc.

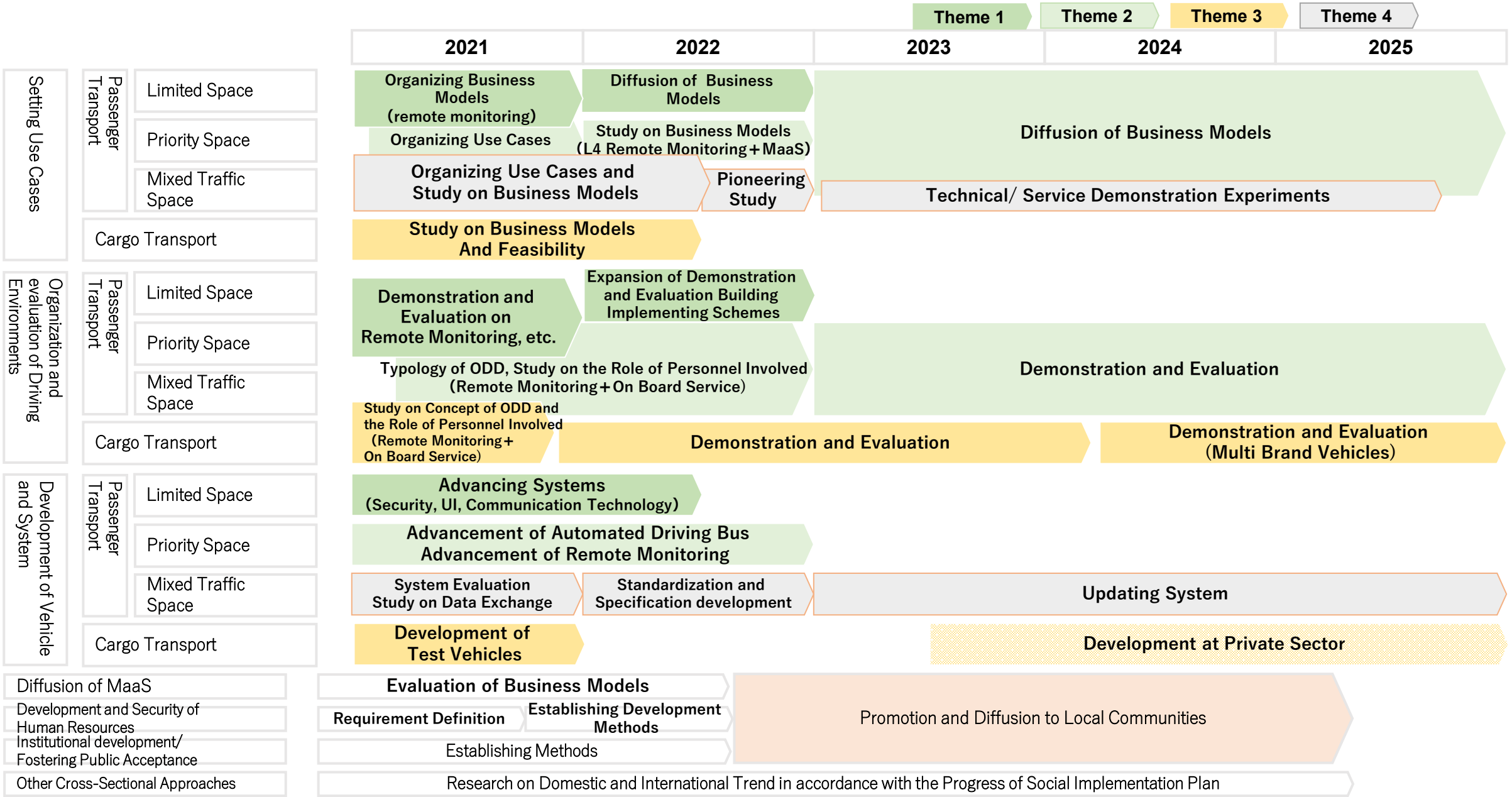
④Fostering social acceptance

- Promote accurate understanding and interest in autonomous driving as well as encourage behavioral change by providing user-friendly information, opportunities to experience autonomous driving in real life and sorting civil liabilities.

Policy of Conduct

- This project aims to socially deploy advanced mobility services including level 4 autonomous driving, in addition to fostering technology development, research and analysis, and demonstration experiment, accordingly to above mentioned Objectives and Targets and KPI.

RoAD to the L4 Project Business Plan (scheduled for FY2021-2025)

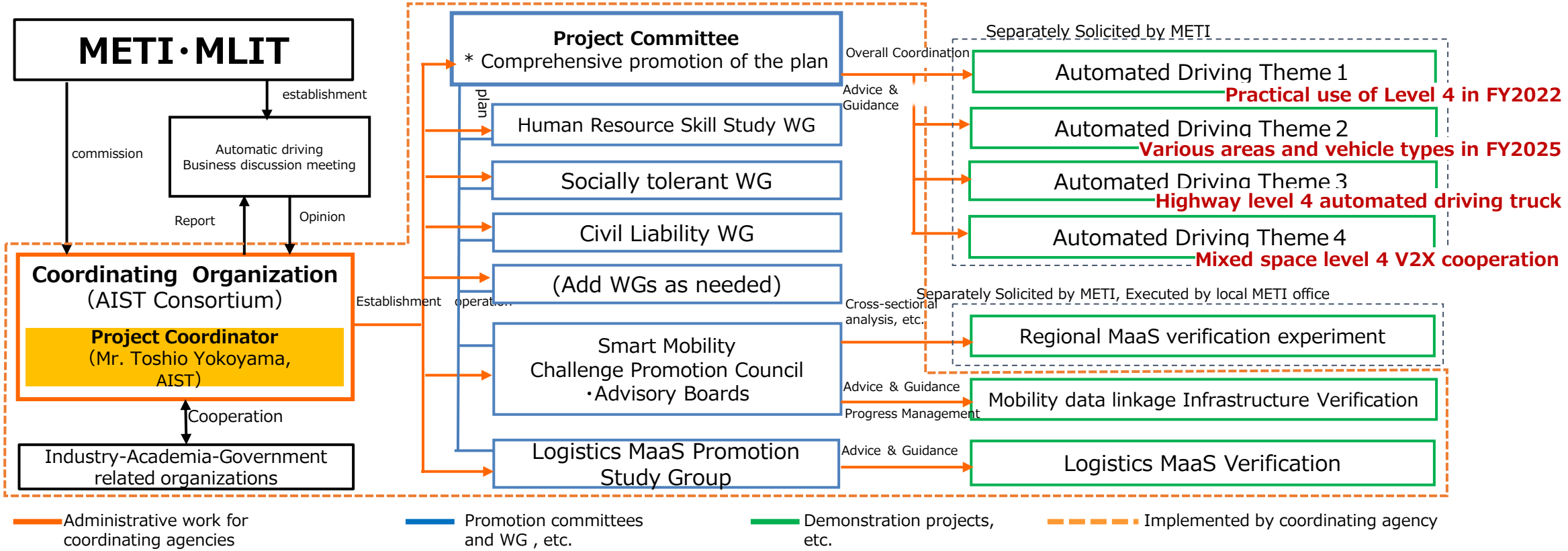


"Automated Driving Level 4, etc. Advanced Mobility Service R&D and Social Implementation Project （RoAD to the L4）"
Overview of R&D and social implementation plan

Implementation structure

○ Establish a project coordinator as the organization responsible for the comprehensive research and study of this project (coordinating organization)

○ The project coordinator is responsible for the PDCA cycle of this R&D and social implementation plan. While listening to the opinions of the ministries and agencies in charge and the promotion committee, prepare a draft plan, manage the progress of each theme based on the plan, and revise the plan as necessary.



Theme 1 Demonstration of an Autonomous Driving Service with Remote Monitoring (Level 4)

Target Result

- **Demonstration of an Autonomous Driving Service on Limited Area and Vehicles with Remote Monitoring by FY2022**
- **Establish Basic Business Models and Institutional Structure for Autonomous Driving Service with Remote Monitoring**

Approach Policy

- This project demonstrates an autonomous driving service with remote monitoring (level 4) at limited locations such as discontinued railway sites using low-speed vehicles.
- It studies the roles of remote operators and their tasks other than driving for establishing technology and the commercial deployment of remotely monitored level 4.
- The result will be shared with other ministries and agencies to build institutional structures and procedures for the deployment of level 4 autonomous driving services.

Remote-operating Autonomous Driving System in Eiheiji-cho

Main Activities

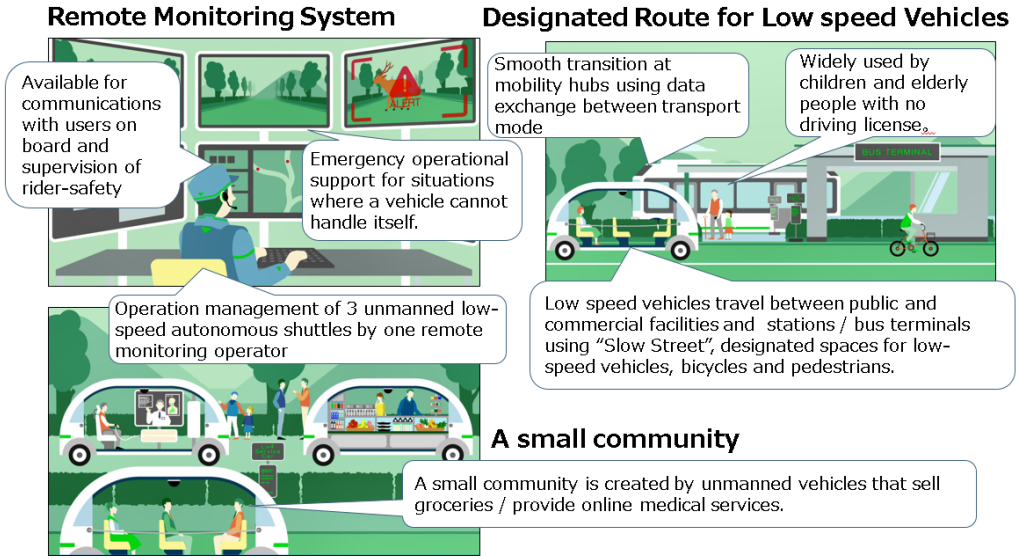
2021

- Organizing business models
- Operation, demonstration and evaluation of systems that enables remote monitoring of 3 vehicles by one person
- Demonstration and evaluation of remote operators' tasks exclude driving
- Advancement to level 4 vehicles and systems
- Evaluation of the security of remote monitoring system
- Improvement of remote monitoring system interface

2022

- Analysis and creation of models for the deployment of business models
- Update the requirements for remote operators to increase the number of vehicle monitored.
- Build structures for tasks excluding driving
- Implementation of safety validation for level 4 vehicles and systems
- Demonstration and evaluation of remote monitoring system and its interface

Future Image



Theme 2 L4 MaaS Service Expansion for multiple Area and Vehicle types, and Improvement of Business Feasibility

Target

- **Deployment of unmanned autonomous driving services to diverse areas and with various type of vehicles (level 4) at more than 40 locations by FY2025.**
- **Establish business models and infrastructure/institutional structure for the deployment of varied services.**

Approach Policy

- Promote the development of vehicles and systems with specification and functions that have appropriate safety for their ODD and operating conditions, assuming autonomous driving services in various areas and with various vehicles.
- Promote efficient rolling out of services by establishing ODD typologies, business models, infrastructure/institutional structures.

(Image) Automated Driving System of Toyota and Hino Motors

Main Activities

2021

- Organizing use cases of unmanned autonomous driving services, and study business models
- Creation of a Typology of ODD for autonomous driving services
- Study on safety assessment in accordance with ODD

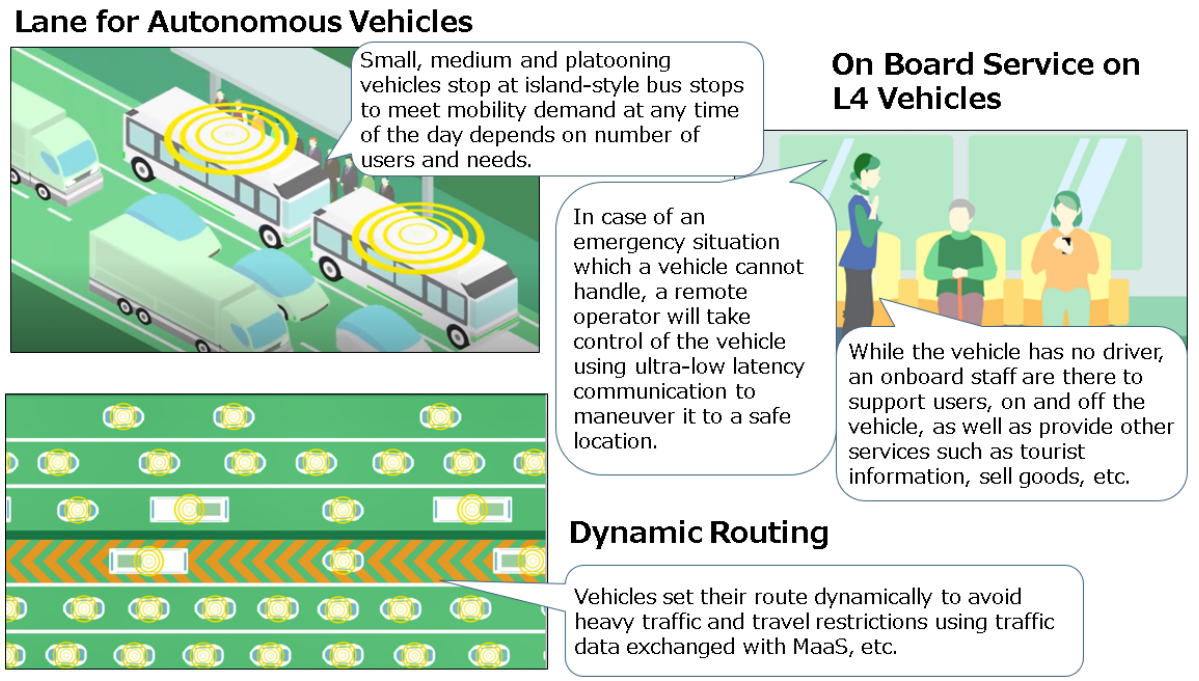
～2022

- Sophistication and diversification in the type of autonomous driving bus
- Advancement of remote monitoring systems
- Examination of connectivity with road infrastructure

～2025

- Increasing number of use cases, and business models
- Demonstration and evaluation of various driving environments and vehicles.
- Deployment of test vehicles developed by private companies

Future Image



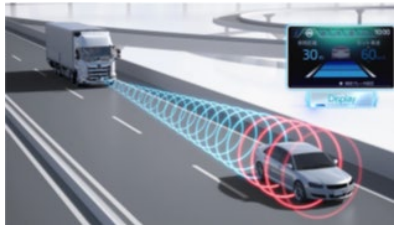
Theme 3 Deployment of High- Performance Trucks including Platooning on Expressway

Target

- **Deploy level 4 autonomous driving trucks and its platooning technology on expressway after 2025**
- **Develop not only vehicle technologies but also necessary environment such as fleet operation management systems, infrastructures and data for business implementation**

Approach Policy

- Development of level 4 autonomous driving trucks utilizing results of previous demonstration experiments of unmanned truck platooning.
- Develop fleet operation management systems utilizing infrastructure data that take the needs of large vehicles into consideration .
- The result will be shared with relevant ministries and agencies to improve of the business environment using road infrastructure, data exchange, etc.



(Image) Automated driving on Expressway

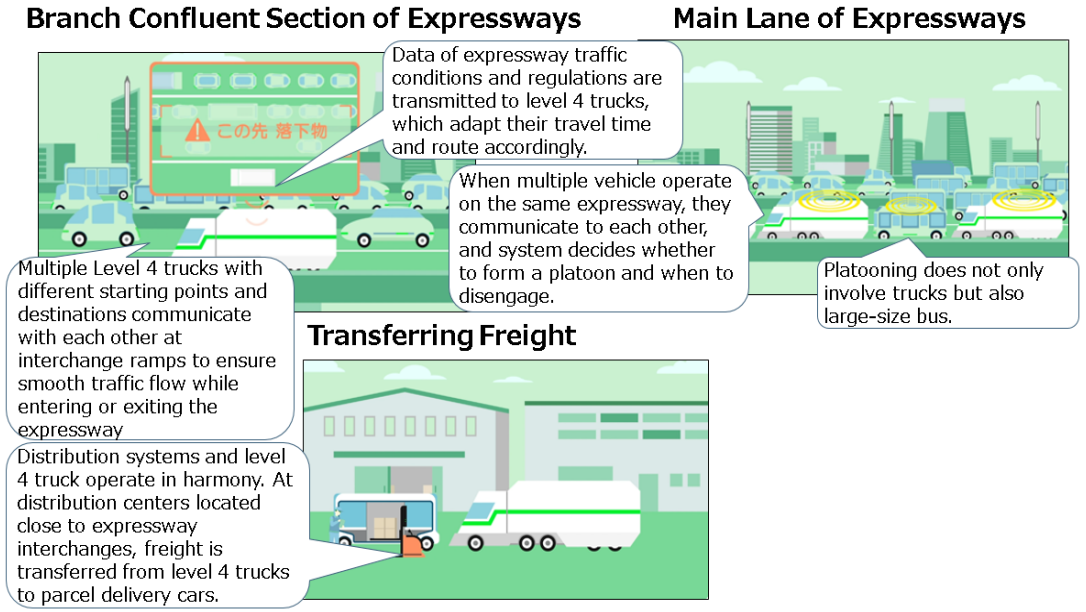
Main Activities

2021
- Evaluate business models for level 4 and their feasibility (e.g. infrastructure support, deployment to other types of vehicles, etc.)
- Development of vehicles and systems to evaluate the ODD of level 4 vehicles.

～2022
- Demonstration, evaluation and establishment of ODD concepts meeting characteristics of large vehicles
- Demonstration, evaluation and establishment of fleet management systems meeting the characteristics of large vehicles

～2025
- Demonstration, evaluation of business models
- Development of systems by the private Sector
- Demonstration and evaluation of collaborative driving of multi brand vehicles

Future Image



Theme 4 Harmonization and interoperability of infrastructure, V2V and V2P communication to achieve level 4 autonomous driving in mixed traffic environment

Target

- **Achieve level 4 autonomous driving services in mixed traffic in diverse areas using cooperative system by around 2025**
- **Create a testbed area where the most appropriate cooperative system, which is adapted to local characteristics such as road environments and traffic situations, may be implemented**
- **Support lower level of automations (level 3, ADAS, etc.) and other type of mobility also.**

Approach Policy

- Promote the implementation of cooperative system in accordance with local characteristics based on analysis and study of regional use cases.
- Develop business models for data exchange schemes that also benefit other types of mobility.
- Promote harmonization and standardization efforts based on domestic and international discussions and technology development

(Image) Driving assistance using data from infrastructure

Main Activities

2021

- Study on use cases and business models based on results of preliminary experiments.
- Study and evaluation of cooperative system
- Study on data exchange schemes

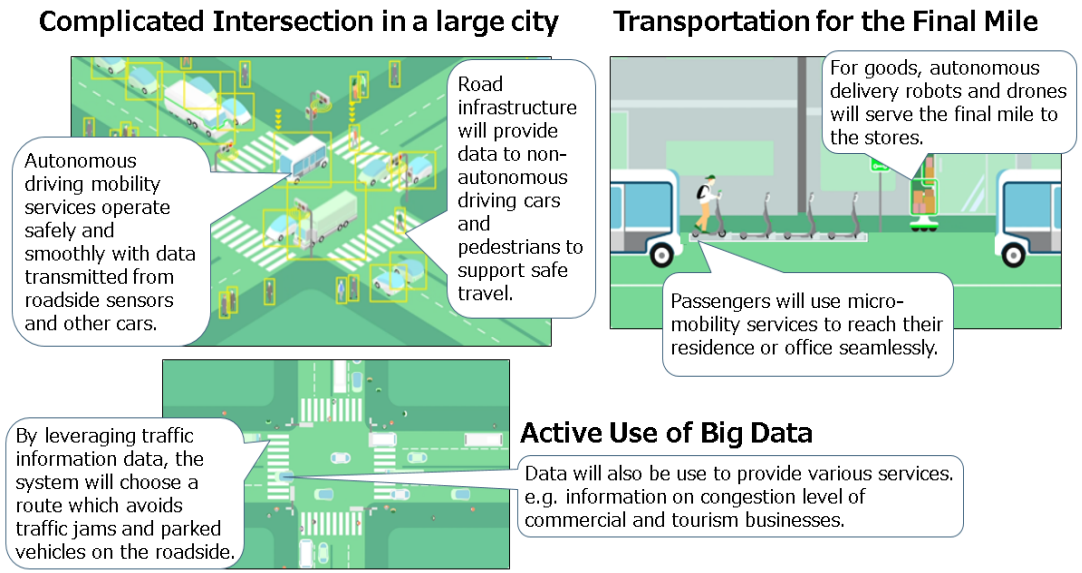
～2022

- Identifying specification of data exchange schemes
- Study on Standardization and evaluation environment of cooperative system
- Study on international trend and strategies of cooperative system

～2025

- Technical/ service / operational/ feasibility demonstration at the test bed area
- Proposal of standardization and harmonization for cooperative system
- Verification using test bed and update the system

Future Image



Thank you for your attention

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