The 3rd phase of the Cross-ministerial Strategic Innovation Promotion Program (SIP), Cabinet office, Japan
Development of Smart Mobility Platform

Extraction of requirements for vehicles, infrastructure that contribute to re-design

Cybernic Smart Mobility
Contributing to Re-design of Vehicles and Infrastructure

March 2025
CYBERDYNE Inc.

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Project Overview: Social Background, Mission, and Project Background for the Smart Mobility

Social Background of the SIP Challenge:

- Progression of super-aging society and increase in people with mobility challenges
- Insufficient public transportation in regional cities and depopulated areas
- Lack of safe and environmentally friendly means of transportation

Mission of the SIP Challenge (Excerpt from Strategy and Plan):

Building a platform that "dynamically integrates both hard and soft infrastructure that enables the utilization of a wide range of mobility resources including private cars and freight vehicles in addition to traditional public transportation, as well as new mobility means, along with the towns and regions that encompass them, from the perspective of moving people, goods, and services, to realize safe, environmentally friendly, fair and seamless mobility"

Current Status and Issues (Project Background) from the Call for Proposals:

- "While various small mobility devices are currently being developed, there are technical challenges for social implementation such as operating time, vehicle weight, and portability"
- "While existing efforts have conducted demonstration experiments in limited applications and external environments such as park pathways and airport passenger terminals, comprehensive travel in all usage scenarios is not sufficiently supported by legal systems and infrastructure"

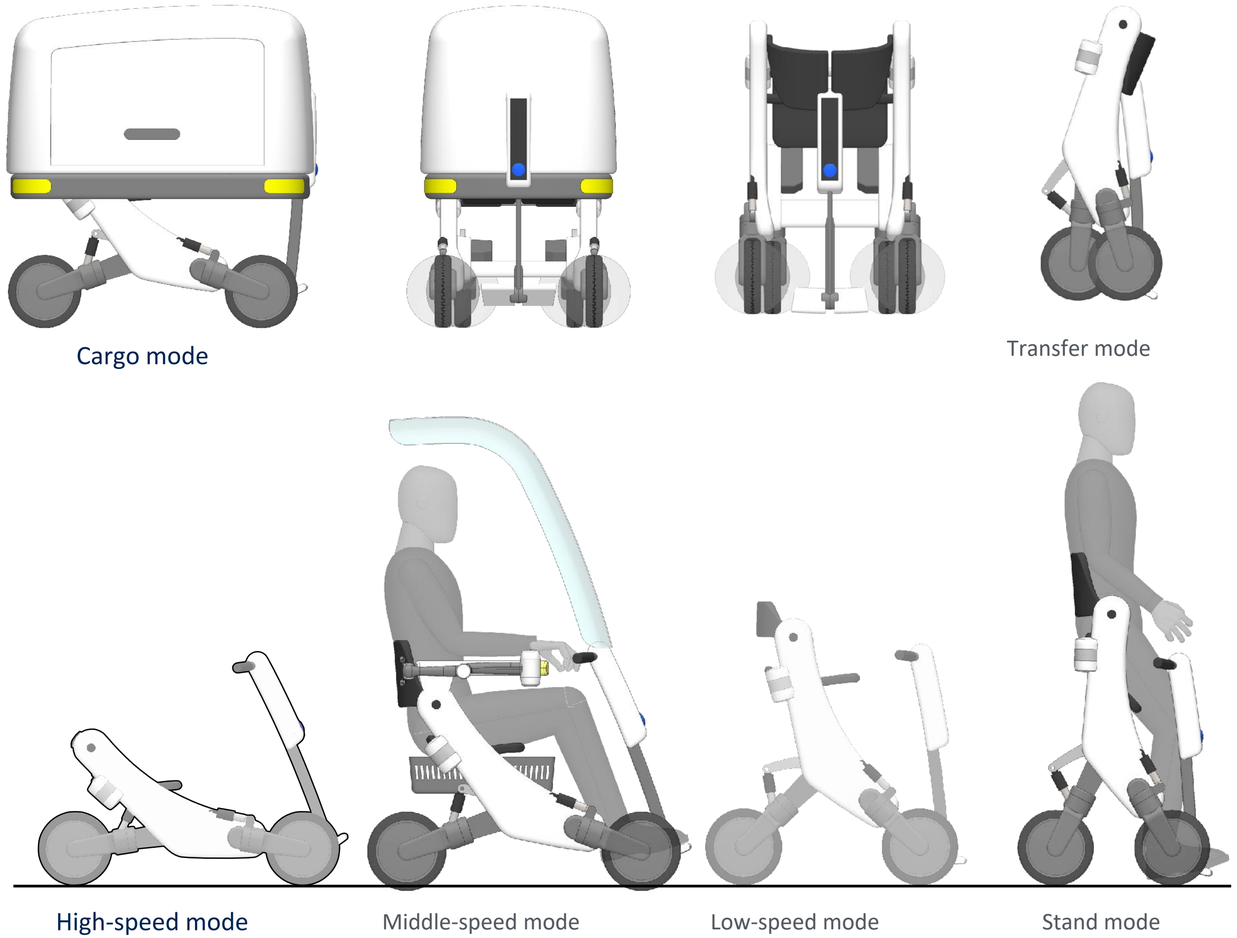
Project Overview: Action Items

To address the aforementioned current issues and contribute to the "redesign" of various mobility services for extracting requirements for vehicles (mobility devices) and infrastructure, we will implement the following action initiatives:

[Action Items] Research and Development Theme: "Cybernic Smart Mobility Contributing to Re-design"

- **Study of next-generation mobility devices and infrastructure, etc.**
  (Specification development, HW/SW design/prototype development/improvement, basic performance verification, study of infrastructure environments where mobility devices function effectively)
- **Design and implementation of demonstration experiments**
  (Field selection, design and implementation of demonstration experiments for human mobility, design and implementation of demonstration experiments for goods transportation)
- **Extraction of service requirements for realizing values that next-generation mobility devices can provide**
  (Analysis of demonstration experiment results, improvement and detailing of mobility device specifications, formulation of business and regulatory recommendations based on demonstration experiment results, proposal for regional mobility resources as infrastructure that efficiently integrates human mobility and logistics without separation through next-generation mobility devices, verification of business models in use cases and demonstration regions)

Overview of Cybernic Smart Mobility: Concept Image



Concept image of various modes of Cybernic Smart Mobility

Expected Specifications (from call for proposals):

- Capacity: 1 person (maximum) (also supports cargo-only mode)
- Load capacity: Approximately 100kg (+20kg cargo)
- Travel speed: Approximately 0-20km/h
- Foldable, capable of indoor/outdoor travel
- Can use elevators (without elevator modifications)

Technical Advantages:

1. **Cybernics Technology**
   - Fusion of humans, AI robots, and information systems (core technology of SIP HCPS Human-Collaborative Robotics)
   - Physiological information monitoring (optional) and safety functions
2. **Autonomous Driving Technology**
   - Environmental recognition functions (camera, LiDAR, GPS, etc.)
   - Obstacle detection/avoidance, fall prevention, speed limitation, etc.
3. **Data Integration**
   - Integration with urban OS, building OS, digital twins, etc.

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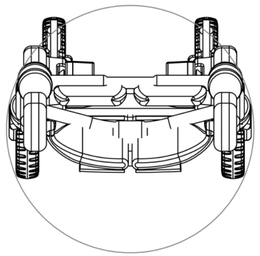
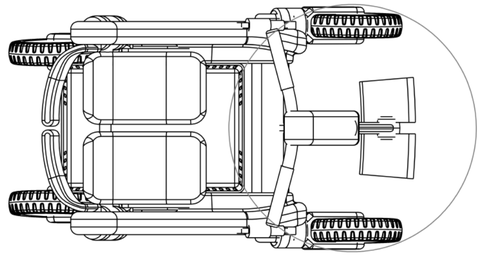
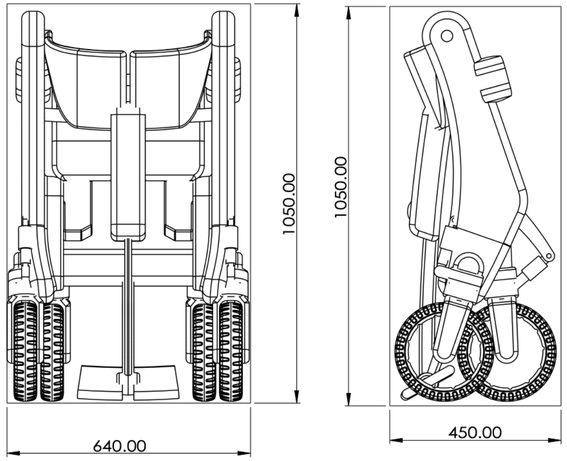
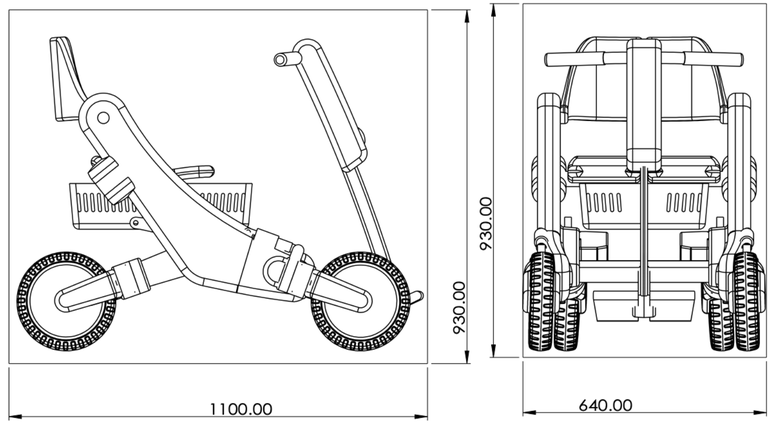
Overview of Cybernic Smart Mobility: Expected Specifications

Expected Specifications:
Size: Length approximately 1,000mm, Height approximately 850mm, Width approximately 600mm Weight: Approximately 30kg Range: Approximately 20km Charging method: Plug-in charging or battery exchange system









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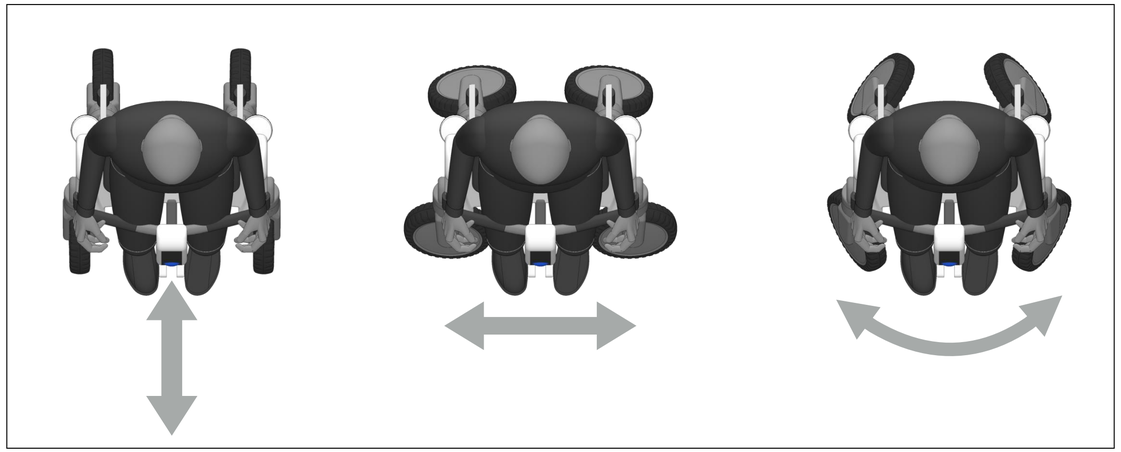
Overview of Cybernic Smart Mobility: Image of Rotation in Elevator

The device is designed to monitor the surrounding environment with obstacle detection sensors such as cameras and LiDAR, and perform in-place rotation by simultaneously rotating the front and rear wheels (4WS) while confirming there are no interfering objects in the turning area.



[Images show the 4-wheel drive concept and rotation

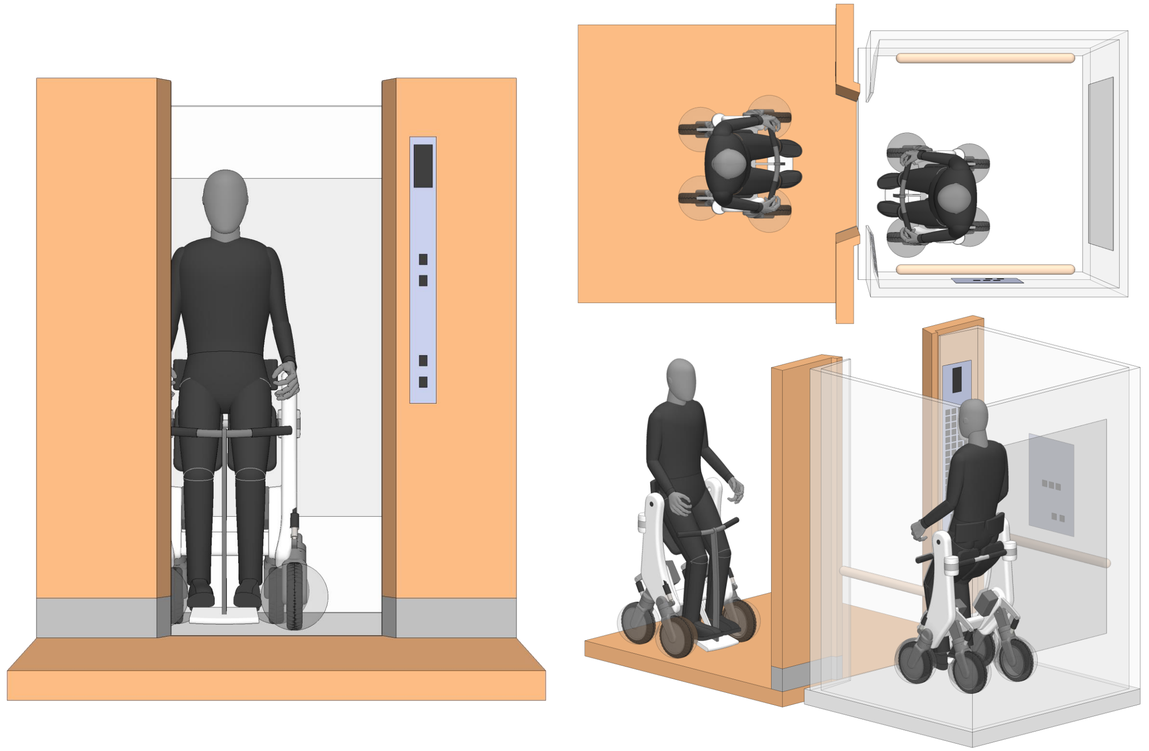
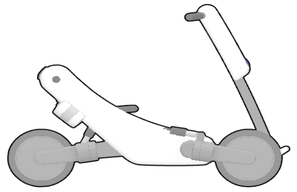


Table 1: Current Status of Small Mobility Devices and Specifications of New Mobility Device in This Project

Name and Type	Appearance	Manufacturer	Main Specifications	Restrictions	Legal Position
e-FREE 01　Electric two-wheeler with cargo basket (Pedal-less electric bicycle type)		CAR MATE MFG. CO., LTD.	Weight: 22kg, Size: Expanded - L1250×W570×H1020mm, Folded - L1250×W320×H620mm, Range: Max 30km, Max speed: Approx. 20km/h, Load capacity: Max 85kg	Load capacity limited to 85kg. Weight of 22kg is somewhat heavy. Loading into vehicles requires special consideration. Requires riding skills to prevent falling as a two-wheeler.	(Special provision) Follows regulations for specified small motorized bicycles.
ELEMOs4MAX　Electric four-wheeler (Four-wheeled specified small motorized bicycle for seated riding)		ELEMOs LLC.	Weight: 53kg, Size: L1150×W590×H1110mm, Range: Max 40km, Max speed: Approx. 20km/h, Load capacity: Max 120kg	Loading into vehicles requires special consideration.	(Special provision) Follows regulations for specified small motorized bicycles.
SCOO XT (Standing Type) (Four-wheeled small mobility vehicle)		Curio Inc.	Weight: 31kg, Size: L980×W550×H1180mm, Range: Max 13km, Max speed: Approx. 5.5km/h, Load capacity: Max 100kg	Foldability of standing-type handle unclear (seated type is foldable)	Similar in form to specified small motorized bicycles (kickboards) but classified as small mobility vehicle, treated as pedestrian under traffic law.
WHILL Model S　Electric senior car (Handle-type electric wheelchair)		WHILL Inc.	Weight: 67kg, Size: L1190×W640×H920mm, Range: Max 33km, Max speed: Approx. 6km/h, Load capacity: 100kg	Loading into vehicles requires special consideration.	Follows regulations for vehicles for physically disabled persons. Treated as pedestrian under road traffic law, so no license plate or mandatory liability insurance required.
COMS　Class 1 motorized bicycle (Mini car)		Toyota Auto Body Co., Ltd.	Weight: 420kg, Size: L2395×W1095×H1500mm, Range: Max 57km, Max speed: Approx. 60km/h, Max load: 45kg (1-person, P•COM)	Cannot use motorways or highways.	Classified as regular automobile under road traffic law and Class 1 motorized bicycle under road transport vehicle law, following corresponding regulations.
Cybernic Smart Mobility (May potentially become a new classification not currently existing)		CYBERDYNE Inc.	Weight: Approx. 30kg, Size: L approx. 1,000×W approx. 600×H approx. 850mm, Range: Max approx. 20km, Max speed: Approx. 20km/h, Load capacity: Approx. 100kg (+20kg cargo, 120kg for cargo-only transport)	As this may become a new category of mobility device, initiatives to increase social acceptance for widespread adoption are necessary.	(From call for proposals) While considering consistency with potentially relevant road traffic law, road transport vehicle law, tramway law, etc., [...] clarification of positioning is necessary, including potentially creating new classifications [...]

Research and Development Plan: Schedule and R&D Objectives

Research and Development Items	FY2024	FY2025	FY2026	FY2027
Specification Development	→ Basic performance requirements and concept development			
	→ Elemental technologies Development			
HW Development		→ Development verification prototype development		
			→ Demonstration experiment prototype development	
				→ Demonstration experiment prototype improvement
SW Development		→ Indoor/outdoor driving function development		
		→ Urban/building OS integration function development		
				→ SW improvement and verification
Verification and Demonstration Experiment		→ Basic performance verification		
		→ Demonstration experiment planning and preparation		
			→ Demonstration experiments in collaboration with other R&D items	
Studies on Social Implementation			→ Improvement and detailing of specifications based on demonstration experiment results	
			⇢	⇢ Study for extracting requirements contributing to re-design

Interim Goals (FY2025):

- Specification development completed
- 80% achievement of prototype basic verification
- 70% urban OS integration functionality
- 30% autonomous driving functionality development

Final Goals (FY2027) :

- Demonstration experiments completed
- All functionality development completed
- Business and regulatory recommendations formulated
- Performance and safety standards proposed

↳ Leading to "Extraction of Requirements Contributing to Re-design"

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Research and Development Plan: Implementation Items (1)

1. Cybernic Smart Mobility Specification Development:
Cybernic Smart Mobility is a new electric vehicle (mobility device) with the following specifications:
• Capacity: 1 person (maximum)
• Load capacity: Approximately 100kg (+20kg cargo, or 120kg for cargo-only mode)
• Travel speed: Approximately 0-20km/h
• Operating time: Sufficient for daily use without major constraints
• Vehicle weight: Loadable by humans into passenger cars (target approximately 30kg)
• Other features: Foldable, capable of both outdoor and indoor travel, able to use various elevators without requiring special equipment installation or human intervention

Additionally, beyond these specifications, it will have the following functions according to usage scenarios:
• Movement sensors: Obstacle detection (e.g., camera, LiDAR), GPS, sound pressure, illuminance, air pressure, humidity, temperature information
• SW integration: Integration with BIM, urban OS, building OS, digital twins, geographic information, sensor information, etc.
• Information display interface: Presents aggregated and organized predictive information to passengers as visual and audio information
• Control: Remote operation/monitoring, collision prevention, fall prevention, emergency stop, autonomous speed limitation
• Options: Passenger physiological information acquisition function, function to safely decelerate and stop upon detecting physiological abnormalities and notify registered contacts

This implementation item will carry out "Basic performance requirements and concept development" and "Element technology development" to define the specifications of Cybernic Smart Mobility.

Research and Development Plan: Implementation Items (2)

2. Cybernic Smart Mobility HW Development:

• As preliminary work before developing the demonstration experiment prototype, we will develop mobility function (basic function) verification prototype and transformation function (automatic transformation by switch operation) verification prototype.

• In developing the mobility function verification prototype, we will verify drive unit/turning unit functions, verify sensor placement positions, and develop robot arms.

• In developing the drive system enabling turning, we will design and prototype a mechanism (4WS: 4-Wheel Steering) that changes the direction of each wheel to enable turning in narrow spaces such as elevators.

• In developing the robot arm for elevator button operation, we will design and prototype an arm with sufficient degrees of freedom to meet required functions.

• In developing the transformation function verification prototype, we will design and prototype mechanisms that automatically transform between riding modes (Low/Middle/High-speed mode, Stand mode), cargo transportation mode (Cargo mode), and loading mode (Transfer mode) by switch operation.

Research and Development Plan: Implementation Items (3)

3. Cybernic Smart Mobility HW Development:

We will develop software necessary for control and integration of Cybernic Smart Mobility, including manual operation driving functions, indoor/outdoor autonomous navigation functions, virtual coupling functions, road/sidewalk detection functions, automatic transformation/speed limitation/vital sign integration functions, robot arm button operation functions, remote operation/monitoring functions, and integration functions with urban OS and building OS.

In collaboration with the SIP HCPS Human-Collaborative Robotics Challenge, we will implement functions to acquire passenger physiological information using small vital sensors that are their prototypes/deliverables, and integrate mobility with vital sensors. This will realize functions to perform gradual deceleration and safe stopping when detecting abnormalities in passenger physiological conditions, and automatically notify registered contacts.

We will continuously implement SW improvements and verification to enhance stability of each function, fix bugs, and improve usability.

Research and Development Plan: Implementation Items (4)

4. Cybernic Smart Mobility Verification:

• We will evaluate and verify basic performance as a vehicle integrating various hardware and software functions. We will conduct reliability confirmation through repeated operation tests, verification of passenger safety and comfort, evaluation of obstacle detection functions and appropriateness of avoidance actions.

• For demonstration experiment planning and preparation, we will plan driving experiments in actual fields within Tsukuba City, selected as a Super City (expected route connecting CYBERDYNE Tsukuba headquarters, Tsukuba City Hall, and IIAS Tsukuba shopping mall). We will collaborate with Professor Kenji Suzuki of University of Tsukuba, who oversees Tsukuba Super City, to receive advice on technical challenges in the real environment of public spaces in Tsukuba Science City and formulate plans.

• Demonstration experiments will be conducted efficiently by combining simulations in cyber space (digital space) with verification in real environments.

Research and Development Plan: Implementation Items (5)

5. Study of Social Implementation of Cybernic Smart Mobility:

• Based on data and insights obtained from demonstration experiments, we will organize vehicle specifications and related infrastructure requirements. We will extract technical requirements for vehicles supporting both human mobility and goods transportation, as well as broadly defined infrastructure requirements including charging facility placement, insurance systems, operation management systems, alignment with current regulations, and consideration of new legal frameworks.

• While implementing initiatives contributing to the formulation of safety standards for social implementation of new concept vehicles from this project and creating an environment conducive to social implementation and acceptance, we will conduct business model verification (economic feasibility study/verification) in demonstration regions, comprehensively organize requirements necessary for social implementation of Cybernic Smart Mobility, and achieve extraction of requirements for vehicles and infrastructure contributing to redesign.

R&D Structure and Partners

NEDO

Elemental technologies Development

R&D Coordinator and Contractor Organization: CYBERDYNE Inc.
Title: Representative Director & CEO
Name: Yoshiyuki Sankai **Location:** Headquarters (Ibaraki Prefecture, Tsukuba City)
Implementation Items: Study and implementation of next-generation mobility devices and infrastructure, etc. Design and implementation of demonstration experiments Extraction of service requirements for realizing values that next-generation mobility devices can provide

Collaboration Partners

University of Tsukuba
Professor Kenji Suzuki
As the architect of the Super City designation in Tsukuba City established in 2022, he possesses comprehensive knowledge of all systems within Tsukuba. Based on this, we will receive advice on understanding and utilizing potential within Tsukuba.

WILLER Inc.
In the demonstration field, we will collaborate in advance with WILLER, which is conducting commercialization of mobility services, obtaining insights on important findings that will contribute to commercialization, as well as advice on vehicle capabilities.

Other Collaboration Partners:

UTMS Association Consortium:
Collaboration related to signal information provision (planned collaboration from FY2027)
Other SIP (HCPS Human-Collaborative Robotics):
Trial use cooperation of prototypes of physiological data monitoring system.

Results and Progress: Basic Performance Requirements and Concept Development

FY2024 Implementation Item: 1-1. Basic Performance Requirements and Concept Development

Cybernic Smart Mobility is positioned as a personal mobility device that enables diverse users, including the elderly and persons with disabilities, to move safely and securely. This year, we developed the following concept:
- Transcending physical boundaries (outdoor/indoor, between floors)
- Transcending user boundaries (elderly, disabled, able-bodied)
- Transcending usage boundaries (human mobility, goods transportation)
- Transcending boundaries between cyber space and physical space (urban/building OS integration, simulation utilization)

To realize this concept, we established the following basic performance requirements:
- Capacity: 1 person (maximum)
- Load capacity: Approximately 100kg (+20kg cargo, or 120kg for cargo-only mode)
- Travel speed: Approximately 0-20km/h
- Operating time: Sufficient for daily use without major constraints (approximately 20km range)
- Vehicle weight: Under 30kg (enabling manual loading/unloading in passenger cars)
- Vehicle dimensions: Approximately 1,000mm×600mm×850mm
- Other features: Foldable, capable of both outdoor and indoor travel, able to use various elevators without requiring special equipment installation or human intervention

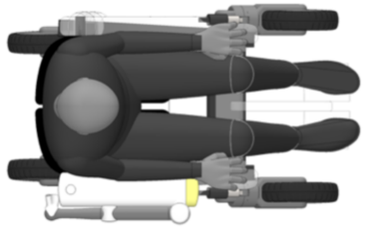
Results and Progress: Elemental Technologies Development

FY2024 Implementation Item: 1-2. Element Technology Development as Basic Performance Requirements and Concept Development - Mobility Function Verification

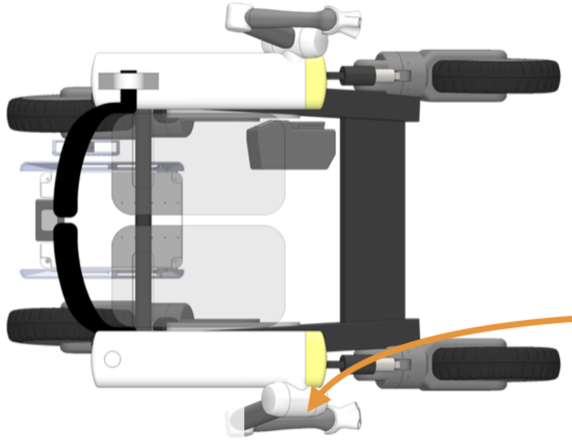
Verification of functions from high-speed mode to standing mode (including turning function verification) through manual transformation

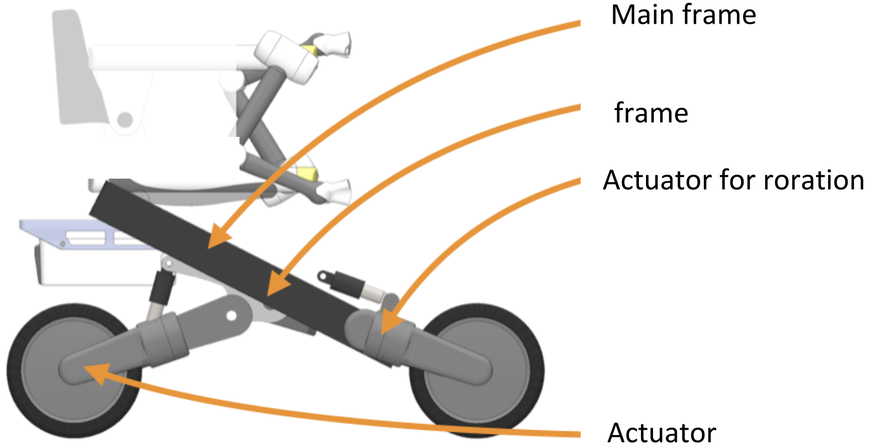
Mobility Function (Drive Unit Function/Turning Function) Verification Prototype

Concept design



Top view



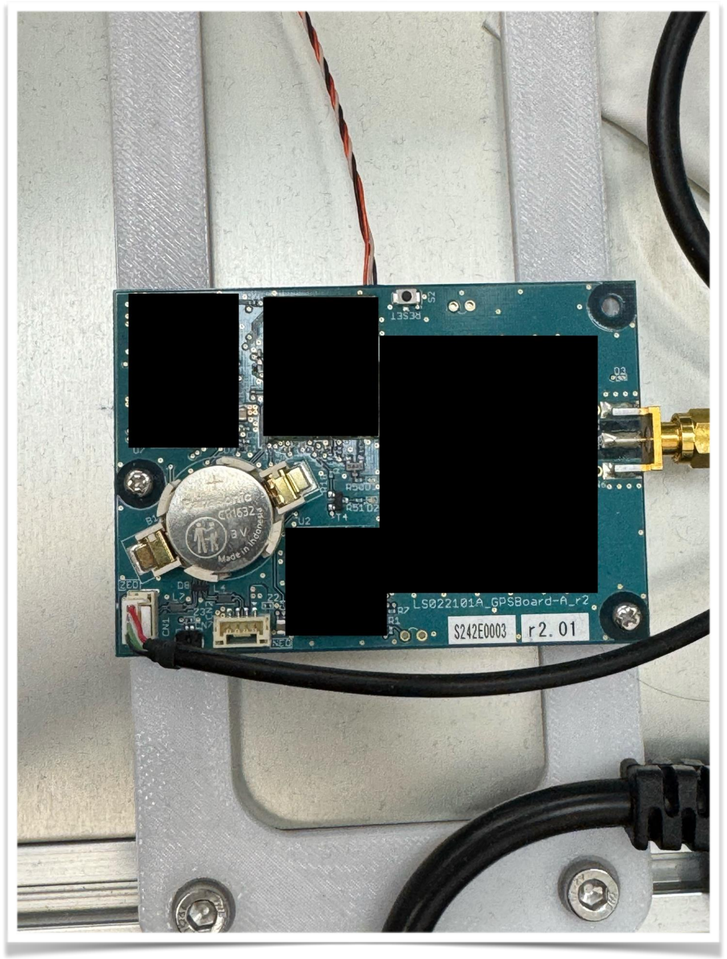


Side view

Design of LiDAR and camera placement positions enabling detection of "obstacles on the ground, close-range obstacles, and obstacles at mobility's height"

Results and Progress: Elemental Technologies Development

FY2024 Implementation Item: 1-2. Element Technology Development
- Centimeter-level Positioning Antenna, GPS/GNSS L6 Processing Board



processing board and GPS/GNSS antennas (L6 band signal processing/latitude, longitude, elevation, speed, etc.)

GPS/GNSS antennas

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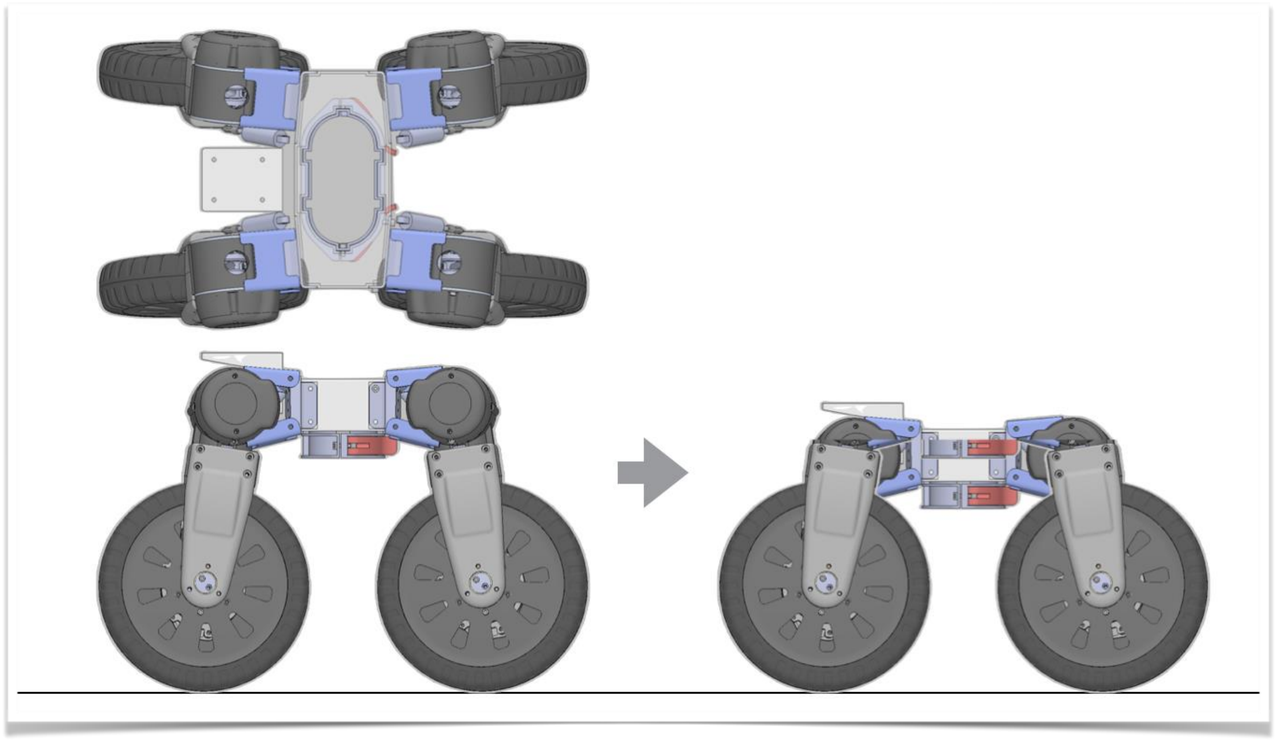
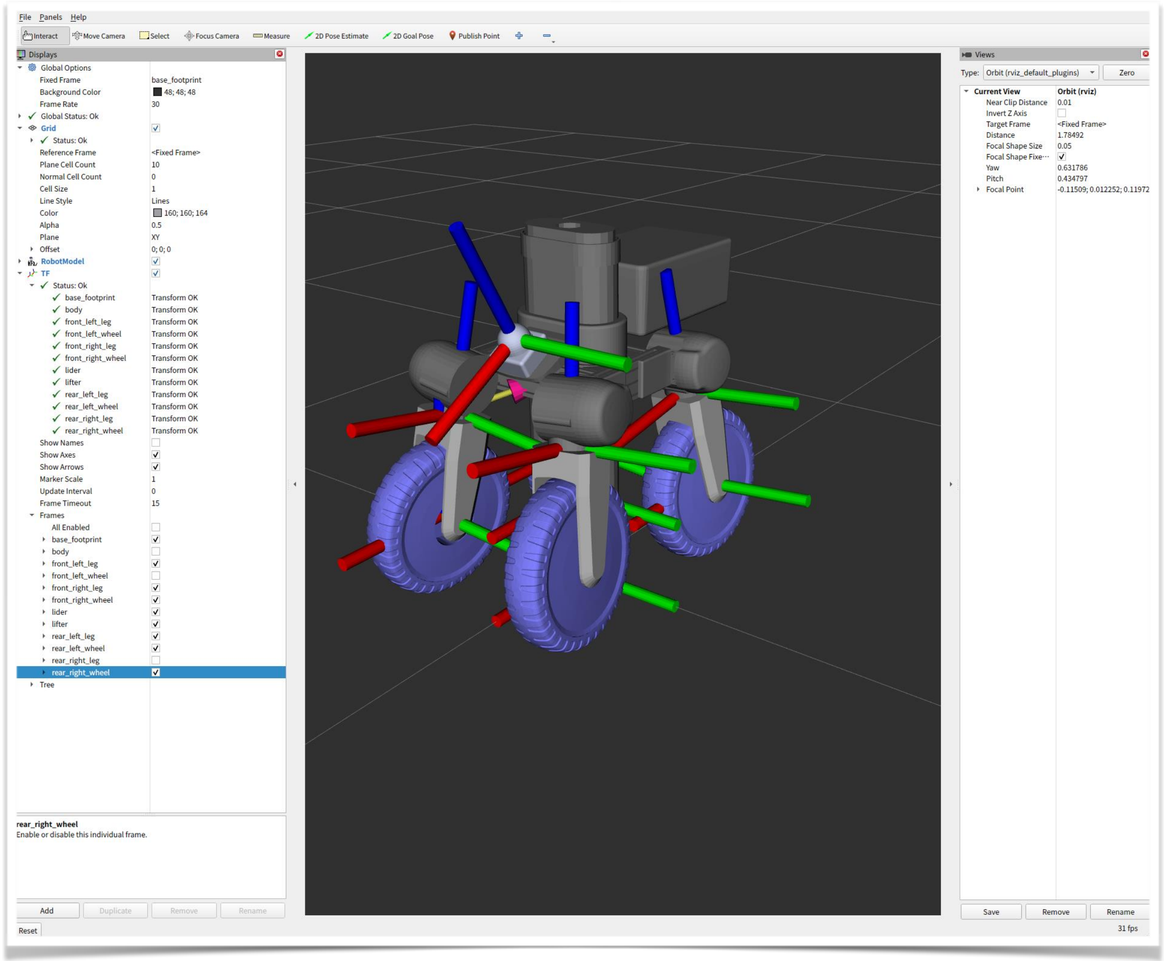
Results and Progress: Elemental Technologies Development

FY2024 Implementation Item: 1-2. Element Technology Development
- Steering, and Software Verification Visualization Simulator



Steering Structure/Mechanism Study



Software Verification
Visualization Simulator

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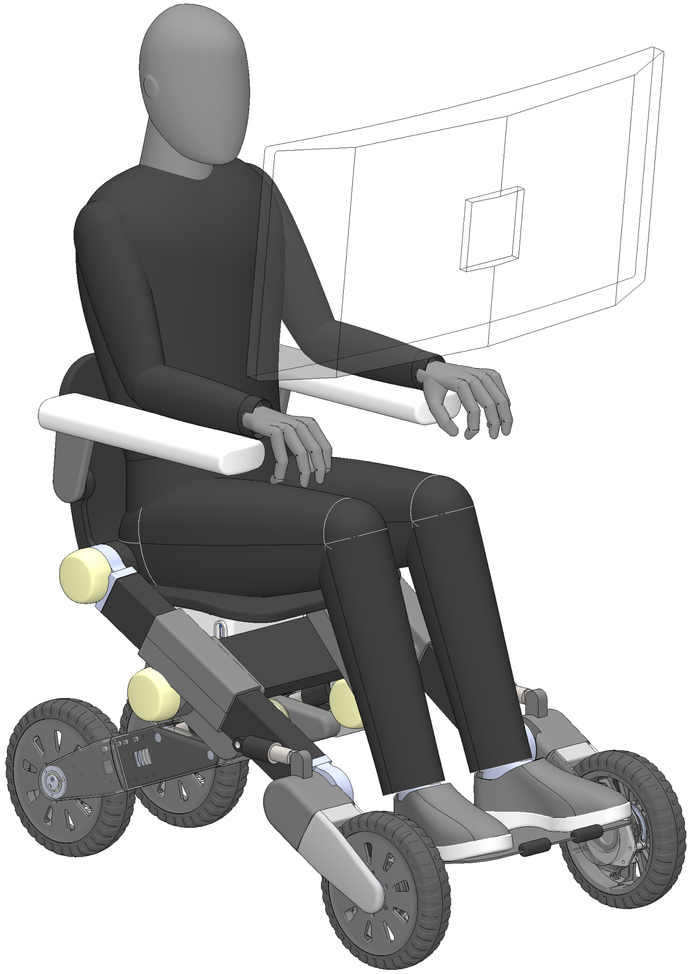
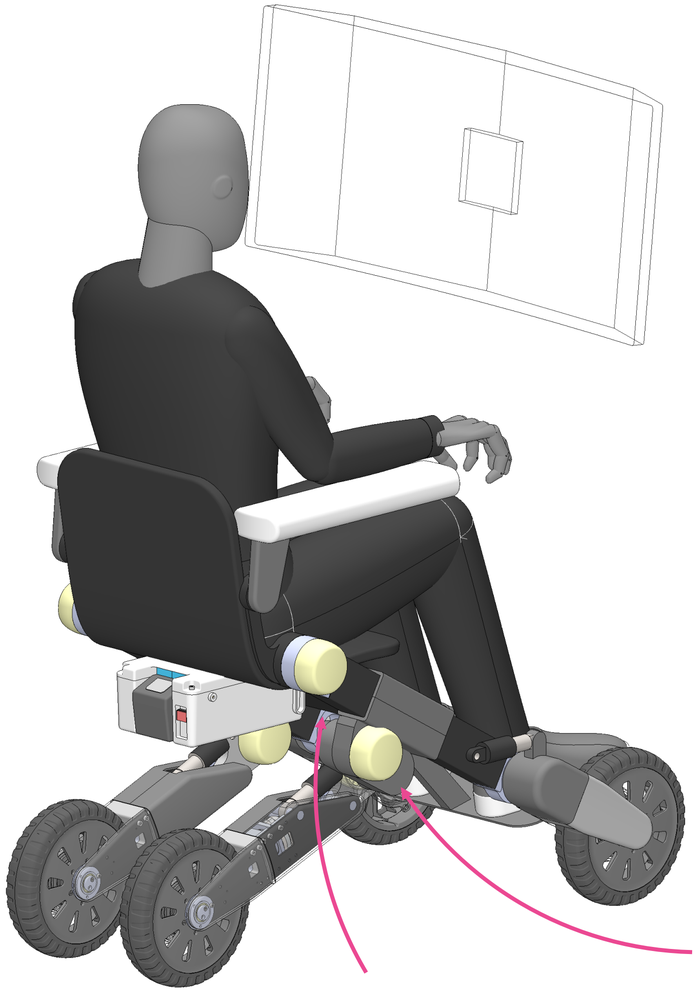
Results and Progress: Elemental Technologies Development

FY2024 Implementation Item: 1-2. Element Technology Development - Transformation Function Verification

（Verifying automatic transformation function via switch input）

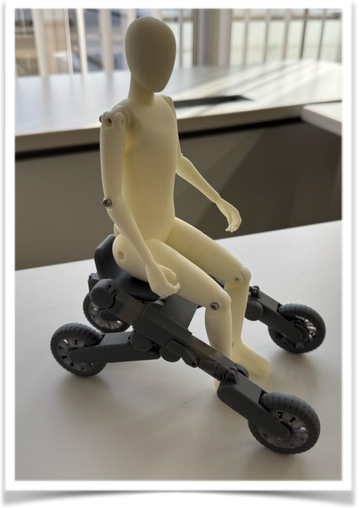


Transformation Function
Verification Prototype



Transformation Actuators
（for changing seat angle in
Standing mode）

Transformation Actuators (for moving rear wheel position)

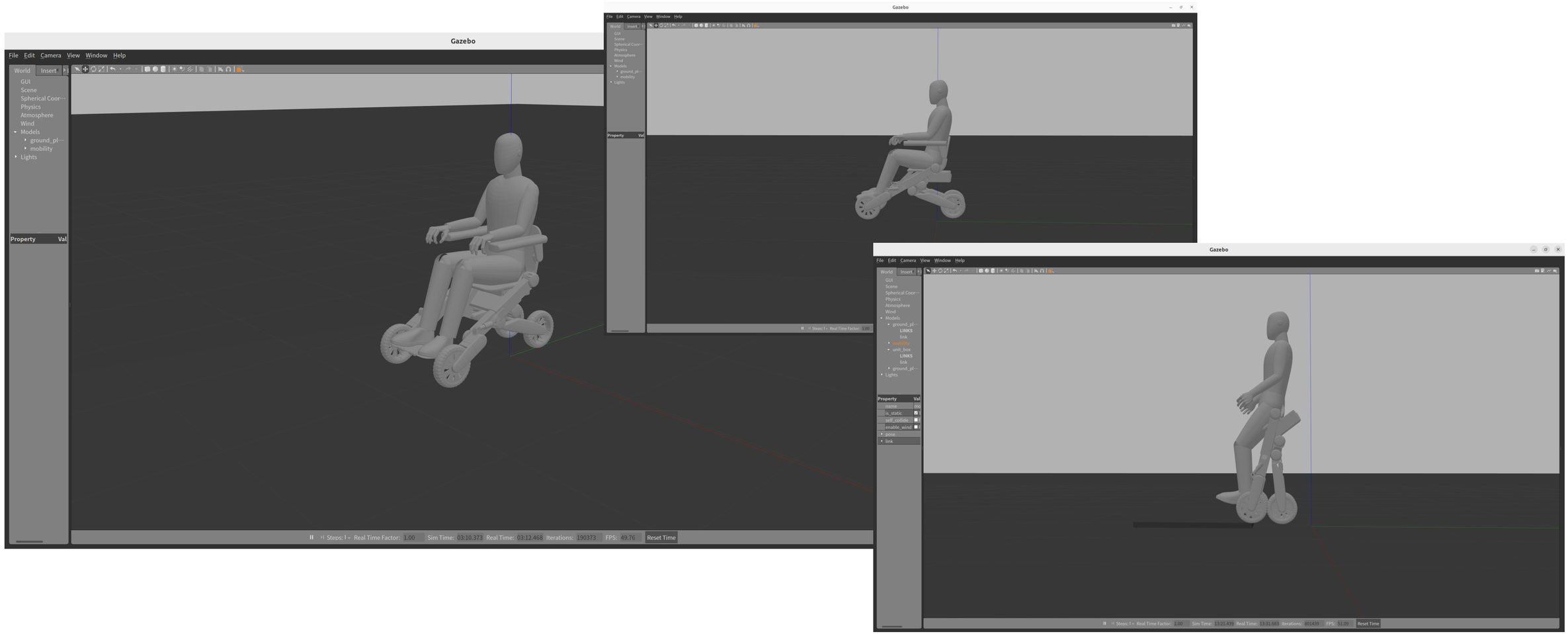


1/6 scale rapid prototyping model and transformation function verification prototype

Expected Loads:
Passenger: Maximum 100kg
Cargo: Maximum 20kg
Vehicle: Maximum 40kg

Results and Progress: Elemental Technologies Development

FY2024 Implementation Item: 1-2. Element Technology Development - Physical Simulator



Physical Simulator (Gazebo, ROS2): Verification of floor friction, step climbing, braking distance, and transformation function confirmation with actual torque

Results and Progress: Demonstration Experiment Planning and Preparation

FY2024 Implementation Item: 4-2. Demonstration Experiment Planning and Preparation (User Review Plan, Field Selection, etc.)

We formulated experimental plans and selected fields for Cybernic Smart Mobility demonstration experiments. The demonstration experiments aim not only to verify the effectiveness of developed technologies but also to identify challenges and explore solutions for social implementation.

User Review Plan: for elderly and disabled persons

- Target: Elderly facility residents, facility care workers, etc.
- Method: Demonstrations and test rides using actual equipment, questionnaire and interview surveys
- Evaluation items: Riding comfort, operability, sense of security, convenience, desired improvements, facility operation, introduction benefits.
- Implementation period: Planned for Q3 FY2026

Prior to evaluation by elderly users, we will conduct preliminary evaluation by staff at facilities where the elderly reside to confirm safety and appropriate usage methods.

Demonstration Field Selection:

1. CYBERDYNE Tsukuba Headquarters and surrounding area:
   - Purpose: Basic performance verification of seamless indoor/outdoor movement, elevator use, goods transportation functions, etc.
   - Characteristics: Managed private land environment suitable for initial demonstration
   - Implementation items: Basic mobility function testing, transformation function testing, autonomous driving testing, elevator integration testing.

2. Tsukuba City Hall and surrounding facilities:
   - Purpose: Practical verification of manual operation (with obstacle detection function) and autonomous driving through public facilities, outdoors, and surrounding facilities (shopping malls), mobility support for elderly and disabled passengers
   - Characteristics: Includes public facility interiors, outdoor areas, and surrounding facilities, enabling verification in actual usage scenarios
   - Implementation items: Inter-facility mobility testing, evaluation testing by elderly and disabled users, cargo transportation testing

We are planning comprehensive demonstration experiments within Tsukuba City, including routes connecting these fields. Through collaboration with Professor Kenji Suzuki of University of Tsukuba, who oversees the Tsukuba Super City Special Zone, we will ensure demonstration experiments align with the Super City concept.

Status toward Social Implementation: Considerations Related to Regulatory Development

(Plans to begin discussions on legal systems from the timing of Implementation Item "5-2. Study and Proposal of Standardization for Social Implementation." Internal business discussions in FY2026, followed by discussions with relevant ministries and industries in FY2027 based on demonstration experiment results)

1. Legal Positioning Study: To enable this mobility device to operate on public roads and sidewalks, we will organize legal category classifications and maximize utilization of existing regulatory frameworks. If creation of a new specific small vehicle category (e.g., category with output greater than 600 watts) becomes necessary, we will consider it. If special zone systems such as Smart City/Super City can be utilized, we will also consider utilizing special zone systems.
2. Safety Standards Formulation: We anticipate the need to formulate safety standards according to vehicle maximum speed and weight. We will identify gaps with related regulations regarding requirements such as lights and turn signals for this redesigned new vehicle, minimum distance from pedestrians, etc., leading to recommendations.
3. Environmental Preparation: If certification systems for new mobility categories are needed, we will provide insights at international conferences and support standards development related to safety based on data obtained from demonstrations, implementing initiatives that contribute to creating an environment conducive to social implementation and acceptance.

Status toward Social Implementation: Considerations for Social Implementation

1. Model Case Demonstration: We plan to conduct demonstration experiments in Tsukuba City's Smart City/Super City field. We will establish use cases such as safe and secure mobility support for elderly facility users and care workers, as well as goods transportation using the vehicles.

2. Stakeholder Collaboration: We will build a cooperative framework for social implementation by consulting and conducting preliminary discussions about this project with Tsukuba City Hall, Tsukuba Smart City Association (in which we participate), police, Ministry of Land, Infrastructure, Transport and Tourism, and others. We will seek consensus on safety management and usage rules to create an environment for smooth demonstration implementation.

3. Evaluation and Deployment Planning: We will analyze data and user responses from demonstration experiments (user reviews) and reflect findings in technical and operational improvements. Furthermore, based on demonstration results, we plan to consider service provision systems and business models for full-scale introduction, concretizing a roadmap to social implementation.

Status toward Social Implementation: Roadmap for Demonstration Experiments

1. Field Testing Commencement: In FY2025, we plan to conduct basic performance tests (field reviews) within Tsukuba City. We will prepare operations including placement of safety management personnel and formulation of emergency response procedures.

2. Stage Gate: Several months after beginning basic performance tests, we will conduct evaluation based on collected data and user questionnaire results. We will evaluate technical achievement levels (e.g., sensor accuracy, driving stability) and satisfaction from expected users, organizing subsequent development challenges.

3. Expansion to Next Phase: Reflecting insights from initial basic performance verification, we are considering expanding demonstration areas and increasing the number of operating units from FY2026 onward. We will continue to verify challenges such as coexistence with other vehicles in public spaces and operational costs, taking steps toward future full-scale service launch.

Status toward Social Implementation: Business Roadmap

FY2024: Project launch. Concept design completed and prototype Unit 1 development initiated. Development structure established based on NEDO contract.

FY2025: Basic performance testing begins with prototype units, stage gate evaluation conducted. Technical improvements continue, decision on project continuation/expansion. Draft business strategy formulated.

FY2026: Full-scale development phase toward productization. Mass production design and manufacturing partner selection begin. Business model and service system considerations for market introduction advance.

FY2027: Pilot introduction and business preparation. Full-scale service trials in demonstration regions and pilot deployment in additional regions conducted. Establishment of commercial operation systems including user response flows and maintenance networks.

FY2028 (Post-SIP): Summarize R&D results and finalize business plan. Aim for commercial service launch (product release/service provision start) after project completion, with final roadmap confirmed among stakeholders.

LEAP | 9-12 Feb 2025

Information dissemination at LEAP 2025 in Riyadh, Saudi Arabia, where numerous government officials and technology company representatives gathered under the theme of "Smart Cities" including smart mobility initiatives

Cybernic City: An innovative future where Humans and AI-Robots live in Health & Harmony

Yoshiyuki SANKAI
CEO & President - CYBERDYNE Inc.
Professor - Univ. of Tsukuba, Japan
Program Director - SIP, Cabinet office of Japan

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MINISTRY OF COMMUNICATIONS AND INFORMATION TECHNOLOGY

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Cybernics fusion of human, machine and information systems
革新的研究開発推進プログラム ImPACT

LEAP 2025
— Into New Worlds: Smart City —

CYBERDYNE
SIP

11th Feb., 2025

Challenges for the Future !

Cybernic City: An innovative future where Humans and AI-Robots live in Health & Harmony

～ toward the "Cybernic Health Society" ～

筑波大学 サイバニクス研究センター

Social Innovation: Society 5.0/5.1

"Cybernics" : Fusion of "Humans"+"AI-Robots/Information systems"
Cybernics improves, regenerates, complements and empowers human's functions.

Sankai Y.

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Outreach activities