Kawasaki's Solutions in Three Fields of Focus

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Introduction

Since its foundation in 1896, Kawasaki has striven to develop product that are the first of their kind in the world or in Japan to meet the needs of rapidly changing times and has been developing cutting edge advanced technologies in the areas of land, sea and air for over 100 years. In the meantime, global warming and infectious disease problems have developed on a global scale recently and we are facing a major paradigm shift, as can be seen with decarbonization technology and the digital transformation (DX). Our Group Vision 2030 has been presented to serve as a compass as we navigate our way to such a discontinuous and uncertain future.

1 Social issues and our three fields of focus

The novel coronavirus disease (COVID-19) that spread across the entire world in 2020 has completely changed our daily lives. If we are unable to discover remedies for COVID-19 and allow the fighting back and forth between vaccines and variant strains to prolong, not only will the burden be concentrated on healthcare professionals, but the world economy may be more seriously affected, mainly in the transport and restaurant industries, due to the activities of people around the world being brought to a standstill. IT-based remote work has spread only among office workers, and I suspect many people are working while desperately trying to avoid the risk of infections.

In recent years, the advancement of global warming should be obvious to anyone. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) recognized that human activities affected climate change as well as the sea-level rise and expressed its view that the achievement of carbon neutrality by 2050 is essential in limiting the rise in the average global temperature to within 1.5°C of pre-industrial levels. In addition, intensifying natural disasters have become an issue recently, and so the development of infrastructure to ensure disaster prevention and natural disaster reduction is urgently needed.

To solve these social issues, Kawasaki has set out three fields of focus: A Safe and Secure Remotely-Connected Society, Near-Future Mobility, and Energy and Environmental Solutions.

Efforts beyond the boundaries of companies are essential in each of these fields of focus, and we are also working to develop a system for making such efforts. The Presidential Project Management Division, which is under direct control of the president, is aiming for early commercialization of the "Automated Robotic Polymerase Chain Reaction (PCR) Testing System," "Near-Future Mobility," and other projects by leveraging technological synergy in cooperation with internal companies. We have also established the Hydrogen Strategy Division in our head office as an organization that plays a leading role in the realization of a commercial-scale hydrogen energy supply chain.

The following describes the concept of our solutions in each of these fields of focus.

2 A Safe and Secure Remotely-Connected Society

In the field of "A Safe and Secure Remotely-Connected Society," we will utilize our technologies for the purpose of applying remote technologies to workplaces where actual physical work is involved to enable all people to take part in society, protecting lives and properties from disasters, and so on.

(1) Medical and health care

The "hinotori Surgical Robot System" is the first made-in-Japan robotic-assisted surgery system developed by

Medicaroid Corporation, a joint company between Kawasaki and Sysmex Corporation. The system is low cost and small enough to fit in a small operating room, and it is easy to operate. Going forward, we will work to incorporate remote operation via commercial 5G, for the purpose of reducing the burden of surgery on physicians.

The Automated Robotic PCR Testing System, developed as a COVID-19 countermeasure, contributes to further reducing the burden of physicians and other healthcare professionals by fully automating the testing system.

Although vaccination is found to be effective on a global basis, development of a screening test system based on high reliability PCR testing is essential to fully restore the mobility of people around the world due to the successive emergence of new variants. The automated and systematic testing system using our robot can perform high volume, high accuracy testing in a short time without omitting any of the required processes. Driving the development at an unprecedented speed, we are implementing the system into the monitoring test service in cooperation with local governments.

Advancing this project requires us to work to solve various issues in addition to developing technology; that is, to clear some constraints including permits and licenses for installing the Automated Robotic PCR Testing System in a short time as well as to learn hospitality skills that are indispensable for the "service of selling experiences" to the general public. This initiative is a perfect example of open innovation and agile development.

Currently, the system is mainly implemented in the monitoring service for local governments, and a future issue in this initiative is to expand the service to a screening service for various events. In a situation where an overwhelmingly large number of countries require an official negative PCR test result certificate to be submitted as an entry requirement, our automated PCR testing service could play the important role of stimulating passenger traffic on international flights. This testing service, for which we aim to fulfill the requirements for obtaining an international certificate, could also play the important role of eventually returning the private sector airline businesses to a growth trajectory by spreading this service.

(2) Proposal on a new way of working and living

As remote work has spread, more and more people are now balancing work and life, which allows them to effectively use their time. However, the types of occupations that allow workers to work remotely are currently limited. In fact, when a state of emergency was declared for COVID-19, workers engaged in nonclerical work deemed to be essential work could not avoid going to their usual workplace.

If actual physical work at a factory, etc. can be performed remotely, not only can the way people work be changed, but manufacturing equipment in factories overseas, for example, can be operated from anywhere in Japan. In addition, manufacturing hours can be significantly reduced because it would not involve travel, which would drastically change the structure of the manufacturing industry. Technologies that could serve as the keys to such

Fig. 1 Implementation of the automated PCR testing service business

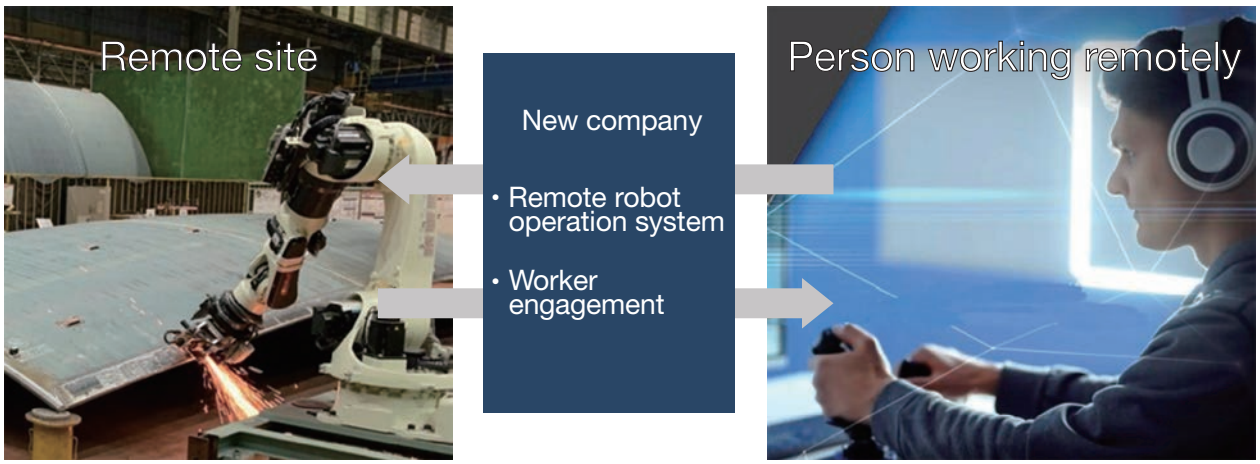

Fig. 2 New value provision based on a platform

a change are remote technologies and robotics.

One such technology is our "Successor," a new robot system featuring remote instruction technology. Remotely operating a robot requires the judgment and senses of a human and introducing a robot in the manufacturing industry, which involves many atypical tasks, is extremely difficult. Our "Successor" is a remote instruction system that reproduces the sensory input of actual physical work and helps the user perform intuitive operations. The user can have the same sensory input in a remote location that they would have doing the actual physical work. The system also enables succession of skills, which was so far impossible with robots, and can be used at a variety of factories because it can be used in combination with a different robot system depending of the purpose of the work.

We are also considering offering a comprehensive service that covers the life cycle of industrial robots, from installation to maintenance of robots, in order to accelerate automation required in many different areas. We are now advancing the development of software functions and the Robot as a Service (RaaS) platform required for that service.

Since remote work that involves actual physical work is needed in the areas of health care and distribution as well as the manufacturing industry, "Successor" is expected to become a solution to the labor shortage.

We are also working to provide new value to our solutions. For the creation of a remote platform that connects people who are willing to work and business operators who need a workforce, we will jointly establish a new company with the Sony Group in fall 2021.

The new company will allow people who had difficulty conducting social activities to take part in society remotely, enabling them to enjoy a new way of working and living regardless of location or time. We will provide new solutions for the "realization of a society that everyone can take part in."

(3) Protecting people from disasters

Realizing a safe and secure society is an indispensable part of dealing with the increasingly intensifying natural disasters in recent years.

In addition to involvement in various infrastructure restoration projects from the Han-Shin Awaji Earthquake disaster in 1995 and the Great East Japan Earthquake disaster in 2011, Kawasaki has been working on products, technologies, and solutions that contribute to disaster prevention and natural disaster reduction.

In the event of a disaster, lifelines such as power and water must be secured first. Installing emergency power generating units is an effective way to ensure a stable supply of electricity. We offer emergency gas turbines, and our Kawasaki PU series includes a total of 21 models covering a wide range of outputs. At the time of the Great East Japan Earthquake disaster, all of our gas turbine units (except one that had not been maintained properly) operated successfully in the wake of the earthquake.

What is needed next is a mode of transportation for transporting goods to damaged areas. With four-wheelers and dirt bikes, medical supplies and other goods can be delivered quickly and stably even if road conditions are poor due to a disaster. The multipurpose vehicle known as the MULE PRO-FX (EPS), which was adopted as a fire engine for the first time in Japan, is well received for its mobility and off-road performance.

The Kawasaki "BK117" helicopter has been adopted by many institutions as a helicopter ambulance to carry patients even if land routes have been disrupted to provide medical care at remote locations. The BK117, jointly developed with Airbus, features a high level of safety and operating performance as a result of improvements over

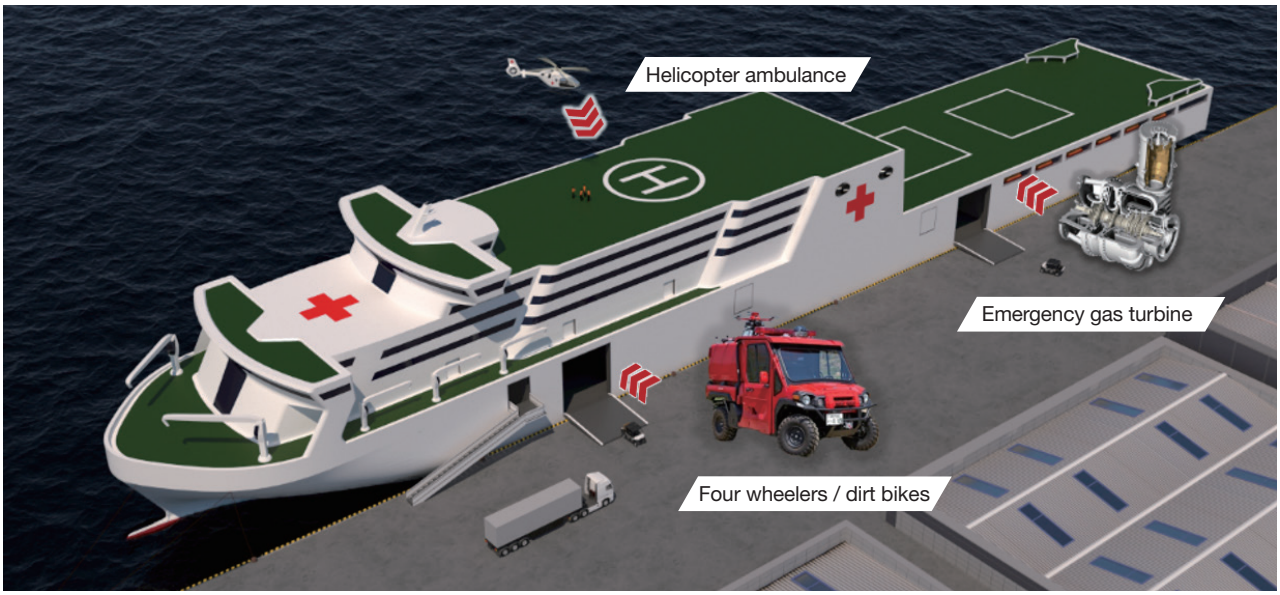

Fig. 3 Rescue hospital ship

many years.

The Japanese government considered the use of a rescue hospital ship in the face of large-scale disasters and the COVID-19 pandemic. Our strength lies in our ability to propose a comprehensive package by combining a remote surgery support robot system and our other products and services.

3 Near-Future Mobility

As a result of changes in people's lifestyles, aside from the progress in CASE (Connected, Automated, Shared, Electric), the environment surrounding mobility is about to make a huge change. At Kawasaki, we have set out "Near-Future Mobility" as one of our fields of focus, aiming at a

Fig. 4 Goods transportation by an unmanned helicopter

society where people and freight can be transported securely, quickly, and efficiently, or while enjoying travel.

Distribution, in particular, is important social infrastructure supporting people's lives. However, the spread of COVID-19 has further accelerated this situation. This momentum has strengthened due to an increase in stay-at-home consumption as a result of people voluntarily refraining from going out and stores and restaurants refraining from operating since 2020, and there is no doubt this situation will become a part of everyday life even in the post-COVID-19 world.

In the meantime, the labor shortage in the distribution industry is becoming serious. The issue of developing a secure and safe environment for delivering goods without being infected with COVID-19 and the issue of securing a distribution network to underpopulated areas must be solved urgently.

With drastic changes such as the development of e-commerce, congestion in cities, and a move towards sharing, in a post-COVID-19 world, changes can also be seen in the movement of people and freight.

Many companies are working to develop autonomous driving technologies to deal with the labor shortage and efficient transport, drones for carrying goods to underpopulated areas and areas isolated by a disaster, other IoT and AI technologies that are necessary for improving efficiency in transport routes and managing goods, and so on.

On the other hand, we provide new solutions combining robotics, mobility, and aviation.

For example, what can be done if we combine the helicopter manufacturing technology that our Aerospace Systems division has cultivated and our lightweight, high output engine cultivated through experience with the "Ninja" Our unmanned compound helicopter, K-RACER, is a realization of such an idea.

The autonomous delivery robot installed on the K-RACER delivers cargo to the entrance of the recipient's home, and the contents of the cargo and the identity of the recipient are confirmed through a conversation between the recipient and AI. Realizing this would bring innovation to the last mile in distribution.

We plan to put it into service in 2022 after going through trial operations at our factory for checking the rotational and running performance as well as the performance of the communication function.

These innovative technologies can be applied to transportation to isolated islands and steel tower work and transport in mountainous areas. We will actively participate in activities in support of deregulation for social implementation of the technologies in regional cities, commercial facilities, hospitals, and so on.

4 Energy and environmental solutions

During the Climate Change Summit hosted by the U.S. held in April 2021, countries around the world announced their greenhouse gas (GHG) reduction targets and goal of achieving carbon neutrality. Japan also declared it will target a 46% cut in greenhouse gas emissions by 2030

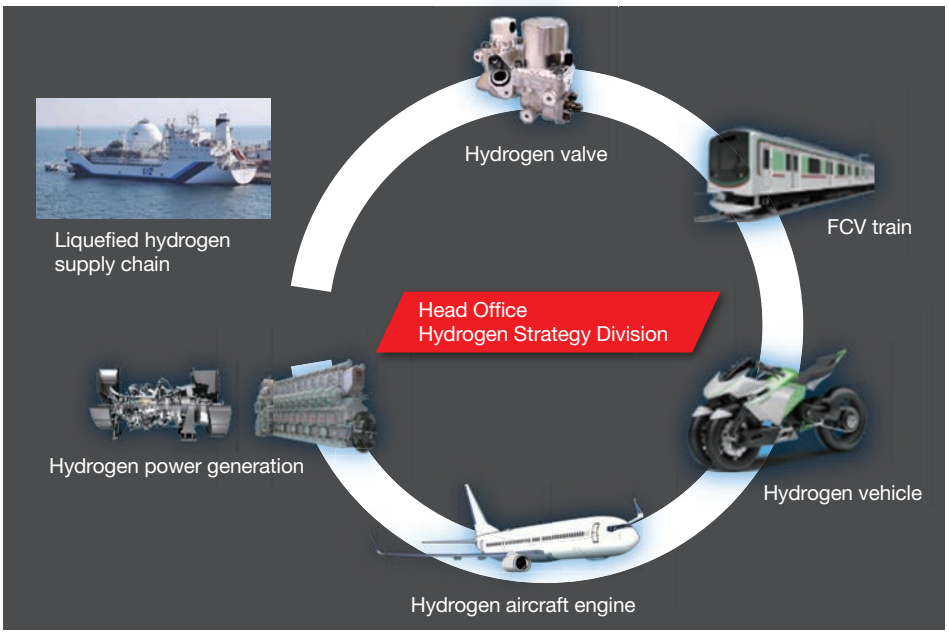

Fig. 5 Further development of hydrogen-related products and businesses

from 2013 levels and achieve carbon neutrality by 2050.

Kawasaki's key solution to the achievement of decarbonization is our hydrogen business that we are working on ahead of others in the world. We have already started demonstration tests, in which mass transportation of blue hydrogen obtained from brown-coal in Australia to Japan is carried out by a liquefied hydrogen carrier. In August 2021, "commercialization demonstration of the liquefied hydrogen energy supply chain" was adopted by the New Energy and Industrial Technology Development Organization (NEDO) Green Innovation Fund Program. In this program, the technologies for large-scale liquefaction and transport of several million tons of hydrogen per year will be established ahead of the world as part of a full-scale initiative to implement a CO_2-free hydrogen energy supply chain in society in anticipation of a hydrogen mass consumption society for achieving carbon neutrality. Then, a demonstration of an international full liquefied hydrogen energy supply chain, including everything from manufacturing, to liquefaction, shipment, marine transportation, and unloading of hydrogen, will be conducted.

We are also undertaking a green hydrogen project, in which hydrogen is manufactured and liquefied from renewable energy and then transported to Japan. In December 2020, we signed a memorandum of understanding (MOU) with Fortescue Metals Group, a major iron ore company, and Iwatani Corporation and are conducting a feasibility study, aiming at demonstration in the mid-2020s.

As a hydrogen utilization project in Japan, we started power generation based on hydrogen mixed combustion at a combined cycle power generation plant for Seibu Oil Company Limited in August 2021.

Although hydrogen is attracting attention as clean energy that does not emit CO_2 during combustion, it emits a lot of nitrogen oxide (NOx). To solve this issue, we have developed a hydrogen dry low NOx combustion gas turbine and succeeded in demonstration testing for the first time in the world. Electricity and thermal energy generated from the hydrogen combustion gas turbine are being supplied to urban areas in Kobe City.

These hydrogen combustion technologies have been implemented in the areas of aircraft, vessels, and motorcycles, and we aim to demonstrate an aircraft engine combustor by 2030.

In the area of international marine transportation, the International Maritime Organization (IMO) has created unified global rules to prevent marine pollution and set out the long-term goal of "aiming to achieve zero GHG emissions as soon as possible within this century." In response, we will lead the world in the development of marine hydrogen engines through collaboration with Yanmar Power Technology Co., Ltd. and Japan Engine Corporation, aiming for a market launch of marine hydrogen engines in 2025.

In addition to such a decarbonization initiative with hydrogen, we are also working on electrification and the use of hybrid technologies while actively applying such technologies to motorcycles and construction equipment including shovels.

Conclusion

Thanks to the efforts of our predecessors who lived through a period of dynamic changes, Kawasaki has accumulated a long history of over 100 years, and by extension, we are now able to live our lives as company employees.

In the face of ongoing global-level historical changes, will we be able to leave Kawasaki Heavy Industries as a vessel for new generations over the next 100 years? We will awaken the DNA we had at the time of our foundation and flexibly improve our internal system so that our corporate culture of continuing to take on the challenge of solving anticipated social issues will be firmly established.

In this way, we will respond to rapidly changing social conditions and issues arising from such conditions with a sense of speed.