Kawasaki
Powering your potential

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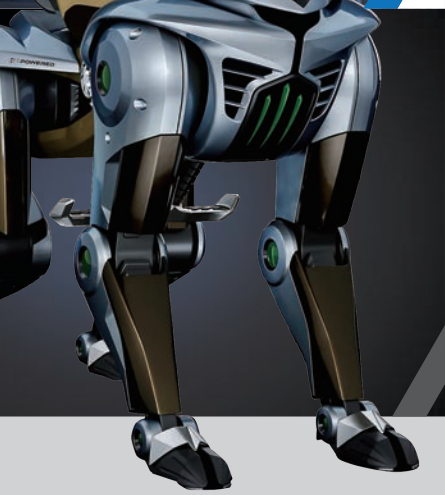
KAWASAKI TECHNICAL REVIEW

Special Issue on 2025 Expo Osaka, Kansai, Japan



TECHNICAL REVIEW

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(Expo 2025)

KAWASAKI TECHNICAL REVIEW No. 187

Interviews

Theme of the Exhibition

Message from President and CEO

Present a dream, unite technologies

Taking up the challenge of showcasing our commitment to “Changing Forward” at Expo 2025

Yasuhiko Hashimoto

Representative Director, President
and Chief Executive Officer

Uniting various technologies, and envisioning a thrilling future

When the company decided to participate in Expo 2025, I requested the project team to “present an inspiring future vision by bringing together Kawasaki’s technologies.” And when I saw the finished exhibits for the first time, I was instantly captivated, even wishing to own one personally. It was a fabulous presentation of a future vision based on the inspiring theme of “Impulse to Move” and covering Kawasaki’s full range of technologies. I am very proud of the team members and others who have contributed to this remarkable feat, and also appreciate them for making me recognize that we have huge possibilities to fulfill our potential.

Committed to two goals since assuming the presidency

Since becoming the president in 2020, I have been committed to addressing two major issues.

The first is related to technological synergy. Back in the earlier days, I had noted the situation of Kawasaki that could be referred as conglomerate discount, an oft-heard term of the time, meaning that diversified enterprises promoting many businesses independently rather than establishing an organizational structure favorable to forming beneficial collaborations and synergy, were undervalued. To address this situation, we defined three business domains to pursue synergistic effects in line with the group vision, and based on this, we have been striving to combine our various technologies effectively while aiming at future goals. Setting a future vision is important in order to make meaningful use of each technology and unite a constructive team.

The second is to promote market-in strategies with a view to solving social challenges. For example, new suggestions for developing robotic nursing technologies would be accepted favorably by many customers. Previously, our approach to making such suggestions were based on currently available technologies, posing limitations in marketing, however. To break through the limitations, we should go one step further to propose cooperation in creating a new future solution, seeking to attract supporters and would-be partners.

Pass on Kawasaki’s new strong DNA to future generations

Our Expo 2025 exhibits CORLEO and ALICE SYSTEM embody our ongoing goal of achieving technological synergistic effects by promoting cross-company cooperation while addressing social challenges looking to build a new future. CORLEO is a personal mobility system that can expand human access to mountainous areas that was previously limited to those with specialist skills. The development of this technology required delicate technical sensitivity for off-road travel as well as robotics and hydrogen technology for power supply. It covers Kawasaki’s full range of technologies, which is worth a perfect score. In addition, I’d like to praise the team’s persistent design efforts to create an attractive appearance, which plays a key role in increasing emotional appeal. The team’s design policy to place emphasis not only on functions but also on the appearance will convey an important message to promote Kawasaki’s future activities.

ALICE SYSTEM is a technology for a future public transportation system targeting people with difficulties in mobility in various ways, including due to aging. I’m confident that ALICE SYSTEM has offered a solution to the desire of such people to eat and discover new things, by effectively applying our technical capabilities in land, sea and air transportation. Actually, we have received favorable feedback from quite a few politicians, including demand for early social implementation.

Also, at the venue, we confirmed positive responses from general visitors, like “CORLEO is pretty huge, and looks handsome” and “I like the first-class like equipment of ALICE SYSTEM with movable armrests.” These have been made possible by the development team’s strong commitment to the value of offering a thrill and comfort. This constitutes Kawasaki’s new development axis to build on.

This is related to our forward-looking mindset as a technology provider, which is to: focus on real needs of society and suggest a best possible solution, regardless of present technical limitations and looking to the future; and form new technical ideas, lay out and carry out plans to realize them while seeking capabilities to fill up deficiencies to achieve innovations. This mindset was demonstrated notably when the world was challenged by the COVID-19 pandemic. Wishing to do something helpful for the situation, a volunteer group of employees proposed launching a project to create an automated robotic PCR testing system, which had to be developed from scratch by the team lacking the necessary knowledge. The recent expo provided a good opportunity to enhance this mindset, which I hope will grow into a strong DNA to pass down to the future of Kawasaki.

World exposition is to present future dreams

I was one of many Japanese children who were fascinated by Expo 1970 and aspired to becoming an engineer. I remember a number of popular exhibits such as watches equipped with television and telephone features, which grabbed my heart, fueling my passion in those days for popular science fiction animation television series, specifically Tetsujin 28, Astro Boy, and Super Jetter. My dream was to live in a world where people live with robots as family members, and had a strong wish to make robots like Astro Boy. So I aspired to a career as an engineer, and this aspiration has been driving me forward to this day.

The mission of the world exposition, I believe, is to present future dreams, particularly to children. The event’s futuristic exhibits should be able to inspire their interest in engineering and inventive activities. Some of such children may become engineers, like me, and some may possibly become interested in our exhibits and consider joining Kawasaki in the future to make their dream a reality as a member of our team. Therefore, it is vitally important to take the opportunity afforded by an expo to present a dream vision and encounter different thoughts and technologies, aiming to innovate new things for the future. And we should continue with such endeavors, I hope, to be able to fulfill our potential to make a revolutionary advancement.

Look beyond Expo 2025

Our Expo 2025 project will not terminate with the end of the world event. Instead, we will continue with relevant activities to be able to deliver real-life products, which is important for the benefit of society, the company, and project team members especially for the purpose of self-fulfillment. In fact, we have received requests to accelerate the development schedule, the target of which was 2050. To accommodate such market responses, we will need to build appropriate commercialization processes while promoting public announcement of the progress even before completion.

In order to make something like a dream a reality, we need to use not only internal but also external resources. For this reason, we have opened the co-creation platform KAWARUBA, where a number of companies have already begun to work together, bringing their respective technical capabilities, to accomplish common goals to create new value. Before that, however, the company should first respond to a sizable number of its personnel expressing a strong willingness to undertake new innovation challenges. The company should provide an opportunity for such personnel to promote activities, on a voluntary basis, to make their dream-like plan a reality, and build appropriate systems to allow them to continue with the activities to achieve goals. I think this is a major role of the management.

We believe it is important to explore various possibilities to solve social issues, regardless of the current production capability and technology availability, and continue with relevant efforts. This policy, as practiced through participating in the recent expo, is essential to creating new innovations on an ongoing basis.

Exhibition Overview

Review of behind-the-scenes details of Expo 2025

“Kawasaki Future Mobility” generated huge buzz, with 100+ million views on social media

Takashi Torii

General Manager,
General Administration Division and Group Manager,
Corporate Communication Group

Start by leading the three-company co-creation project

Expo 2025 represents the second time this international exhibition is hosted by Osaka, with the previous one held 55 years ago in 1970. Headquartered in Kobe, a major city in the same region, Kawasaki was willing to contribute to the success of the planned event, and also take the opportunity to participate in the world’s fair as an exhibitor to showcase the company’s vision of the future.

Kawasaki received a request from Japan Association for the 2025 World Exposition to participate in the exhibition co-hosted by 12 companies in the Future City pavilion, and by accepting the request, the company officially decided on its participation in Expo 2025. Within the Future City exhibition, Kawasaki, jointly with Mitsui O.S.K. Lines and Kansai Transmission and Distribution, took charge of the Transportation and Mobility category. Being eager to achieve an outstanding and crowd-wowing presentation and noting the need for effective co-creation efforts for this purpose, we visited the two partners to directly hear their opinions.

We found that each company had an independent exhibition plan, giving rise to a fear that a joint presentation under the single category would likely lack an appropriate sense of unity. To address this issue, we reconsidered the exhibition floor layout plan provided by the Association and proposed a new plan. We also discussed with the two co-exhibitors to explore a host of possible measures for beneficial cooperation, such as making efficient use of the space to install a large screen monitor for shared use, and collaborations for construction and operation efficiency. Those efforts were similar to those being promoted at Kawasaki’s collaboration park KAWARUBA opened within the site of Haneda Airport. Like participants in the park, the three companies shared the common goal of delivering a successful Expo 2025 exhibition and worked together toward the goal while ensuring close cooperation with each other. As a result, our exhibition was able to produce a distinctive feeling of unity befitting the category theme, helping make it the most successful in the pavilion in terms of drawing public attention.

Background behind the decision on the theme of “Impulse to Move”

Within the company, a special taskforce was formed with about 50 members participating on a voluntary basis, and it began to discuss what constitutes “problem-solving future mobility.” Numerous opinions were expressed and collected to search for key terms, among which we took particular note of what could be phrased as “redefinition of being rich.” Values of happiness and richness change along with the times. So, in order to think about future mobility, we recognized the need to define what it would mean to be rich in the future. Based on this recognition, we continued additional discissions, and encountered research articles published in the U.S. that discussed the theory that humans are predisposed to derive happiness from the act of moving. Simply put, the human brain is genetically programmed to feel happy in response to the act of moving. This could mean that for a human being to have freedom of movement constitutes being happy, and an eternal form of being rich. This thinking gave us a significant suggestion for the direction of continued discussions. That was where we began moving toward determining the exhibition theme of “Impulse to Move” and working out plans for creating future mobility models to fulfill the human impulse to move.

Showcasing manufacturing capabilities and technical basis

For giving shape to ideas for creating “future mobility models to fulfill the impulse to move,” we decided to follow two different paths leading to the personal and mass transportation mode. Technical proposals were prepared accordingly to create three systems — CORLEO for personal mobility, ALICE SYSTEM for mass mobility, and O’CUVOID, hydrogen power generator to power the two mobility systems, a plan to be implemented by utilizing Kawasaki’ technological development capabilities for using hydrogen as a hopeful next-generation energy source.

Many interesting ideas were discussed in the company. For ideas on the table to be adopted, they needed to have a technical basis, following the most essential policy as a manufacturer to showcase its technical strengths. Therefore, we requested engineers in the fields of land, sea and air transportation, as well as motorcycle and robotics, to participate in development activities in order to create implementable design drawings and specifications by actually drawing designs and conducting calculation.

Adopt life-size display style highlighting the unique character of Kawasaki

We adopted the life-size display style according to the company’s exhibition related policy. This is based on the insights gained through running our corporate museum Kawasaki Good Times World. Take for example the exhibit of the real 0 Series Shinkansen train car. Just sitting in the real car is a special “experience,” allowing many visitors to have a good time enjoying new sensations and recalling old memories of traveling. Using the real thing on display is quite a simple exhibition style, but it should be noted that being real is an essential element of the experience value. This is what we have found from operating Kawasaki Good Times World over 20 years. Based on this finding, we chose to adopt the life-size display style for the Expo 2025 exhibition, which we believed and expected would stir the imagination of many visitors.

Effect of participating in Expo 2025 on corporate value

The recent expo exhibition project included the voluntary participation of many employees, thus allowing them to increase their sense of pride and satisfaction with the manufacturing business. In fact, many participating employees reported feeling happy to see their families enjoying the exhibits, receive media attention and hear feedback directly from visitors in person. I noticed a remarkable improvement in their engagement and motivation.

I also noted that, by engaging in the Exo 2025 project, team members have built new skills, to a significant extent especially for project management. Management of projects with very few specific design requirements, like the recent exhibition, often becomes difficult due to budget inflation. I advised them to try to keep expenses below 90% of the budget, seeing them struggling to make the project a success on a cost-benefit basis with a tight budget and schedule and despite a lack of experience in this kind of work.

Pursue revolutionary concept-based approach, producing unprecedented achievements

The promotion video of CORLEO has received more than 100 million views in one week on social media, while drawing a lot of responses from around the world. This is largely thanks to the pre-launch strategies characterized by staged release of preview information on planning and exhibits and promotional clips featuring the image of the rider barreling across the landscape astride the vehicle, which aimed to build anticipation and momentum. The marketing strategies for ALICE SYSTEM were also successful, chiefly due to intuitive video descriptions of its mechanisms. Additionally, we conducted pre-event activities by sending instructors to local elementary and junior high schools to hold workshops, looking to encourage conversations on this topic.

Particularly for the recent project, we chose to adopt a revolutionary concept-based (“Impulse to Move”) innovation approach, while avoiding our long-established technology-based incremental innovation approach. I consider this successful attempt to forge a new path as a factor bringing about an unprecedented achievement. I hope this successful result will open up new possibilities for Kawasaki’s growth.

Technical Overview

From “Concept” to “Co-creation”

Design philosophy for emotional inspiration to create the future

Yoshimoto Matsuda

President, Precision Machinery & Robot Company
In charge of Hydrogen Strategy
Presidential Project Management

To be meaningful, it must be fun

I was engaged in the Expo 2025 exhibition project as concept and design director. While primarily striving to fulfill my responsibilities to ensure the presentation would effectively convey appealing and memorable messages to visitors, I was also trying to enjoy myself using that precious opportunity, according to the statement: “To be meaningful, it must be fun.” This is no spur of the moment kind of thing. Rather, it is a life motto I have cherished over the years while building careers in the fields of education, theater, painting, robotics, motorcycles, and hydrogen technology.

Everything is for the good of children for the future

In the past, I pursued in earnest a career in theater, forming a theater company, writing plays, directing stage plays, and appearing on stage. So, I have a very strong passion to make work “emotionally inspiring.” This background, I guess, may have been behind my assignment to the directorship of the Expo 2025 project.

Upon assuming that role, I decided to give primary consideration to general visitors, rather than professionals and specialists. “Our exhibits must wow families and children to grab their hearts and minds.” That emotional experience may not necessarily make many children immediately begin to dream of becoming an engineer, but at least can pique their interest in doing creative activities, which may lead to their future aspiration. This is how we determined the overall direction to take for developing the exhibition project.

Our exhibition theme is phrased as “Impulse to Move,” and this encapsulates the essence of our message. It is associated with my belief that humans are predisposed to derive irreplaceable inspiration from kinetic activity as well as public concerns about the recent rapid evolution of AI technology, giving rise to a fear of it outperforming humans in the future. In what areas can humans essentially outdo AI? I asked myself this question and found the answer, which is ”moving.” Humans are able to move to many different places and environments, seeking to experience and discover new things and get inspiration from them. This constitutes the very unique value of human beings, in terms of which AI is no match for humans.

Integrate sensitivity (side A) and reasoning (side B) to deliver inspiring experiences

The design concept of the Expo 2025 exhibition was developed centering around the two axes represented by sensitivity (side A) — intuitive and emotional appeal — and reasoning (side B) — convincing technical basis. We aimed to deliver genuinely inspiring experiences by integrating the sides A and B.

Side A: Emotional appeal of design

For the purpose of designing futuristic mobility models like CORLEO and ALICE SYSTEM, it is important to place greater emphasis on ensuring an appealing look than engineering functionality. To design the two exhibit models according to this policy, we entrusted the relevant tasks to the motorcycle design team, a function that excels in intuitively presenting an attractive appearance and a strong sense of presence.

To be honest, I myself was initially skeptical about the design idea of ALICE SYSTEM. It just did not hit me right. However, I was impressed by the team members’ strong passion and changed my attitude in order to appropriately respond to their passion. It was because I noticed that I should display leadership sensitivity by giving trust to the value the members were seeing even though I was not. That recognition was a major lesson I learned from interactions I had with the project team members. And I am glad seeing their efforts resulting in a good interactive exhibition.

Side B: Convincing technical and conceptual basis

Also, when something is inspirational, it must have a convincing technical basis — the principle of side B. This principle was embodied by O’CUVOID, a technology for a decentralized hydrogen power generation system with units swappable and supporting parallel connection. With the lightweight body, easy-to-maintain system, and affordable costs, this model is a realistic proposal.

We put particular emphasis on establishing a convincing technical basis that could satisfy the rigorous standards of professional engineers and industry representatives. For this purpose, we drew on our strategic hydrogen technologies developed over many years. I believe this was a reason ALICE SYSTEM has been accepted as a realistic future technology rather than being dismissed as a wishful dream story.

Kawasaki-style Sagrada Familia Concept — Exhibition for co-creation platform

I think the exhibits should be a proposal for the future rather than just products exhibited at the expo. The exhibits are a “blank canvas” for viewers to fill by responding to the relevant proposal, providing a source of future creations.

This view was inspired by a visit to the Sagrada Familia in Barcelona, Spain, in my younger days. The world-famous church has not been completed, giving a blank canvas for supporters from around the world to fill, forming something like a platform for co-creation. Subsequently, I visited the church a number of times, and confirmed the steady progress of construction each time. This is where I got the idea for a future kotozukuri business model.

These experiences have been reflected in the creation of KAWARUBA, a co-creation hub opened by Kawasaki on the site of Haneda Airport to invite researchers, engineers and designers from inside and outside of the company to strive for advanced prototype development.

CORLEO and ALICE SYSTEM evoke a feeling of strangeness and incompleteness, which was created intentionally in order to provide a “blank canvas” to be filled by future efforts. I hope this blank canvas, like the Sagrada Familia, can spark imagination to promote future creations and provide centripetal force.

Realistic hydrogen strategies and mobility functions

One of the biggest challenges facing hydrogen adoption today is the classic “chicken-and-egg” dilemma: hydrogen is too expensive because there’s not enough demand, and there’s not enough demand because it’s too expensive. As a solution to this situation, we are offering “hydrogen-ready” products, a viable option that can accommodate a full range of implementation from 1 to 100 percent.

In this context, we are promoting hydrogen use in the mobility sector to provide a breakthrough. In doing this, we are capitalizing on our past experience in developing electric motorcycles and hybrid vehicles while overcoming challenges by first confirming individual capacities and then spurring organizational capabilities. At present, we are proactively seeking to collaborate with automakers in Japan and overseas.

Present proposals that can spark worldwide interest

The technology of CORLEO, ALICE SYSTEM, and O’CUVOID is not simply for the sake of industrial production. Instead, it implies a proposal for the future and a design blueprint for co-creation.

Going forward, Kawasaki will present itself to the world as a provider of co-creation platforms, which is more than just delivering finished products. Present new proposals constantly, seek partners who share our passion, and shape a future together. Unite all these elements — dream-like ideas and solid technical capabilities, sensitivity and reasoning, and individual capacities and organizational capabilities. We will pursue these endeavors as a “designer of inspiration.”

184 days of Thrills

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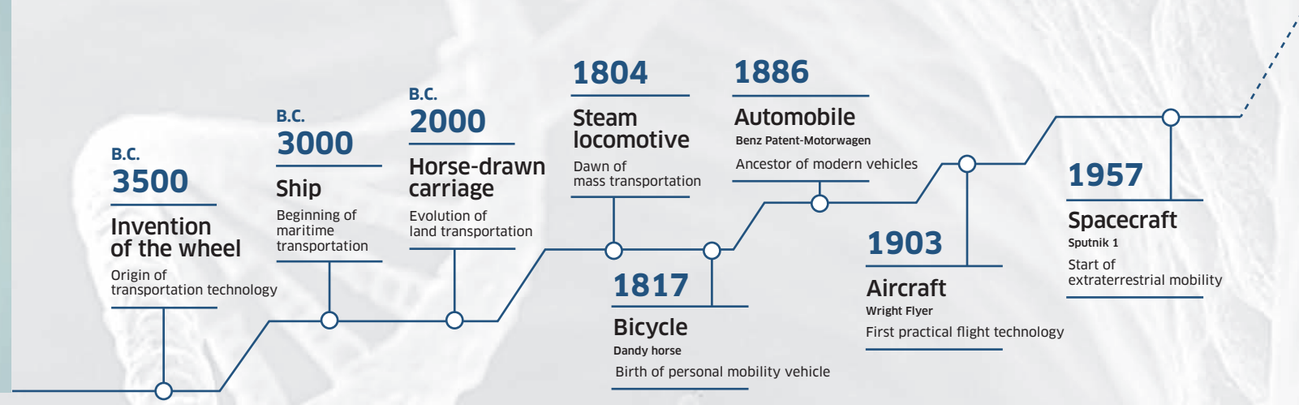
Theme of the Exhibition

Exhibition Theme: Impulse to Move

The human impulse to move evolves society



Setting the exhibition theme

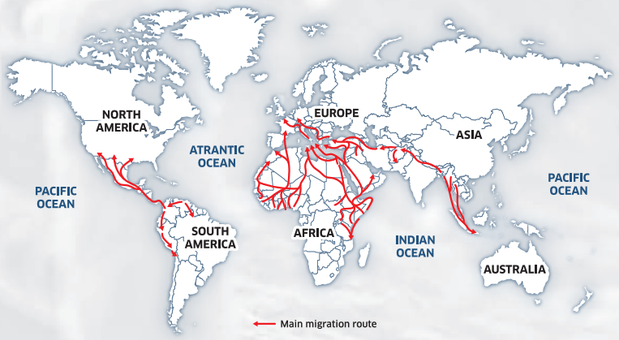
The theme of the exhibition was determined by considering two major requirements:1. to align with the grand theme of Expo 2025 “Designing Future Society for Our Lives” and the theme of “Transportation and Mobility” category within the Expo’s “Future Life Expo: Future City” showcase project; and 2. to befit the character of the Kawasaki Group boasting its more than 120 year history of providing mobility functions for social infrastructure. As an exhibitor in Expo 2025, we were responsible for clearly conveying universal and fundamental messages evoking a sense of anticipation for hopeful future lives. We began discussions by asking questions like “How does mobility occur?” and “Why do people move?” We continued with explorations seeking for the answer, and encountered the key term “impulse to move” while also learning about academic theories stating that the act of moving has been an integral part of humanity since the dawn of history and it is something like an instinctive impulse rooted at a deep psychological level rather than simply a function for survival. This article provides the relevant background descriptions by shedding light on three aspects — occurrence of the human impulse to move; history of evolution of mobility associated with the impulse; and the future of the act of moving and mobility — while referring to related academic findings.

Occurrence of impulse to move

Since ancient times, humans have been constantly moving for various reasons, principally looking for food and water, in response to changes in the climate and environment, and out of curiosity about the unknown. Dr. Chuansheng Chen at UCI stated in his report that, compared by ethnicity, the distance of migrating out of Africa, thought to be the place of origin of humankind, is positively correlated with the percentage of carriers of certain genes. In the generally accepted model, the human species originated in Africa about seven million years ago. Basically, early humans were nomadic hunter-gatherers. As moving was a crucial means of survival, they constantly changed location, in search of prey and according to the transition of the seasons. Around 60 thousand years ago, humans began to migrate out of Africa to populate the rest of the world, mainly in Eurasia, Oceania, and the Americas. It could be assumed that during the course of the extended duration of its evolution, humankind had developed an instinctive impulse to move slowly on a genetic level. Within the entire history of humanity, it is only very recently, several thousand years ago, that a settled way of life began. Given this model, we could think that the act of moving is an inherent aspect of humanity and fulfilling the related instinctive impulse helps fulfill human life.

We also searched the latest brain science research results, and discovered an article written by Dr. Aaron Heller at the University of Miami, which stated that humans are predisposed to derive happiness from the act of moving, and the longer the distance, the greater happiness. This finding was the result of a long-term survey of people by combining migration tracing and emotional assessment processes, and brain imaging analysis revealing that humans’ daily kinetic activities have effects in increasing their positive feelings. Specifically, actions with a high degree of exploration, such as accessing new locations, can promote activity in the brain region responsible for a feeling of happiness. This suggests that humans have an innate desire to move, and satisfying it is a major reason for global-scale human migration started from time immemorial, and also that various means of mobility have been developed during the process.

In addition to the above, many research efforts have been made to elucidate the principle of the human act of moving, globally and from different angles. Not a few findings from these efforts suggest that the theme is associated with universal and fundamental elements of life, including genes, survival, migration, the brain, and happiness. We determined that this view was suitable for constituting the theme of the Expo 2025 exhibition to showcase our vision of future transportation models that can evoke a sense of anticipation for hopeful future lives, and adopted the phrase “Impulse to Move®” to express the theme. The term reflects our commitment to continuing to provide mobility functions to fulfill the human impulse to move, one of our most important reasons for existence.



Evolution of mobility

In order to fulfill its impulse to move, humankind has created a variety of means of mobility by promoting inventive and innovative technology development efforts. The related history can go back to around 3500 B.C. when the wheel, the origin of transportation technology, was invented. A major subsequent invention occurred about 3000 B.C. when humans built ships to sail across the seas to reach the islands they saw in the distance, in a bid to satisfy their explorative curiosity, which represents the beginning of the human history of maritime transportation. This was followed by the horse-drawn carriage invented about 2000 B.C., providing a breakthrough for the technology evolution of land transportation. Ancient civilizations developed land and water transport networks using horses and ships as major means of transportation. This long-established concept of mobility underwent a significant transformation in the 18th century as the Industrial Revolution started. The invention of steam engines brought about the appearance of railways and steamboats, making long-distance travel far easier. Against the background characterized by that dramatic change in society, Kawasaki Tsukiji Shipyard was opened in Tsukiji, Tokyo, starting business in 1878. Transportation technology continued to advance, with automobiles appearing in the late 19th century, bringing about a significant improvement in convenience of personal transportation, and the advent of aircraft in the 20th century expanding the possibility of fulfilling the impulse to move into the realm of the air. In this context, Kawasaki began to expand its business domain from shipbuilding to include locomotives, aircraft, helicopters, and motorcycles while increasing capabilities to constantly launch new mobility products in land, sea, and air transportation sectors, in accordance with changes in societal structures driven by evolving mobility technology and on the back of urbanization, development of the tourism and leisure industry, and accelerating growth in international exchanges.

Future outlook of mobility society

In the 21 st century, mobility evolution is continuing, being accompanied by new developments, such as: the modes of mobility ever-increasingly diversifying; technological innovations effecting a fundamental change in the way we move; the idea of “moving information” and “traveling in virtual space” beginning to have important implications as an outcome of advancement in digital technologies; growing interest in the principle of sustainable mobility for addressing issues posed by climate change and urban congestion; reviewing public transportation systems, encouraging walking and bicycling, and introducing Mobility as a Service (MaaS) and other similar concepts as part of efforts to reduce environmental impacts while fulfilling the impulse to move; space travel business, Mars colonization plans, traveling in the metaverse, and others proposing the possibility of implementing mobility functions to go beyond the earth — all these not just for the sake of technical challenge, but for satisfying a fundamental desire of humanity by fulfilling the impulse to move with a view to accessing new locations and exploring the unknown world. The act of moving pushes human evolution forward, enables cultural cross-pollination, and opens the gate to the future. Our Expo 2025 exhibition has been designed to present our vision of future mobility, wishing to stimulate viewers’ impulse to move and make them feel the thrill of imagining new modes of mobility in future society.

PROFILE

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*There are various theories regarding the birth of mobility.

CONCEPT 01

CORLEO

Explore new frontiers Novel interactive four-legged off-road mobility

Hydrogen canister housing

Hydrogen storage alloy canisters are employed to enable flexible layouts despite the limitation of space to achieve efficient housing. Swappable and portable canisters provide a good refueling solution even in an outdoor environment where appropriate facilities are difficult to access.

Patent application: 2025-043181

Stirrups

Stirrups and handholds are equipped to detect weight shifts of the rider to maneuver the machine. The length of the stirrups is automatically adjusted by the machine to help the rider maintain the optimal posture at all times.

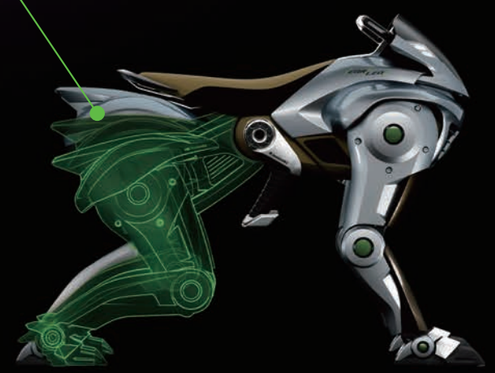
Patent application: 2025-013589

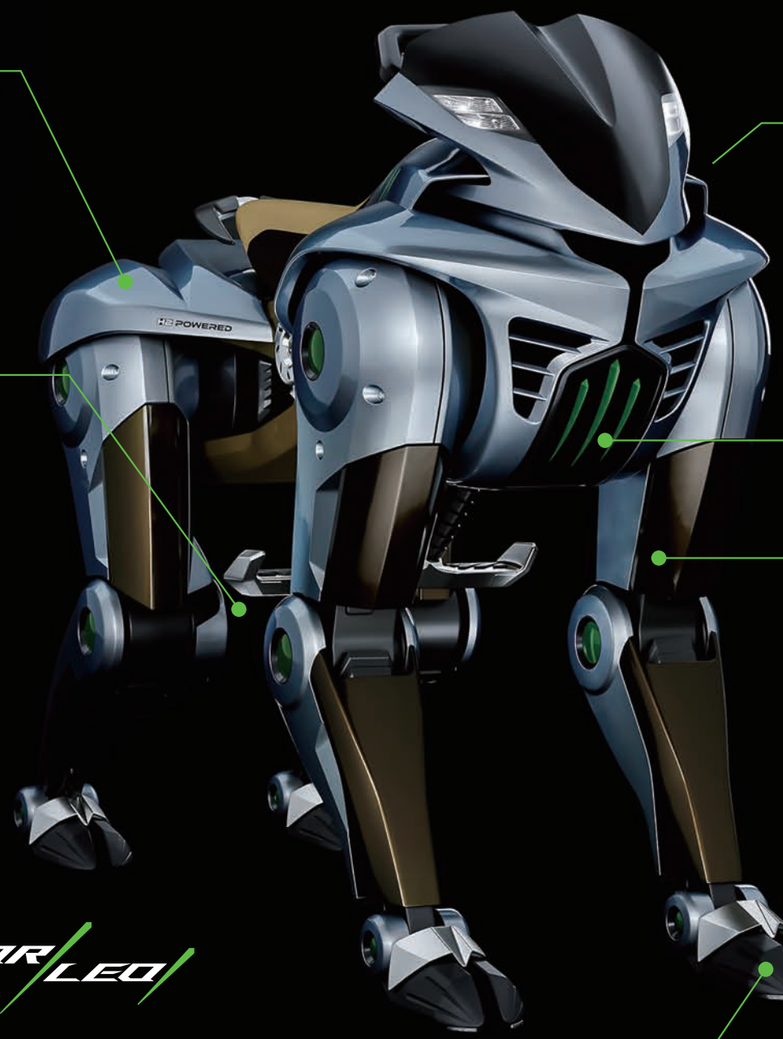
Patent application: 2025-013591

Swing arm

A movable shaft is installed in the mid-section of the chassis to enable the rear-leg mount to swing vertically relative to the front-leg mount, in order to absorb the impact and vibration related to walking and running. This mechanism can also provide attitude control at the level higher than that is difficult by the legs alone. For example, the vehicle can keep the saddle horizontal even when climbing, allowing the rider to avoid facing upward and to easily confirm the topographic conditions ahead.

Patent application: 2025-013587





Power unit

A 150 cc hydrogen engine for electricity generation is adopted to achieve a compact and efficient layout in the limited space engine bay. Electricity is generated using hydrogen supplied from canisters mounted in the rear section, in order to power actuators located in the four legs and vehicle body.

Patent application: 2024-231649

Cooling system

In the front section of the chassis, the radiator for cooling the engine and the inter-cooler for cooling intake air heated by the turbocharger are housed so as to achieve an efficient layout. The temperatures of the engine and intake air are appropriately controlled to prevent the abnormal combustion,one of the major issues posed by hydrogen combustion engines.

Patent application: 2025-013588

Leg suspension

The suspension is designed to achieve smooth bending and stretching movements of the legs. A broad range of flexible motion is secured to offer a comfortable ride and supporting dynamic actions, including making agile jumps.

Patent application: 2025-013590

Rubber hoof

The legs have left-right divided cloven hooves made of rubber, a material that is slip-resistant and absorbs land surface irregularities. These hooves can adapt to all different types of terrain, including grassland, rocky ground, and loose gravel, enabling the vehicle to maintain a stable attitude. Also, by absorbing landing impact, the structure helps the legs keep the shock-absorbing control operations to a minimum, thus reducing energy consumption.

Patent application: 2025-013578

CORLEO aims to provide the rider with a distinctively novel mobility experience characterized by the feeling of having personal communication with the machine. The machine detects the rider's behavior to assist safe operation. The four-legged structure supports strong off-road riding performance on rugged rocky ground or uneven woodland surfaces, easily jumping hurdles. The rider will feel like riding on a lion, the animal associated with the vehicle's name, to go on an adventurous trip to locations inaccessible with previous mobility capabilities and have a view of magnificent natural landscapes.

This machine has adopted an advanced off-road mobility control concept for employing autonomous control to prevent dangerous operation and ensure safety while reflecting the rider's intentions, in a bid to overcome the challenge of off-road travel posed by the safety-joy trade-off dilemma. According to this concept, safety can be assured for all types of riders regardless of age and gender while delivering a thrill similar to the sense of adventure specific to off-road vehicle maneuvering. This has been made possible by utilizing the Kawasaki Group's technological assets, specifically by combining design concepts about maneuverability and stability established for motorcycle development and mechatronics design and system control technology built for robot development.

Also, development of additional features is planned for various purposes, such as stable ultralow-speed travel that is difficult for conventional two-wheelers to perform , and safe tandem riding. The machine's use is not limited to leisure. Its strong ruggedness will be suitable for disaster rescue and relief operations.

Robotics

(1) Four-legged mobility

CORLEO represents a novel off-road personal mobility model proposed by Kawasaki. It is characterized by a four-legged structure with good off-road adaptation to ensure stability as well as a distinctively novel-concept maneuvering system — the machine detecting the riders' behavior constantly while allowing them to have fun maneuvering the vehicle, looking to deliver a strong sense of security by having the person and the machine move as one (human-machine interaction), and the rider expanding their moving capability, notably for barreling over even the worst terrain effortlessly while feeling like being merged with the machine.

(2) System control

Flexible motion, a pivotal feature in robotics for a four-legged structure, is to be achieved by synchronously controlling drive shafts in the legs and chassis using the torque controller along with the less than one millisecond cycle time controller. This provides not only attitude control but also fine tune control to absorb contact impact and stabilize travelling performance. Discussions are underway to increase the number of drive shafts in order to enable finer control.

It is equipped with an inertial measurement unit (IMU), a basic function for a four-legged robot, to provide attitude control, and a switch for riding mode change (walking, running, etc.). In order to verify and develop these basic functions, it is essential to conduct simulations using a physical engine in an appropriate environment to do comparisons with actual machines in order to increase reliability.

CORLEO's system control is composed of the following four elements:1. Torque control as centerpiece; 2. safety control — safety units designed to ensure deceleration stop in a safe position in the event of abnormalities and to be able to continue to move in case of a software abnormality in order to secure a safe state of hardware; 3. learning control — utilizing behavior logs of actual machines to step up from imitative learning to reinforcement learning in order to enhance performance; and 4. control for human-machine interaction — detect weight shifts of the rider to read the rider's intent and reflect

it in system control, aiming to provide intuitive operability for all types of riders regardless of skill level.

For the development environment of CORLEO, a hybrid development environment platform is built by combining a model-based process and machine learning models. The model-based process is to express the machine dynamics and control algorithm using mathematical models and start performance verification at the design stage. Machine learning models are to be used in learning for environmental recognition and control optimization utilizing data from actual machines and simulations. Moreover, the MLOps (Machine Learning Operations) process is introduced to be able to adapt machine learning models to the environment flexibly and promote their evolution while operating them at the same time. This will enable constant control optimization in accordance with changes in ground surface conditions and the user's operating characteristics. This cyclical approach consisting of MBSE (Model-Based Systems Engineering)/MBD (Model-Based Definition), ML (Machine Learning), and MLOps provides a key basis to support CORLEO's highly reliable and adaptative control functionality.

(3) Adaptive shared control

CORLEO is equipped to be maneuvered using input received from the rider's weight shift, and is designed to use this function for two major purposes: one is to extend human capabilities; and the other is, in a dangerous situation such as that carrying the possibility of jumping off a cliff, to make appropriate corrections to the rider's command, by overriding the person's maneuvering intentions autonomously, which is a form of robotic control technology that has already been applied notably to medical robots and power-assisted suits. In the CORLEO system, the rider's intentions and robotic operating conditions are shared between the human and the machine involved, and appropriate robotic processes are adopted to adjust the level of autonomous interference control according to the rider's skill levels. This represents a method known as "adaptive shared control." Using this method, CORLEO is able to read the intentions of all types of riders regardless of experience and skill levels and ensure their safety in a manner suited to each person, thus achieving a groundbreaking robotic feature for human-machine interaction, which makes CORLEO a distinctively novel mobility invention and also shows a stark contrast with the conventional robotic process of ensuring safety by following completely unilateral procedures with no consideration for human input.

(4) Issues

In order to implement CORLEO, enhance its traveling performance, and enable high-level control, it is necessary to make advancements in various technology fields. For the design of the vehicle body, additional advancements are needed in materials technology. To create a four-legged structure with a size sufficient to accommodate human riders and that can achieve high-speed traveling and make dynamic jumps, the materials to be adopted must be highly durable and lightweight at the same time. This requirement is crucial particularly for the legs, a section responsible for performing high-speed motions while supporting the entire body. Weight reduction is key to substantially improve kinematic performance in traveling at high speed and making jumps.

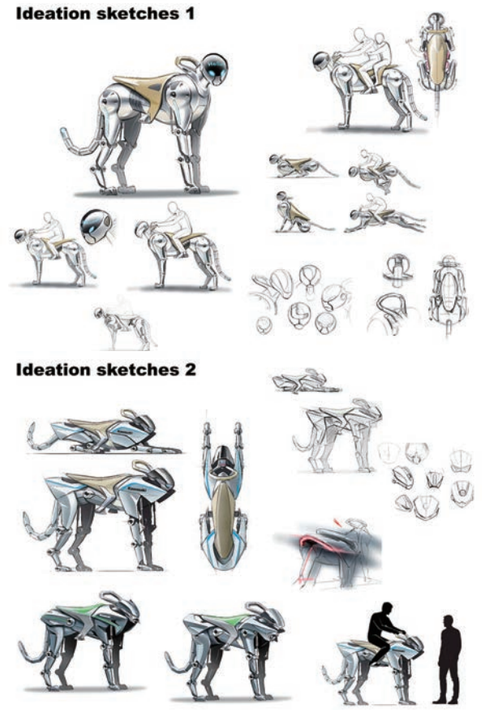
For control functions, advancements need to be made principally in sensing technology, in order to improve sensing performance and build more advanced signal-processing capabilities. For example, to ensure stable motion and prevent collision and falling when traveling at high speed, it is necessary to establish technology to have a view of the road ahead over a range of tens of meters to recognize topographical features and hurdles with a high degree of accuracy, process signals at high speed and reflect the results in control operations.

To implement the adaptive shared control process, it is essential to establish a highly advanced human-machine interface that can detect the rider's weight shift based on input from handholds and stirrups and read the rider's intentions to reflect them in control operations.

Appearance design

The appearance design of CORLEO contains elements that evoke a sense of mobility while being suggestive of animals. The most difficult challenge was to determine which of the two elements — motorcycle or robot animal — should be emphasized more, although the general image was determined early on based on the basic concept of off-road mobility. A stronger emphasis on the former element will likely result in something like an ordinary vehicle just with legs attached but lacking a playful mind, and that on the latter is likely to effect a deviation from the target mobility concept and rejection of communication with the human. There were additional crucial requirements to meet to represent Kawasaki's traditional motorcycle design philosophy that values the quality of being

Initial design sketch



"powerful" and "sporty." A myriad of ideas were brainstormed and processed to satisfy standards for universal approachability, an animal-like dynamic appearance that can arouse interest in riding, and the feasibility of the mobility technology in a physical sense, before the present design was finalized.

Ergonomics verification

In pursuit of safety, ergonomics verification tests were conducted with cooperation received from the equestrian club of Kobe University. Test participants rode the clay mock-up and reported their feelings of safety and stability. Also, adequacy evaluations were conducted for the stirrups in terms of the height, proportion to prevent the rider from being caught, footwork and other issues. The obtained feedback was used to establish a more comfortable riding position and functional beauty supported by a technical basis.

Clay mock-up

Navigation system (operation panel)

The instrument panel is installed in the front part of the machine. Information to be provided includes not only navigation data, such as a route map and estimated time of arrival, but also advice to assist optimal riding performance in consideration of road surface conditions and the center of gravity position, as well as environmental information such as altitude and the time of sunrise and sunset. The panel is also equipped with a navigation light to indicate the route by highlighting the path on the ground surface, as a measure to support the rider to move along the right path even under conditions of low visibility, such as in the evening.

Rider's view during the evening

Power unit

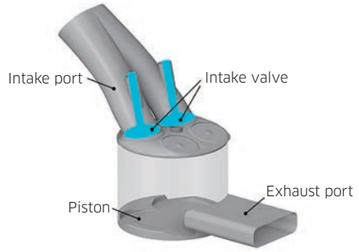
(1) Power unit design concept

CORLEO's power unit has adopted a series hybrid system where the actuator is powered by electricity generated by the Hydrogen internal combustion engine. The power unit has must satisfy two major requirements: "small in size and weight, and capable of high output" to be able to produce sufficient power to meet the output requirement of the unit despite the limited space; and "carbon neutral" by using hydrogen. In order to satisfy the above requirements, The power unit design concept was determined based on hydrogen combustion, with specifications including a rated output of at least 15 kW and an engine displacement of 150 cc. values determined by analyzing CORLEO's travelling pattern.

(2) Turbocharged two-stroke engine

While hydrogen engines virtually do not emit carbon dioxide (CO_2) while running, they can generate nitrogen oxides (NOx) when burned around the stoichiometric air-fuel ratio. As it is difficult to contain an exhaust gas purification catalyst due to space constraints, the combustion concept has been designed to create a lean-burn engine using a turbocharger as a measure to reduce NOx emissions, thus enabling clean operations. However, lean combustion means a lower output. To address this issue and achieve the required output, the concept has employed a turbocharged poppet-valve two-stroke engine that uses Kawasaki's prior art.

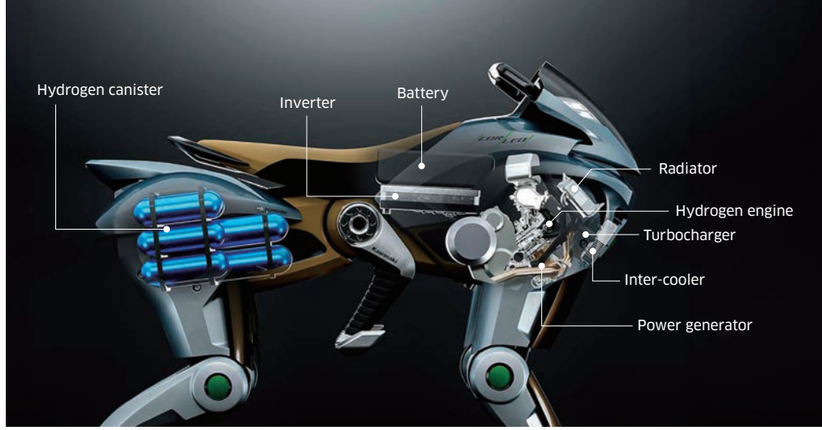
A two-stroke engine completes a power cycle with two strokes of the piston in one revolution of the crankshaft to do the intake and exhaust processes at the same time (scavenging), a mechanism capable of high output and thus is expected to improve the output of a small-displacement and lean-burn engine. With the existing two-stroke engine, however, carbon neutrality cannot be achieved due to its structure to feed a mixture of fuel and engine oil (for lubrication), which inevitably involves the engine oil being burned together with fuel, resulting in CO_2 emissions. To overcome this problem, Kawasaki's two-stroke engine has been employed. This technology has a proprietary mechanism that uses a poppet valve synchronized with the revolution of the crankshaft, a standard feature of the four-stroke engine, for the intake valve. This mechanism allows for independent processes for fuel feed and lubrication, eliminating the need for mixing fuel and lubrication oil, thus achieving carbon neutral operations with virtually zero CO_2 emissions. Moreover, a turbocharger is installed to improve the efficiency of scavenging in the engine for the intake process, which is conducive to higher output and stable combustion. In addition, for the fuel feed system, a direct-injection system (where fuel is directly injected into the combustion chamber) is adopted to hinder fuel from being blown out toward the exhaust side during the gas exchange process, thus helping improve combustion efficiency and promote exhaust gas purification.



(3) Hybrid system configuration

The concept has adopted a series hybrid system, with the overall structure comprised of generator (generate electricity), inverter (process electricity generated) and battery (store electricity generated). A compact configuration is achieved by uniting the generator and the gear box to be built into the engine, a technique that has applied processes established chiefly for building motocross engines.

The inverter and the battery are located under the seat for efficient layout. The battery can be accessed independently, easily by removing the seat, a structure allowing the battery to be charged independently as a measure to secure a longer range.



(4) Hydrogen storage alloy canister

Due to its high layout flexibility, hydrogen fuel contained in hydrogen storage alloy canisters is adopted. This allows multiple containers of different sizes to be housed, which is important in order to make effective use of the limited fuel storage space of CORLEO. As far as small-size containers go, the hydrogen storage alloy canister excels in the storage capacity per container compared with the high-pressure hydrogen tank, offering good storage efficiency of the entire system housing multiple containers. CORLEO contains a total of six canisters of two different sizes, which can secure an adequately long range.

The canisters are easy to replace, which is important for easy hydrogen refueling. And being portable and swappable like dry-cell batteries, this option can provide a good refueling solution in outdoor environments where appropriate facilities are difficult to access.

Intellectual property

More than ten applications for patent, design, and trademark have been completed for features characteristic to CORLEO, especially related to hydrogen engine-based power unit and hydrogen canister, swing arm, hoof, and stirrup. Also, for device configurations and designs that are currently in the process of improvement, application filing process is underway. At the same time, additional plans are on the table to file applications for services that will be developed by utilizing the machine, with a view to building a patent portfolio of a new off-road mobility encompassing both hardware and software functions. The relevant IP strategies do not only aim to prevent imitation by other companies but also seek to secure a competitive edge by obtaining patents and facilitate the formation of partnerships and consortiums with various business corporations. This is also to build co-creation frameworks to accelerate development activities, rather than pursuing monopolistic policies for technology development and service deployment.

Conclusion

CORLEO is a result of combining expertise built up by Kawasaki while operating the mobility business and robotics business, which we understand has received the highest-ever praise for its concept, performance, and styling design, constituting a reason for the global resonance the technology had. Going forward, we are aiming for early commercialization, looking to form partnerships with various business and other organizations while utilizing internal expertise at the same time.

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CONCEPT 02

ALICE SYSTEM

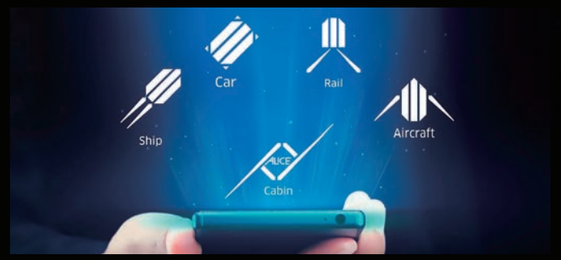
Public transportation system for more convenient and comfortable transport enabled by Kawasaki's comprehensive strengths in land, sea and air transport technologies

ALICE SYSTEM is our answer to the theme of fulfilling the "Impulse to Move" for the purpose of mass mobility. The goal is to provide a convenient and comfortable public transportation system, and the plan aims to implement the relevant technology in 2050.

The system is built centered around ALICE Cabin (the "Cabin"). The concept is that independent passenger cabins are able to autonomously connect with different modes of transportation, including cars, trains, airplanes, and ships, and to be carried by them. This interconnected mobility system aims to eliminate the need for passengers to transfer and provide a solution to issues posed by existing public transportation services, such as chronically overcrowded trains and inadequate barrier-free environments.

In the present situation, while universal design is being adopted by various facilities, many passengers, especially those with disabilities or traveling with small children, still have concerns about inconvenient facilities and feeling uncomfortable in public places. Existing public transportation services provide some options to meet the need for privacy, however, these are generally targeted only at high-end users.

Wishing to solve these issues, the design concept of ALICE SYSTEM contains our commitment to delivering an easy-to-access solution to those in need of privacy in public.



To go on a trip, make your plans by selecting options related to mobility mode — land, sea, or air — as well as destinations, food, and other details. When you are ready, send a request for an ALICE Car to pick you up at home or any other place.

ALICE Car

Road vehicle to carry the Cabin. Supports transshipment of passengers. Adopts the hydrogen power generator O'CUVOID (details are provided later in this document)

ALICE Ship

High-speed passenger vessel modeled after a fully submerged hydrofoil (Jetfoil). Provides safe, comfortable and free movement throughout the ship during navigation P.26

ALICE Cabin P.22

ALICE Aircraft

Aircraft pursuing passenger comfort, notably with lounge areas with a view created by taking advantage of the latest airframe geometry P.24

ALICE Rail

Complete with the Cabin, dining car and lounge areas, the train delivers good privacy and comfort. Adopts the hydrogen power generator O'CUVOID (details are provided later in this document) P.23

Cross-sector cooperation for joint development

The development of ALICE SYSTEM involves Kawasaki's largest-ever inter-company collaboration, specifically to carry out the following procedures: for car, train, airplane, and ship to connect with the standardized cabin, first determine the dimensions of the cabin, which should be based on that of the train, the mode with space requirements tighter than others; and the airplane and ship are designed in alignment with the dimensions determined.

FUEL

Hydrogen fuel is adopted for use in each mode of mobility. For fueling, a range of options were considered to make the best possible choice for each. Looking at the possibility of hydrogen being adopted in various forms in society, such as high-pressure or liquid hydrogen, filling or cartridge type, the plan is laid out to use this opportunity to promote Kawasaki's related technical capabilities.

POSSIBILITY

One of the objectives of developing ALICE SYSTEM is to present a proposal that will trigger public discussions on "What constitutes better public transportation systems?" The proposal will be made by introducing a range of possible ways of deploying cross-sectoral services using this mobility model, such as: ALICE Car serving as a taxi for passengers to transfer between transport modes; the Cabin equipped with medical service functions to provide ambulance service; and the Cabin as a travelling shopping center.

Cabin

Dimensions: 2200mm (H) × 3050mm (W) × 2175mm (D)
Weight: 1000kg
Capacity: 4 seats

Concept

ALICE SYSTEM's interconnecting module. Designed with an emphasis on passenger comfort and convenience while adopting the barrier-free concept, specifically by securing a more-than-sufficient space for a maximum capacity of four seats, which can be removed to create a space for wheelchairs. The Cabin's power supply capabilities are reduced to the minimum required, by omitting a power generator and with electricity supply received from the facilities housing the module. This enables a significant reduction in purchasing and maintenance costs, compared with private jets and cruisers, enabling privacy of comparable quality to be offered at an affordable price.

Remote communication system

A semi-transparent glass display is installed on one of the interior walls of the Cabin. This is a remote communication support tool, primarily to enable passengers to consult a doctor remotely or attend an online business conference while traveling. In addition, the system includes a real-time video streaming function for different cabins to share images of their inner situation with each other, allowing users of more than one cabin to feel like being together in one place. Also, a directional speaker is installed to give public announcements in an appropriate manner. For giving information to passengers with visual or hearing impairments, voice or text format can be chosen by each cabin, improving the accuracy of delivering information to the target, compared to the existing information communication capabilities.

Operation using the display within the cabin

Concierge function

The Cabin comes with a concierge function aided by a robotic arm mounted on the side of the seat. Robotics technology is applied to provide semi-automated processes for tasks performed previously by human attendants, such as serving drinks, helping passengers put on and take off coats, and holding a book, smartphone, or the like in the right position.

Support provided by the robotic arm mounted on the side of the seat

Rail

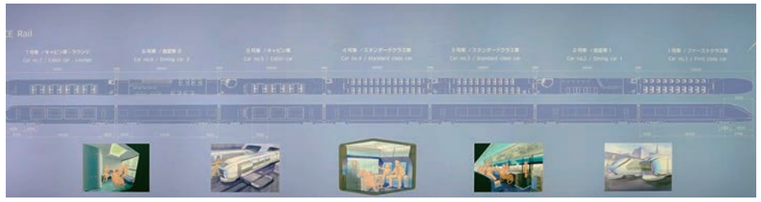
Concept

ALICE Rail is the railway system to carry the Cabin with the objective of offering a high-quality passenger experience in terms of privacy and comfort. The plan aims to deliver quality on par with that of private jets and cruisers, facilities equipped to provide high-level confidentiality protection for attending important business meetings and flexibility in customization of the interior space that cannot be matched by private compartments offered by some existing limited expresses, including premium options for adequate comfort and relatively high privacy.

In ALICE SYSTEM, the Cabin comes in several different types to be chosen by users according to their specific needs, and with an interior layout and facilities prepared to accommodate customization needs. This is for offering quality comfort particularly targeting businesspersons, group travelers, and wheelchair and stroller users.

Train formation

The train is composed of a total of seven cars, which are divided into a cabin section for Cabin users and a general section for general passengers to use as usual. The general section is subdivided into standard and first class blocks. In order to ensure privacy, passage between the two sections is restricted, and each section is staffed independently. Also, each has a dining car offering different service options and food menus attached. The cabin section includes exclusive lounge areas.



Train formation

Space design

Dimensional designs are based on full-size Shinkansen specifications. First, the aisle width was set to 900 mm to ensure that wheelchair users could pass through without difficulty. Then, the depth of the Cabin (2,175 mm) was determined to allow passengers to move comfortably between the aisle and the Cabin. As a result, the overall height of ALICE Rail exceeds that of the Shinkansen train car by 300 mm.

In consideration of wheelchair users, barrier-free designs are included in the floor plan. In addition to step-free floors, particular considerations are given to reduce their stress when moving between cars to access the dining car. Also, special measures are taken to create a sunken kitchen in the dining car to allow those in wheelchairs to interact with the staff and chefs comfortably at the same eye level when ordering and eating a meal.

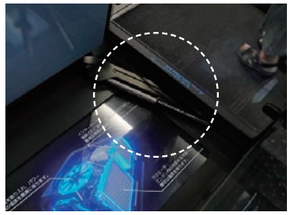
Docking

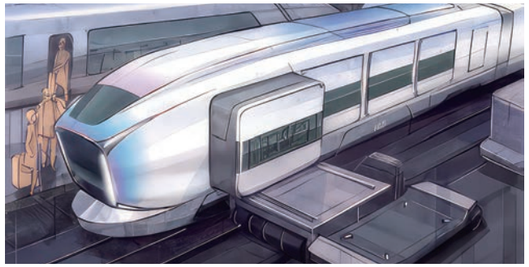
The plan for docking the Cabin onto ALICE Rail is by moving the Cabin to position itself in parallel with ALICE Car and inserting it from the side. The insertion process is started by deploying the conveyer equipped with ALICE Car and completed by using pull-in arms mounted on ALICE Rail to lock the Cabin inserted.

As ALICE Rail is operated by shar-

ing platforms with general trains, the docking process is to be performed only from the side opposite to the platform. This is to avoid interfering with conventional platform operation procedures, including first-class and standard-class passengers using the platform for embarkation and disembarkation.

In the case of docking on a double track platform, the insertion process will be performed over the track. To do this, a self-propelled bogie-mounted conveyor is to be placed over the track to allow the Cabin to slide on it into the train.


Pull-in arm


Docking using a self-propelled platform

Fuel

For fuel, a high-pressure hydrogen cartridge system is employed. Refueling will be completed by exchanging cartridges during standby for shuttle train operation, thus achieving high work efficiency to overcome time restrictions. The plan has employed the hydrogen fuel engine O'CUVOID.

Exchanging hydrogen cartridges

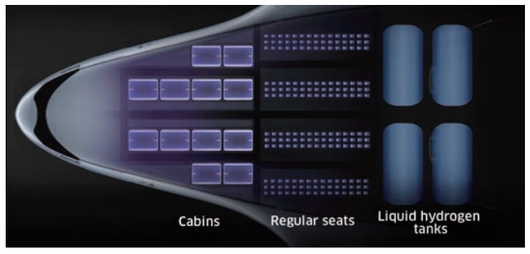
Specifications table (estimates)	
No. of cars per train:	7
Track width:	1,435 mm
Total train length:	148,650 mm
Total width:	3,225mm
Total height:	3,950mm
Floor level:	1,300mm
Total seating capacity:	152 (7 ALICE Cabins + 124 general passengers)
Maximum speed for commercial use:	260 km/h (fully electrified section); 130 km/h (non-electrified section)
Fuel:	High-pressure hydrogen (875 L/car)
No. of O'CUVOID units installed:	9 (35 kW)/car
Interior facilities:	Passenger car (cabin, first-class, standard class); dining car; lounge: restroom, etc.

CONCEPT 02 ALICE SYSTEM

Aircraft

Concept

ALICE Aircraft is distinguished by its structure design to deftly connect the private Cabin space and public areas offering good in-flight freedom of movement. Our vision is to establish technologies to eliminate the discomfort experienced by many passengers from being confined to their seats for many hours, a major issue posed by the existing flight service, and allow all passengers, including individuals with special needs and those traveling with small children, to enjoy the freedom of moving with comfort, comparable to that found on large cruise ships, which itself is often the purpose of traveling.



Interior floor plan

Design

Major design requirements are to be able to: 1. carry ALICE Cabin with its design standards established; 2. fly about 10,000 km from Japan to Paris; and 3. have sufficient hydrogen fuel loading capacity. For fuel to meet these requirements, the plan has chosen liquid hydrogen, which is smaller than high-pressure hydrogen in volume. With liquid hydrogen, compared to traditional kerosene-based jet fuels, while the fuel volume will be about four times as large, the weight can be reduced to one third. To secure the required loading capacity, a blended wing body has been employed to achieve high volumetric efficiency.

Docking

The cabin docking process uses the boarding entrance for cabin passengers to be built on the both lateral sides of the fuselage. Like existing aircraft, only the portside entrance is to be used in normal times, and the starboard side entrance will be used only for emergency escape. The Cabin is robotically led to the entrance, loaded by the conveyor or other devices onto the aircraft, and locked in its specified location on board. Before the decision was made to choose this method, a number of other options were discussed and excluded for various reasons. Among such candidates were a plan to locate the cabin loading bay at the aft and another to lift up the cabin to load from above, which posed concerns, such as the discomfort of passengers about being handled like cargo, the hazard posed by lifting up the Cabin, and the risk of rainwater entering from the opening in the ceiling. The entrance for general passengers will be created in parallel and used in the current manner.

Facilities

The plan includes the creation of lounge areas containing restaurants and observation facilities. The space can be designed to feature skylight windows to offer a good view of the star-filled sky. To ensure stress-free movement of passengers on board, the aisle width is set to 1,500 mm, particularly to enable two wheelchairs to pass each other comfortably, and restrooms will have a sufficiently large space to accommodate needs for nursing care. Also, robotic processes will be introduced to play some of the roles that are traditionally performed by human cabin attendants, aiming to increase efficiency in providing in-flight services.

Issues

In the context of air transport operations, the highest priority issue is to ensure safety, which should come before realizing the above-described design concepts. Future discussions are needed to establish specific technology solutions to ensure the safety of Cabin users. Among the ideas on the table are: an earthquake-proof structure could be adopted to enable the Cabin to control shaking in the interior, even in a shaking aircraft; and the Cabin could have a feature to receive oxygen supply and eject itself out of the aircraft on an individual basis in the event of an emergency.

Development of capabilities to use hydrogen fuel is based on the hydrogen aircraft core technology currently under development at Aerospace Systems Company. Major challenges to be addressed are: to meet the fuel requirement for large volumes of liquid hydrogen, specifically by securing sufficient hydrogen fueling volumes at airports and establishing a high-speed refueling process between flights; and reduce the weight of the overall aircraft including hydrogen related equipment and the overall airframe structure.

In order to implement this project, further studies are needed to work out solutions from the perspective of technology and regulations (safety requirements).

Specifications table (estimates)	
Total length/width:	60 m long; 60 m wide (equivalent to Boeing 787-9)
Main wing area:	360 m² (including fuselage section)
Engine/output:	Hydrogen combustion engine (400 kN unit x 2)
Fuel:	Liquid hydrogen (40 t)
Cruising speed:	900 km/h (Mach 0.84)
Cruising range:	10,000 km (Japan-Paris)
Total seating capacity:	228 (12 ALICE Cabins + 180 general passengers)
Takeoff weight:	250 t
Liquid hydrogen tank:	150 m³ tank x 4

Ship

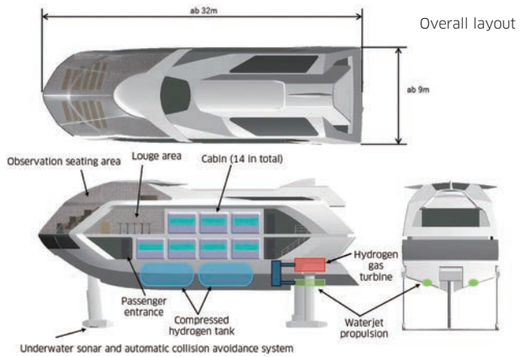
Concept

ALICE Ship is a high-speed vessel modeled after Jetfoil — the passenger-carrying fully submerged foil type-hydrofoil produced by Kawasaki — and a carrier of the Cabin. The goal of this project is to offer a distinctively comfortable passenger experience on board by incorporating the Cabin's functions effectively. Looking to differentiate itself from ALICE Aircraft, which offers a long-distance transportation capability, ALICE Ship is designed to have a capacity for an around 150 km cruising range. By combining the Cabin's features with the Jetfoil's strong anti-rolling features and high-speed capabilities, the highlight of this technology, this maritime mobility model aims to allow all types of passengers to have a transfer-free, comfortable and convenient trip by sea.

Design

This ship will be able to navigate with its hull lifted above the water, like the Jetfoil. To establish this ability, the design plan gives particular consideration to weight and space.

By adopting hydrogen fuel, this project faces lower fuel efficiency than conventional light fuel oil, due to difference in energy density, meaning a requirement for a larger fuel storage space. To address this requirement, the cruising range is reduced from around 500 km at present to 150 km to secure sufficient space.



Overall layout

For hydrogen fuel to be loaded on board, compressed hydrogen has been chosen for the purpose of weight reduction and space saving. By choosing compressed hydrogen, the fuel system can omit a tank structure with ultra-low temperature resistance (-253℃) and a carburetor, essential functions to run a liquid hydrogen-fueled system. Please note that this design plan assumes that the development of hydrogen turbines will advance so that their performance will achieve a level comparable to conventional gas turbines in terms of power-to-weight ratio by 2050.

Docking

Cabin docking takes place from the both sides of the hull, and the maximum loading capacity is set to 14 cabins in combined total. One major problem with this process is that it is susceptible to the effect of waves in the quay rocking the ship, and it is essential to keep the ship stable during docking operations in order to ensure the safety of the Cabin. One solution proposal is using a lifting device to raise the vessel above the water surface so that the ship is not impacted from wave motion and tidal differences and retains a stable state suited to receiving the Cabin from its sides safely. With currently available lifting devices, it will take from several tens of minutes to one hour to raise the vessel to an appropriate level, posing a challenge to overcome by taking measures to shorten the overall cabin docking time to ensure a comfortable travel experience. Another important issue is related to the ship's structure of accommodating Cabins on two different levels. Future discussions will be needed to determine which of the two methods to apply — adjust the level of the vessel using the lifting device or the level of the Cabin on land.

Facilities

One of the key features of ALICE Ship is automatic anti-collision systems equipped with underwater sonars, a measure to free people from using a seat belt, a standard requirement for Jetfoil passengers and a factor restricting their freedom of movement during the voyage, and allow them to walk around on board as they wish and in safety. This reflects the project's commitment to delivering a distinctive passenger experience specific to this ship. Also, the ship features a fully autonomous navigation system, which can eliminate the need to install a cockpit and assign relevant crew, resulting in space on the second floor with a good view freed for creating an observation seating and lounge area. In addition, barrier-free designs are adopted for onboard facilities in reference to the barrier-free law, such as an aisle width set to accommodate the passage of wheelchairs and barrier-free toilet systems.

Issues

In general, ships are equipped with various functions to be able to endure severe marine environments, typically to prevent salt corrosion and submergence. For this ship, especially, strong watertightness at the connection section between the vessel and the Cabin is imperative to prevent the entry of seawater. As the Cabin composes a part of the exterior of the vessel, it is essential to implement measures in the Cabin to protect it from salt corrosion, and appropriate measures are needed to enable navigation even when the cabin loading capacity is not filled up.

For emergency escape, considerations are necessary to determine whether to adopt only conventional methods or to add a lifeboat function to the Cabin.

Given the ship's design range of 150 km, hydrogen refueling will be needed not only on the mainland but also on islands, meaning that development of hydrogen fueling infrastructure on an island is a precondition for making the ship's service available, which poses a major hurdle to many remote islands at present.

Discussions will be held continuously to address these issues specifically, aiming to implement the project.

Specifications table (estimates)	
Vessel type:	Passenger-carrying fully submerged foil type-hydrofoil
Propulsion:	Waterjet propulsion
Total length/width:	32 m long; 9 m wide
Deadweight capacity:	26 t
Engine/output:	Hydrogen gas turbine (2,000 kW unit x 2)
Fuel:	Compressed hydrogen (11 m³ tank x 2)
Maximum velocity:	40 knots (approx. 74 km/h)
Cruising range:	80 kairi (approx.150 km)
Total Seating capacity:	120 (14 ALICE Cabins + 64 general passengers)
Special notes:	Fully autonomous navigation system; underwater sonar and automatic collision avoidance system

Conclusion

ALICE SYSTEM represents the possibility of future public transportation systems envisioned by Kawasaki. We have showcased the relevant technology concept to the world through Expo 2025, anticipating that it will trigger public discussions to identify additional issues and suggest improvements. Making effective use of such feedback from society, and bringing together the expertise of each company, we will continue with this endeavor toward achieving the goals.

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CONCEPT 03

O'CUVOID

Hydrogen power generator package based on motorcycle technology to respond to diverse electricity needs and promote hydrogen adoption

O'CUVOID is a hydrogen power generator package designed to be used in a hydrogen society for a diverse range of applications from a power source for train cars, automobiles, and construction equipment, to power supply for various events and emergency situations.

This new invention is based on a motorcycle engine, which has been redesigned to use hydrogen as fuel and incorporate a turbocharger, aiming to innovate an electricity generation unit that is compact, high-output, cost-effective and capable of carbon neutrality.

As a power generator package that can be connected to others, like dry cell batteries, and by changing the number of units to be connected according to the power required, O'CUVOID can respond to diverse electricity needs. It is employed by ALICE SYSTEM, the future public transportation model proposed by Kawasaki, in which the number of units to be installed will be set for each mode of mobility to achieve the optimum power supply.

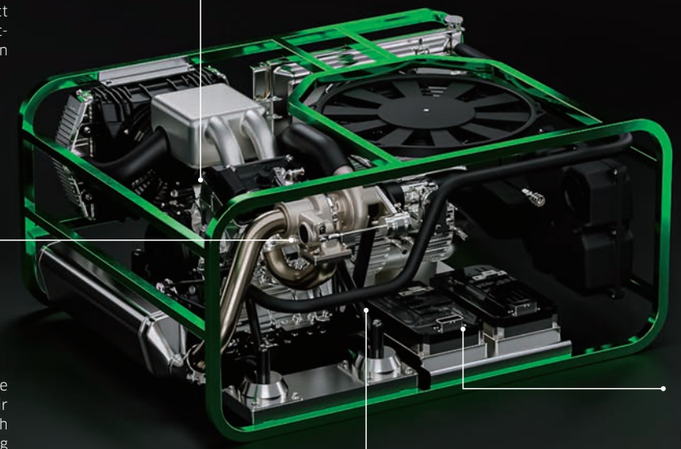
This multi-unit connection structure makes it possible to control the burden imposed on each unit independently to remain within the appropriate range for the unit to maintain efficient operations. It can also support downtime-free operations by allowing failure of some of the units to be compensated for by the remaining units.

The storage system containing hydrogen tanks is externalized to improve its flexibility in terms of layout and capacity selection.

O'CUVOID
HYDROGEN GENERATOR

Hydrogen engine

Heart of the unit. Based on a motorcycle engine redesigned to use hydrogen as fuel. Coming in a compact body, it achieves cost-effective, high-output, and carbon neutral performance.



Turbocharger

Driven by exhaust gases, the device supercharges extra air into the engine. Delivers high engine output while enabling clean combustion at the same time by increasing the excess air percentage to promote lean burn operation that can reduce NOx emissions.

Inverter

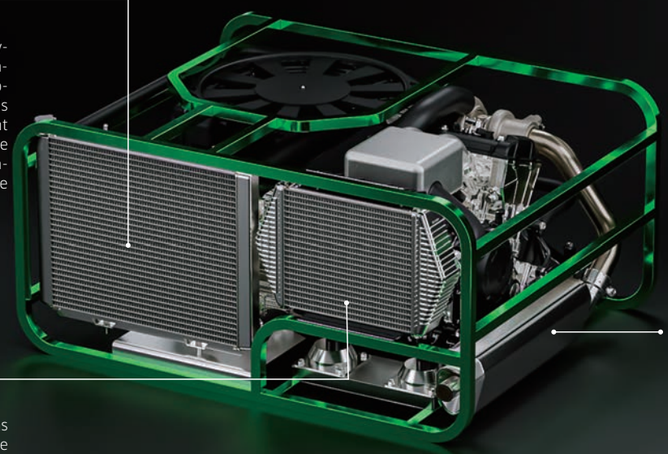
Regulates the generated electrical power to have the volt-ampere rating required by the equipment to be used. Its specifications can be changed to respond to various electricity needs.

Generator

Converts the engine's rotational kinetic energy into electrical power. A speed reduction mechanism is contained in the engine to achieve the optimal engine speed for power generation.

Radiator

Essential component of a hydrogen engine for temperature control to prevent abnormal combustion. Controls the temperature of coolant circulating within the engine to maintain its proper temperature in order to ensure stable continuous running.



Exhaust System

Exhaust catalysts are installed as a measure to achieve clean exhaust gas emissions. Equipped with a silencer to reduce the exhaust sound of the engine, thus ensuring low-noise electricity generation.

Intercooler

Cools hot intake air that has been compressed by the turbocharger. Prevents abnormal combustion, a major issue with hydrogen engines, and ensures high-output engine running.

Introduction

O'CUVOID is a next-generation carbon-neutral power unit featuring new-concept unit connectivity. This section gives an introduction to the basic concept and elemental technologies of this invention as well as its future application potential.

O'CUVOID: Basic concept and advantage

(1) Reasons for adopting a hydrogen engine

O'CUVOID has adopted a hydrogen engine, a choice suited to taking advantage of the Kawasaki Group's expertise to promote practicality, cost effectiveness, and simplified system configuration in this technology field, compared with the fuel cell, the main power generator using hydrogen.

Compared with a hydrogen engine, a fuel cell excels in power generation efficiency on an individual basis, but its load following output capability is low, particularly for rapid load changes. One solution for improved response to load change is by mounting large-capacity batteries as a buffer. A larger buffer battery means a larger-scale system and a lower cost effectiveness. In comparison, a hydrogen engine, a type of internal combustion engine, has good following and responding capabilities against output fluctuations, allowing for significantly downsized buffer batteries. This allows for lightweight and affordable systems, which can provide optimal power units in response to diverse electricity needs in consideration of performance, cost and efficiency in a balanced way.

Featuring a simple system configuration, O'CUVOID can offer a solution to issues faced by conventional fuel cell vehicles employed by public transportation systems, which require many components to be mounted, resulting in increased weight and lower maintainability.

(2) Unit design in consideration of connectivity

In addition to single-unit operation, O'CUVOID is also capable of multi-unit connection to increase system output and ensure high-efficiency operation. According to the principle of the internal combustion engine, fuel efficiency changes within the range of engine speed and load, and the maximum domain varies according to the type of engine. Specifically, fuel efficiency tends to decline during high-speed high-load operation in small engines, and during idling or low-load operation in large engines.

In the O'CUVOID system capable of multi-unit configuration, the number of units can be optimized according to the output requirement in order to maximize per unit fuel efficiency. Take the example of the case of O'CUVOID applied to the operation of train cars, which is characterized by a high maximum system output requirement and an extremely low load during constant-velocity running. O'CUVOID can produce high output by connecting multiple units. For low-load operation, it can achieve high-efficiency performance of the overall system by limiting the number of units to be engaged in service within a high-efficiency domain, rather than engaging the entire connected structure in service at a single average rate.

(3) Packaging design for high versatility

Looking to accommodate diverse application uses, O'CUVOID is designed to house all the necessary accessories in a single unit coming in a compact body.

In addition, owing to its connectivity designed to ensure flexible response to system output requirements, O'CUVOID has a wide range of applications from a portable compact power source for emergency situations and various outdoor events, to public transportation systems, construction equipment, and personal mobility vehicles, which demonstrates its high versatility. This property will be exhibited to introduce hydrogen power generation capabilities to various fields. For example, a construction equipment manufacturer, even if lacking hydrogen engine technology, can produce hydrogen-powered models by adopting O'CUVOID as a power unit.

As just described, O'CUVOID aims to be a power unit with high versatility to provide an electricity supply source to all types of equipment used in society.

(4) Flexible system configuration with hydrogen tanks separated

The O'CUVOID system is configured to externalize the storage system containing hydrogen tanks, pressure governors, and other components. This is a measure to respond to a wide variety of requirements for the storage system as an outcome of the power unit's requirements for output and continuous run time changing depending on needs. In this context, a configuration with an internal storage system containing hydrogen tanks would pose difficulties with achieving an optimal design to satisfy specific needs. For example, in the case of a request for satisfying a low output requirement and a high continuous run time requirement at once, excessive units would have to be connected in order to increase the storage capacity, constituting a failure in optimal design. As a way to avoid such problems, O'CUVOID is designed to have a separate storage system to ensure flexibility for choosing the type and volume of tank best suited to the users' needs related to continuous run time and availability of hydrogen infrastructure. Also, by externalizing the storage system, this configuration has increased flexibility in designing the layout of the power unit to be mounted in various types of equipment, which is often constrained by physical restrictions associated with the storage system.

O'CUVOID: Elemental technologies

(1) Hydrogen engine

The engine, the heart of the unit, has been developed employing a 650 cc two-cylinder motorcycle engine as its base, redesigning it to use hydrogen as fuel, and incorporating a turbocharger. By combining a motorcycle engine, characterized by its compact structure and high output capacity, and a turbocharger, the development has achieved a broad operating range with a high load following capability.

While a hydrogen engine can be designed to achieve a high combustion efficiency and implement a broad range of operating conditions by taking advantage of the major characteristics of hydrogen, specifically a high burning rate and low minimum ignition energy requirement, it also carries the risk of abnormal combustion, such as spontaneous ignition, due to the very same characteristics. This issue can be addressed by leveraging the expertise on hydrogen combustion cultivated by the Kawasaki Group while developing technologies for hydrogen gas turbines and hydrogen motorcycle engines. Also, by adopting a mass production engine as the base, the initial investment can be kept to the minimum while achieving high productivity by using the same line as producing motorcycles in a highly cost-effective manner.

(2) Generator

The generator is a non-integrated structure to be connected by a shaft to the engine, a configuration to provide high flexibility in choosing an appropriate model to combine according to the power generation requirements. Also, the transmission mechanism mounted in a motorcycle engine can be utilized as a decelerator as a measure to optimize the engine speed to ensure efficient performance of the generator.

(3) Inverter

The inverter, a device to regulate electrical power to have the volt-ampere rating required by the equipment to be connected, is configured separately from the generator to allow for the choice of model suitable for the equipment.

(4) Turbocharger

In order to achieve a high output rating at 50 kW and good efficiency, O'CUVOID contains a supercharging system based on a turbocharger, a mechanism powered by energy recovered from engine exhaust gases, thus enabling high supercharging efficiency. This supercharging system plays a key role in combustion control. While hydrogen engines virtually emit no carbon dioxide (CO_2) while running, thus being capable of carbon neutral operation, they can generate nitrogen oxides (NOx) when burned around the theoretical air fuel ratio (stoichiometric combustion) due to a rise in the burning temperature. One major solution to this issue is provided by introducing a gas purification catalyst into the exhaust ducts. Among others, one suited to operation with a low per unit load requirement is by supercharging air to create a lean-burn engine, a measure to decrease the burning temperature, which is conducive to controlling NOx emissions from hydrogen burning around the theoretical air fuel ratio. Lean-burn operation involves lower output relative to stoichiometric combustion, but this issue can be addressed by adopting a supercharger to minimize output reduction. As described above, by choosing the better of the two methods — environmentally friendly lean-burn engine or high-output stoichiometric combustion — according to the situation and the specification of the unit, O'CUVOID can respond to needs for high environmental performance and various types of load requirements alike.

(5) Cooling system

Anticipating the possibility of accommodating many different application needs, O'CUVOID houses within the package a cooling system containing a radiator and an intercooler. The cooling system has achieved a compact layout while installing an individual cooling fan in the radiator and the intercooler as well as one for the whole unit on the ceiling. This enables the unit to be included in the layout for various use settings, such as underfloor spaces of train cars, and the engine room of small mobility vehicles and construction equipment.

O'CUVOID: Application deployment

Due to its unit configuration and related technologies, O'CUVOID allows for its innovative implementation in terms of efficiency and maintainability.

(1) Concept of downtime-less operation enabled by unit replacement

O'CUVOID's unit configuration can bring about a significant change to maintenance processes to minimize system downtime, thus implementing the concept of "downtime-less" operation. One possible use case is for a single-engine train service, which carries a sizable risk of a failed engine causing an immediate operation shutdown and entire system failure. This poses a serious problem especially to freight train services operating in undeveloped regions overseas.

A solution to this problem can be provided by O'CUVOID taking advantage of its standard design for multi-unit connectivity, which can enable a possible failure to be compensated for by the remaining working units to continue operation without interruption. The capacity for avoiding a complete system shutdown and continue operation to reach the nearest base represents the principle of redundancy, the primary pillar of the downtime-less operation concept.

The secondary pillar is related to a swift restoration of normal operation by replacing units. Due to its package configuration including the necessary accessories, O'CUVOID is capable of a quick on-the-spot selective replacement of failed units to restore the system to a normal state easily. In the case of train cars, conventionally, an engine failure means a failed large engine to be replaced and repaired by specialized engineers in a dedicated factory. In this situation, O'CUVOID, which is capable of package replacement, can reduce the need for special facilities and workers. Furthermore, appropriate service manuals can be prepared based on those for motorcycle engines and distributed to service garages and dealerships to allow them to respond to maintenance and repair requests. This can avoid the need for large maintenance facilities, conducive to the expanded scope of applying hydrogen power units.

(2) Assumed use case of hydrogen train cars for regional railway service

The above-described redundancy and maintainability are eminently suitable particularly for public transportation systems. To provide hydrogen-powered train cars for regional railway services, for example, multiple units will be put together and mounted in each car (development of the "hydrogen-ready" car to allow for easy replacement of a diesel-engine car is underway at Kawasaki Railcar Manufacturing), which can enable a failure of one component unit to be compensated for by the remaining units to continue operation and avoid a service suspension. The failed unit can be replaced by a backup unit in stock at terminal stations or shuttle operation bases. Additionally, stockpiled units can serve as an emergency power source.

GreenHICE Car, hydrogen-ready train car to replace a diesel engine car

This plan for hydrogen train cars aims to provide regional railway service with capabilities for autonomous operations on non-electrified sections where the power-feeding system is not available, with the capacity for running at around 60-80 km/h assumed.

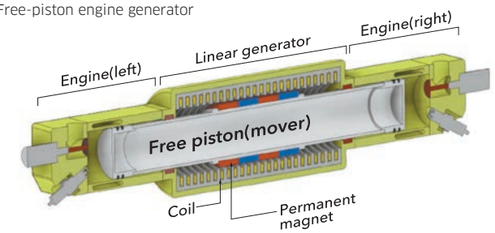
The number of units to be operated is controlled according to the output required by the integrated control unit mounted on the train car sending a command to the ECU of each unit of O'CUVOID.

Owing to the compact package configuration including necessary accessories, multiple units of O'CUVOID can be installed together in train cars using underfloor spaces. This is also effective in lowering the center of gravity, offering a sense of stability to passengers.

O'CUVOID: Application development

One possible plan for O'CUVOID's application development is related to a monitoring function aimed at the sophistication of downtime-less operation. Efficiency of the operation can be improved by building an advanced management system for performing real-time monitoring of the operating time and status and parts replacement history of each unit to determine an optimal timing of unit replacement to maximize efficiency, Among other possible plans is one to adopt a free-piston hydrogen engine generator in order to further reduce the size and weight and increase operation efficiency of the unit while promoting effective use of its connectivity. The free-piston engine generator is an electricity generation system that uses a linear generator to convert the linear motion of the piston directly into electric energy. One of the main advantages of this system comes from the absence of a crank mechanism, which brings about decreased mechanical friction and ensures flexibility for optimizing the compression ratio according to the amount of power generation, thus enabling high-efficiency operation. Also, fewer components can facilitate a further reduction in size and weight.

Free-piston engine generator



Conclusion

O'CUVOID has been developed by adopting as its core the well-established mass-produced motorcycle engine model, and designed while pursuing versatility, cost-effectiveness and scalability and based on the package design concept. Especially, equipped with unit connectivity, providing flexibility for responding to various application needs, and a unit replacement system supporting ease of maintenance, this technology holds the latent potential to bring about a substantial reduction in cost and need for specialized skills, a major hurdle to the adoption of hydrogen energy at present. In the context of the Kawasaki Group promoting its initiative to create a hydrogen society by building a supply chain that covers the entire range of processes from production, transportation and storage to utilization, O'CUVOID, a hydrogen-based function to respond to diverse electricity needs in society, represents the first step to offer a real solution in the utilization phase.

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Expo 2025 post-event session

The Expo 2025 Promotion Section Reveals the behind-the-scenes story

The EXPO 2025 Osaka, Kansai, Japan Promotion Section (the "Promotion Section") was organized to promote the Group's project for participating in the expo as an exhibitor. Six members were assigned to the section to engage in a broad spectrum of tasks related to concept formulation, planning and production of exhibits, and PR strategy planning. For the closing of the Special Issue on Expo 2025 Osaka, Kansai, Japan, we held a special talk session for the members to share their thoughts and feelings about the related experiences while looking back on the project themed on the "Impulse to Move."

How would you describe "Impulse to Move" as the exhibition's theme?

Murakami: Around the end of 2021, a task force was launched to consider details of the exhibition, inviting about 20 members mainly from head office divisions. We held online workshops to discuss how to create a basic list of candidates for selecting the exhibition theme with more than 100 participants.

Keisuke Murakami

Manager, EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group

Head of the EXPO 2025 Osaka, Kansai, Japan Promotion Section. Responsible for overall management of the section and negotiations with the Japan Association for the 2025 World Exposition and other organizations.

In order to give concrete shape to the ideas and suggestions discussed, the Promotion Section was formed in 2023. We started activities based on the recognition shared within the task force about the need for redefining the values of happiness and richness, which change with the times, in order to think about the future.

Nagahara: As a hypothetical prospect of a future society 50 years from now, we adopted the assumption that people will spend more time on their hobbies, traveling, and participation in social activities. Against this background, we envisioned a future society using the method known as "future foresight," and drawing up specific images. Among them was one depicting "a society in which animal-like vehicles are a popular means of personal mobility" and featuring people traveling around the world by riding leopard-like vehicles. That very image of the leopard-like robotic vehicle provided the basis for developing the concept of the four-legged mobility machine.

Murakami: Also, around that time, Japan Association for the 2025 World Exposition, supervisor of the Future City exhibition, announced the venue allocation plan that included a request for Kawasaki to enter the "Transportation and Mobility" showcase category. In consideration of these conditions, the Promotion Section started discussions to explore the possible ways of presenting our exhibition.

Nagahara: The Promotion Section took over discussions from the task force and set their direction so that the exhibition theme should convey universal and fundamental messages to all people, based on the results of discussions held at the task force and the grand theme of Expo 2025 "Designing Future Society for Our Lives." For this purpose, we looked into academic studies on transportation and mobility and learned about the theory stating that humans are predisposed to derive happiness from the act of moving. We adopted this theory as the basis for establishing the theme of "Impulse to Move."

Amatatsu: We delved into this subject more deeply and found the explanation that the impulse to move had two different purposes to accomplish: comfort of traveling as a way to reaching the destination; and the thrill of adventure regardless of the destination. Based on this finding, we decided to develop the concept of two different modes of mobility, specifically for mass and personal transportation.

Murakami: In addition, we felt a responsibility to contribute to the future of the both sectors, as Kawasaki has established businesses both for public transportation systems related to railways, aircraft and ships and personal vehicles such as motorcycles and jet skis.

Inoue: In line with this, we decided to include a hydrogen power unit in the concept by adopting it as the power source for both the mass and personal mobility systems, considering that the Kawasaki Group has established a full-scale hydrogen supply chain, the world's first of its kind.

Would you explain the concept of CORLEO?

Amatatsu: In the field of personal mobility, Kawasaki's specialty lies in motorcycles. However, we were negative about choosing a wheeled vehicle as the subject of showcasing a future vision because such a plan would likely focus only on pursuit of technological evolution, which might result in too professional, or even geeky, exhibits. This would not be suited to the purpose of the expo. Rather, the expo exhibits should be something novel and have intuitive appeal. So, we thought we needed to create an unprecedented, completely new type of vehicle, and at the same time, it should be able to offer the equivalent of the distinctive sensation that captures what many motorcycle riders experience, the feeling of being one with the machine. We also decided to develop totally new-concept maneuvering mechanisms to replace traditional steering and accelerator systems.

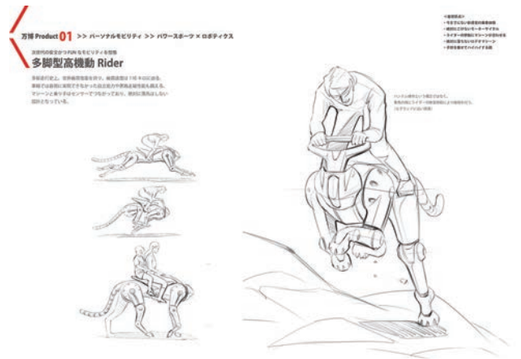
Yusuke Amatatsu

Senior Staff Officer, EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group; Branding Section, PR Department, Corporate Communication Group

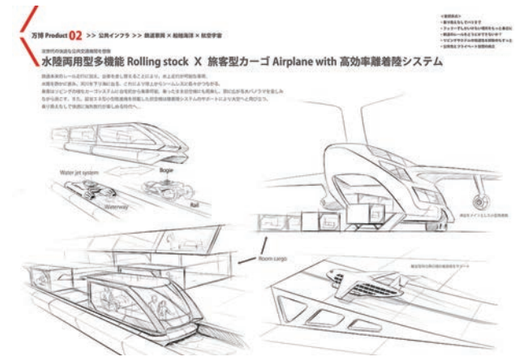
EXPO 2025 Osaka, Kansai, Japan Promotion Project Leader. Responsible for all exhibits, videos and other works created for the project.

For developing the new mechanisms, we used the control principle based on weight shift, an essential function of horse riding. Imagine that you are giving your child a ride on your back. You will move while detecting the shift of the child's weight in order to prevent them from falling. A similar process can be applied to innovate an unprecedented form of maneuvering method while increasing the safety of tandem ride to an appropriate level, which is difficult to achieve with conventional motorcycle technology. In addition, "legs" can offer greater stability than wheels, and can enable even children and physically weak people to climb up rough mountain roads safely and have a new experience of viewing scenery that has been virtually inaccessible to them before.

Our plan was to create a vehicle that can be maneuvered simply by the rider shifting their weight while ensuring the safety of off-road travel. Implementation of that innovative idea could be made possible only with a multi-legged structure. For appearance design, we started by planning to use the cheetah as a motif, and changed later to the present motif of the lion, looking to present a robust appearance in a bid to offer a clearer sense of safety and security.



Initial design drawings of CORLEO, some accompanied by a proposal for using the tail for hydrogen refueling.



Amphibious vehicle designed to change modes by replacing parts (left). Aircraft loading private rooms (right).

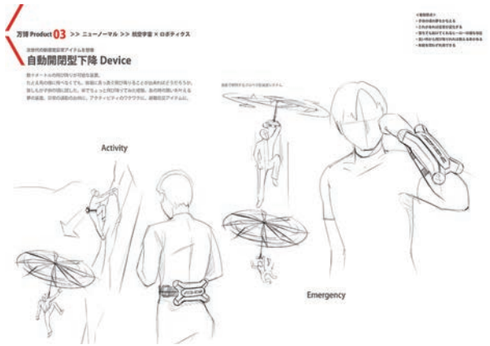
—— Would you explain the concept of ALICE SYSTEM?

Inoue: We began by thinking how we could realize our wish to utilize Kawasaki's technological capabilities in the mobility sectors of land, sea and air in order to solve issues associated with ongoing public transportation service systems. Among many issues, we took particular note of the stress experienced by passengers in various situations, such as riding a crowded train and needing to transfer. We also looked at the recent trend of a growing number of consumers choosing personal mobility modes rather than mass transportation means. Against this background, we set the goal of creating public transportation system models that can eliminate the stress felt by all types of passengers while enabling services to provide comfortable private spaces.

We brainstormed many interesting ideas, including one for the cabin to transform itself into an automobile, train car, ship and helicopter easily by fitting optional parts, and finally decided on the plan for an interconnected mobility system centered around the cabin that allows for transfer-free travel, which has taken shape as ALICE SYSTEM.

—— Could you give some other examples of plans considered but rejected?

Hayashi: Among the finalists was my proposal for an automatic parachute, a device to be worn on the arms so that it will be activated automatically as needed to protect the user jumping from a high place. It would allow for efficiently leaving the office by enabling the user to avoid using the stairs and elevators and instead jumping from the window down to land safely. This would also effect an "extreme" leaving session. The idea came from my passion for rock climbing and represents a dreamlike tool to enable lifeline-free cliff climbing. Personally, I was instinctively very excited about this proposal, which however was rejected because it just did not qualify as a means of mobility.

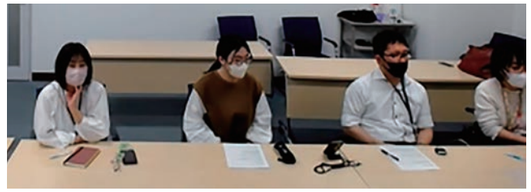


Imagery of the proposed (but rejected) automatic parachute, a device for jumping from a high place to land safely, like the traditional parachute.

Kensuke Inoue

Senior Staff Officer, Global Marketing & Sales Department, Advanced Smart Mobility Supervisory Department, Presidential Project Management Division; EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group

Previously engaged in the design of railroad vehicles before taking the current position involved in the planning, marketing and sales of service robots. Also assigned to the EXPO 2025 Osaka, Kansai, Japan Promotion Section to take charge of the ALICE SYSTEM.



Hearing from workers at Kawasaki Heartfelt Service about issues with public transportation systems.

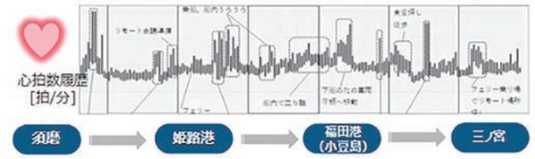
—— Could you give some details about the field research?

Nagahara: We did field research for a number of issues in response to advice received from President Hashimoto to listen to people on site and consider comfort for all people.

Inoue: We began by collecting feedback from wheelchair users and those with hearing difficulties working at Kawasaki Heartfelt Service about problems with using public transportation services. We learned specifically about the inconvenience they experienced related to eye levels and handling of coats and recognized the need for a design to solve such stressful situations.

Nagahara: To gain a better understanding, section members organized a hands-on experience session to travel in a wheelchair from Kobe to Sannomiya using a train. This provided us with firsthand knowledge of present issues faced by many train passengers in wheelchairs due to difficulties with getting on and off the train and buying tickets and drinks.

Reaching out in an attempt to press the button on the vending machine while sitting in the wheelchair but failing because of the height (left). Having difficulty controlling the bodily position appropriately to use the ticket machine (upper right). In the car ferry, staircases are a major means of moving between decks (lower right).



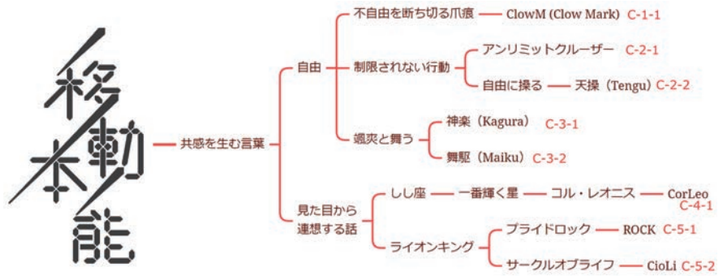
Heart rate monitor readings recorded while traveling on the car ferry, indicating elevated heart rate associated with moving up and down the steps on board. The data also revealed the accelerating heartbeat recorded at the time of boarding.

Hayashi: We also conducted an on-site survey on a car ferry.

In the express train with sleeping berth, having difficulty passing down the 60 cm-wide aisle while carrying bulky luggage.

While noticing people with disabilities having difficulties in moving on board, mainly due to narrow aisles and particularly between decks, I also took note of the benefit of traveling on a ship that houses large public spaces on decks where interaction with other passengers are likely to occur naturally. Actually, I happened to meet one of my fellow rock climbers during the survey, a happy surprise coming from traveling. Findings from these experiences were reflected in the concept of ALICE SYSTEM that places importance on public spaces such as the dining car and lounges.

I wore a heart rate monitor during the survey, and the readings indicated an elevated heart rate not only while climbing up and down the steps between decks but also when boarding the ship, though I didn't know why. I guessed that the phenomenon might come from the thrill I felt about embarking on a journey, and it was evidence supporting the theory about humans being predisposed to deriving happiness from the act of moving. I also did a survey on an express train with sleeping berth, and identified major issues with passing down the aisles while carrying bulky luggage and in private compartments with insufficient convenience despite a certain degree of consideration given to comfort. This gave a basis for discussions to determine the ideal aisle width.



Tomoyuki Hayashi

Assistant Manager, External Affairs/ Regional Co-creation Section, General Administration Department, General Administration Division; EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group

Responsible for operating events and the exhibition booth related to the EXPO 2025 exhibition. Also organized related events at the General Administration Division.

Inoue: One interviewee at Kawasaki Heartfelt Service shared with us an unforgettable episode, which was about the tremendous challenges for wheelchair users to overcome to ride an airplane, which is often an indispensable process to engage in "supporting my fave" activities. This poses extraordinary stress on the person, which however could not damp down their passion for the activities, revealing the strong human impulse to move.

Nagahara: That episode and the wheelchair experience helped cement my determination to propose a future society that can solve the present stress we have identified. Also, the surveys made us more confident in the concept we developed for ALICE SYSTEM.

—— How did you decide the names of CORLEO and ALICE SYSTEM?

Murakami: In the early days, we just used symbolic terms "Concept 1" and "Concept 2." Before long, we began to think of giving a concrete name to each in order to make our exhibits memorable to Expo 2025 visitors while also increasing our sense of attachment to them.

Tanaka: We also thought that having a name would help get good media exposure and aid promotion activities.

Murakami: One hopeful but unsuccessful candidate name for the present CORLEO was "Kagura," a Japanese word meaning

"divine joy," which referred to the "ultimate joy of riding a vehicle" in our context. Our expectation was that the Japanese name would have a particularly strong appeal to foreign visitors. Unfortunately, however, the term turned out to be a registered trade name.

Amatatsu: Further out, some suggested that in order to cause a huge buzz, the idea should have attractive background stories and logical reasons. That was the beginning of the painful days Mr. Murakami had to do massive amounts of brainstorming. The history of his painful efforts can be traced on this diagram.

Murakami: The name CORLEO is coined from the words "Cor Leonis," the brightest star in the constellation Leo, which means "the heart of the lion." Reasons for this choice lie in evoked images fitting in with the appearance as well as our commitment to creating mobility solutions for fulfilling the human impulse to move to take a brave step into the unknown. ALICE is an acronym for "Accessible Linkages for Innovative and Comfortable Experiences," an expression of the image of the system, and in line with the direction of discussions to use an abbreviation of multiple words given the difficulty with finding just the right single term to represent the system. Among many unsuccessful candidates was "C4 System," a coined phrase beginning with an abbreviation for "cabin," cube," "comfortable" and "connect," which could not outdo "ALICE." A deciding factor was that, as the name ALICE is used in the title of a world-famous classic novel, it sounds familiar to many people, and the thrill of the lead character's "adventures in wonderland" has a common base with the impulse to move.

Amatatsu: I was impressed by Mr. Murakami's strong commitment to the naming of the exhibits while overcoming a lack of relevant expertise. The Promotion Section, as a project team, follows the principle of individual initiative and responsibility. So all members encouraged each other to "do what you want," showing mutual respect.

Inoue: Expo 2025 created a golden opportunity to take up the challenge to do what you want to do. Thanks to members having diverse backgrounds, the team was able to build a culture of openness and generosity to embrace challenges.

Hitoshi Nagahara

Senior Staff Officer, Innovation Promotion Department I, Innovation Center, Corporate Technology Division; EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group

Responsible for formulating the exhibition theme and concepts for the Expo 2025 exhibition and promoting activities for discussing the mobility of a future society

Promotion Section members explore the future possibilities of mobility with students.

Owing to this environment, everyone was able to fulfill their responsibility for completing all the tasks. This was beneficial to each individual.

—— What did you do specifically in the promotion of the Expo 2025 exhibition?

Hayashi: We visited elementary and junior high schools throughout the country to run workshops, in which we explored the possibilities of future mobility systems with local students while introducing the concept of CORLEO and ALICE SYSTEM to them. Our tour encompassed large areas from Fukushima in the north to Hiroshima in the west, giving classes to more than 1,000 students in total. Some of them visited our exhibition and we had a happy reunion.

Tanaka: We received cooperation from students of HAL Osaka, junior college of technology and design. Kawasaki had no relationship with the school before then, and we directly made a request, which was accepted willingly, in spite of our fear of rejection, fortunately. The students participated in the production of our exhibition at Virtual EXPO, and worked as interns mainly on the design of the "Impulse to Move Lab." We had a very meaningful time engaging in creative work with young people.

Nagahara: I think the theme of Expo 2025 "Designing Future Society for Our Lives" should also be the theme of the overall society. I noticed a sign of this view coming true when I saw many children at workshops expressing their creative ideas vividly. I truly felt the important meaning of Expo 2025 aiming to engage many people in thinking how to create a bright future society.

Kawasaki's exhibition booth "Impulse to Move Lab" at Virtual EXPO.

—— CORLEO caused a huge buzz, recording more than 100 million views on social media in a week from its unveiling. What do you think of this phenomenal response?

Amatatsu: From the beginning, development of our PR plans centered around social media promotion. The most important policy was to present an appealing appearance. To this end, we prepared good-looking materials and appropriate media kits, which helped achieve a good result. Our goal has been that our exhibits will leave their mark, primarily, on the record of Expo 2025 as well as the memory of its visitors, and this did not necessarily consider global-scale targeting. So, honestly, we were pretty surprised at the big sensation caused by CORLEO around the world. In the promotion of ALICE SYSTEM, we carried out preemptive strategies, chiefly by distributing information online about the concept and purpose from early on in a bid to build a good understanding, and hosting seminars and workshops. These worked well.

Image of CORLEO in silhouette, used for promotion before its unveiling for the first time when Expo 2025 opened according to the strategy for increasing a sense of expectation.

Murakami: At the exhibition venue, we received favorable feedback from many visitors requesting early implementation while expressing high expectations for Kawasaki's technology. That was what we aimed for by achieving the right balance between the reality and the dream. The dream only could not go as far as this.

Nagahara: Visitors' responses revealed their confidence in Kawasaki. This is largely attributable to our strength in diverse business areas. A specialist in a single sector, motorcycle or robotics, might be able to present a comparable exhibition but could not receive comparable responses.

Inoue: We obtained many specific suggestions about the possibility of application, such as CORLEO for disaster rescue and ALICE SYSTEM for cabin-based shops. This also means a successful achievement of one of our goals to inspire many people in the world to have discussions in pursuit of better mobility systems.

Shinji Tanaka

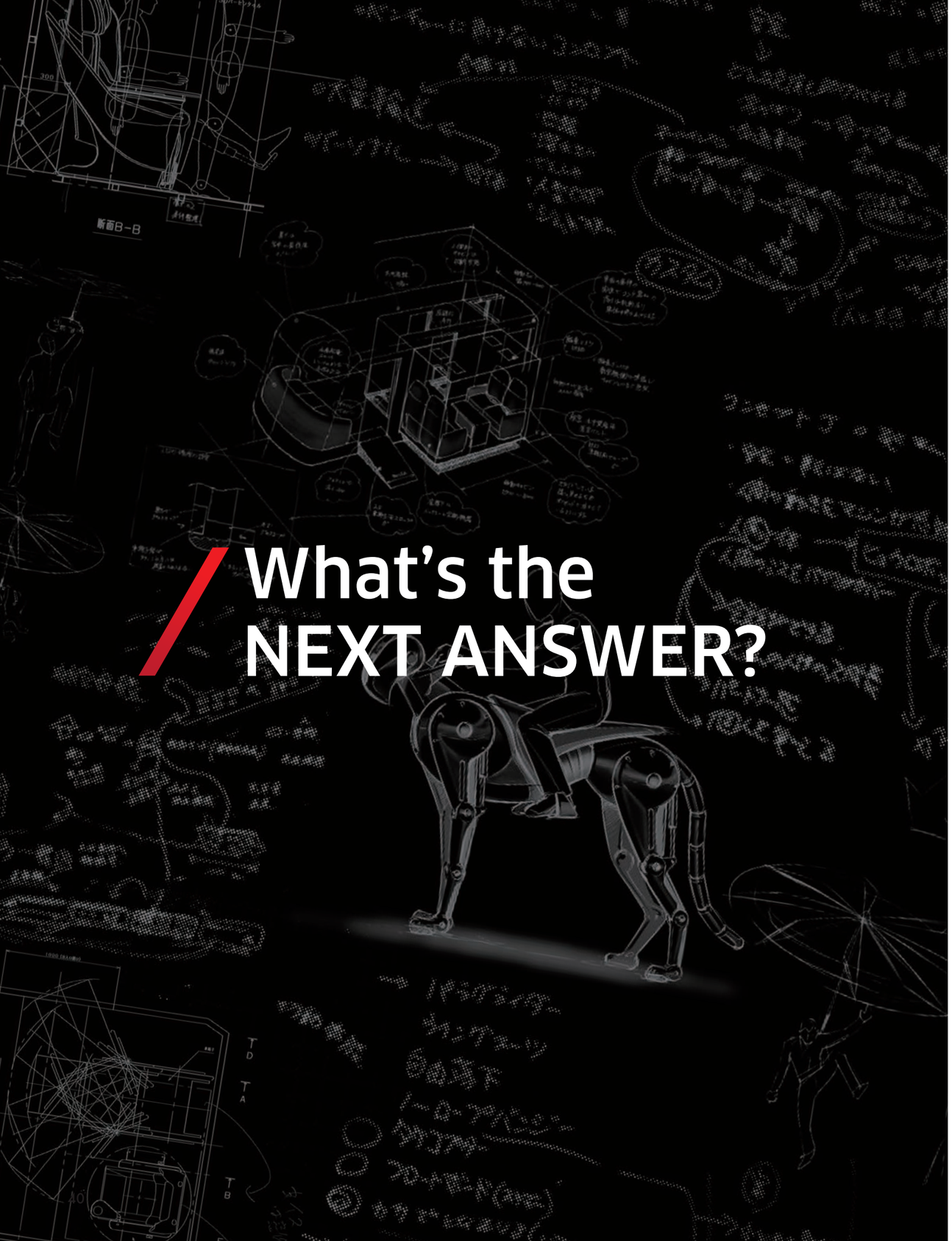
Assistant Manager, Inner Area Section, PR Department, Corporate Communication Group; EXPO 2025 Osaka, Kansai, Japan Promotion Section, Corporate Communication Group

Promotion Section member responsible for public relations planning and the planning and production of the virtual exhibition for Virtual EXPO.

—— Now the successful Expo 2025 exhibition has closed, what are your future plans for taking up a challenge?

Tanaka: After Expo 2025, the actual exhibits of CORLEO and ALICE SYSTEM will be transferred to Kawasaki Good Times World and be on display. The virtual simulation space created for Virtual EXPO will also be included in Kawasaki's special site for Expo 2025. We hope many people will visit there to meet them and experience a futuristic society presented by Kawasaki.

Amatatsu: One of the notable exhibits of the recent expo was the "Human Washing Machine," a remodeled version of the attention-grabbing product that appeared in Expo 1970 in Osaka. Like this, symbolic exhibits that have left their mark on the history of the world exposition are likely to be updated and appear in the event years later. We hope we can showcase a more sophisticated model of CORLEO and ALICE SYSTEM in the next expo to take place in Riyadh, Saudi Arabia, in 2030. I'm ready, willing and able to do this. So, join me and work together aiming at the next expo!



Kawasaki Heavy Industries Group
Main Products and Production Bases by Business Segment

Business Segment	Main Products	Main Production Bases
Aerospace Systems	• Aircraft (fixed-wing aircraft and helicopters), missiles, electronic equipment, space systems and peripheral equipment, simulators	Gifu Works (Kakamigahara, Gifu Prefecture) Nagoya Works 1 (Yatomi, Aichi Prefecture) Nagoya Works 2 (Tobishima-mura, Aichi Prefecture) Kawasaki Rail Car Lincoln, Inc. (U.S.A.)
	• Aircraft components, target systems, rocket components, space equipment • Aircraft servicing and remodeling	NIPPI Corporation • Yokohama Plant (Yokohama, Kanagawa Prefecture) • Atsugi Plant (Yamato, Kanagawa Prefecture)
	• Aircraft engines, Aircraft gear boxes	Akashi Works (Akashi, Hyogo Prefecture) Seishin Works (Kobe, Hyogo Prefecture)
Rolling Stock (Kawasaki Railcar Manufacturing Co., Ltd.)	• Train cars, integrated transit systems, freight cars	Head Office & Works (Kobe, Hyogo Prefecture) Harima Works (Harima-cho, Hyogo Prefecture) Kawasaki Rail Car Lincoln, Inc. (U.S.A.) Kawasaki Rail Car, Inc. (U.S.A.)
	• Rotary snowplows, deicing material spreaders • Railway motor cars, heavy-lift cars	NICHIJO CORPORATION. • Akebono Plant (Sapporo, Hokkaido) • Inaho Plant (Sapporo, Hokkaido)
Energy Solution & Marine Engineering	• Cement, chemical, conveyers, and other industrial plant systems • Industrial boilers, power generation business boilers, etc., for land and marine use • Waste treatment facility • LNG tank and other low temperature storage facilities	Harima Works (Harima-cho, Hyogo Prefecture) Anhui Conch Kawasaki Energy Conservation Equipment Manufacturing Co., Ltd. (China)* Anhui Conch Kawasaki Equipment Manufacturing Co., Ltd. (China)* Shanghai Conch Kawasaki Engineering Co., Ltd. (China)*
	• Industrial gas turbines (for cogeneration, emergency power generators), gas engines for power generation, industrial steam turbines • Centrifugal compressors, air blowers and other aerodynamic machinery • Main engines, propulsion systems and other marine machinery	Kobe Works (Kobe, Hyogo Prefecture) Akashi Works (Akashi, Hyogo Prefecture) Harima Works (Harima-cho, Hyogo Prefecture) Wuhan Kawasaki Marine Machinery Co., Ltd. (China)
	• Air conditioning equipment, general-purpose boilers	Kawasaki Thermal Engineering Co., Ltd. • Shiga Works (Kusatsu, Shiga Prefecture)
	• Crushers, recycling equipment and plant	EARTHTECHNICA Co., Ltd. • Yachiyo Works (Yachiyo, Chiba Prefecture)
	• LNG carriers, LPG carriers, crude oil carriers, bulk carriers, container ships, car carriers, high-speed vessels, submarines, ships for government and municipal offices	Kobe Works (Kobe, Hyogo Prefecture) Sakaide Works (Sakaide, Kagawa Prefecture) Nantong COSCO KHI Ship Engineering Co., Ltd. (China)* Dalian COSCO KHI Ship Engineering Co., Ltd. (China)*
Precision Machinery & Robot	• Hydraulic equipment for construction machines, hydraulic equipment and systems for industrial machines • Marine application machines, steering gear and other marine deck equipment • Industrial robots • Medical and pharmaceutical robots	Akashi Works (Akashi, Hyogo Prefecture) Nishi-Kobe Works (Kobe, Hyogo Prefecture) Kawasaki Precision Machinery (U.K.) Ltd. (U.K.) Kawasaki Precision Machinery (U.S.A.), Inc. (U.S.A.) Wipro Kawasaki Precision Machinery Private Limited (India) Kawasaki Precision Machinery (Suzhou) Ltd. (China) Kawasaki Chunhui Precision Machinery (Zhejiang) Ltd. (China)* Kawasaki (Chongqing) Robotics Engineering Co., Ltd. (China) Kawasaki Robotics (Kunshan) Co., Ltd. (China) Flutek, Ltd. (Korea)
	• Hydraulic presses	Kawasaki Hydromechanics Corporation (Akashi, Hyogo Prefecture)
Powersports & Engine (Kawasaki Motors, Ltd.)	• Motorcycles, off-road four-wheelers (Side × Sides, ATVs), Jet Ski® personal watercraft • General-purpose gasoline engines	Head Works (Akashi, Hyogo Prefecture) Kakogawa Works (Kakogawa, Hyogo Prefecture) Kawasaki Motors Manufacturing Corp., U.S.A. (U.S.A.) Kawasaki Motores do Brasil Ltda. (Brazil) India Kawasaki Motors Pvt. Ltd. (India) Kawasaki Motors Enterprise (Thailand) Co., Ltd. (Thailand) PT. Kawasaki Motor Indonesia (Indonesia) Kawasaki Motors (Phils.) Corporation (Philippines) Kawasaki Motores de Mexico S.A. de C.V. (Mexico) Changzhou Kawasaki Engine Co., Ltd. (China)

*Affiliated company-equity method

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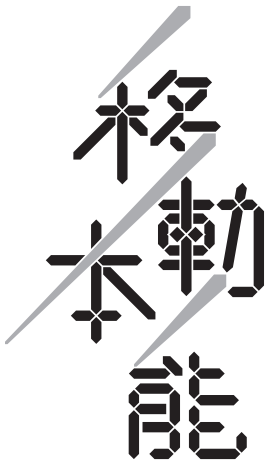

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