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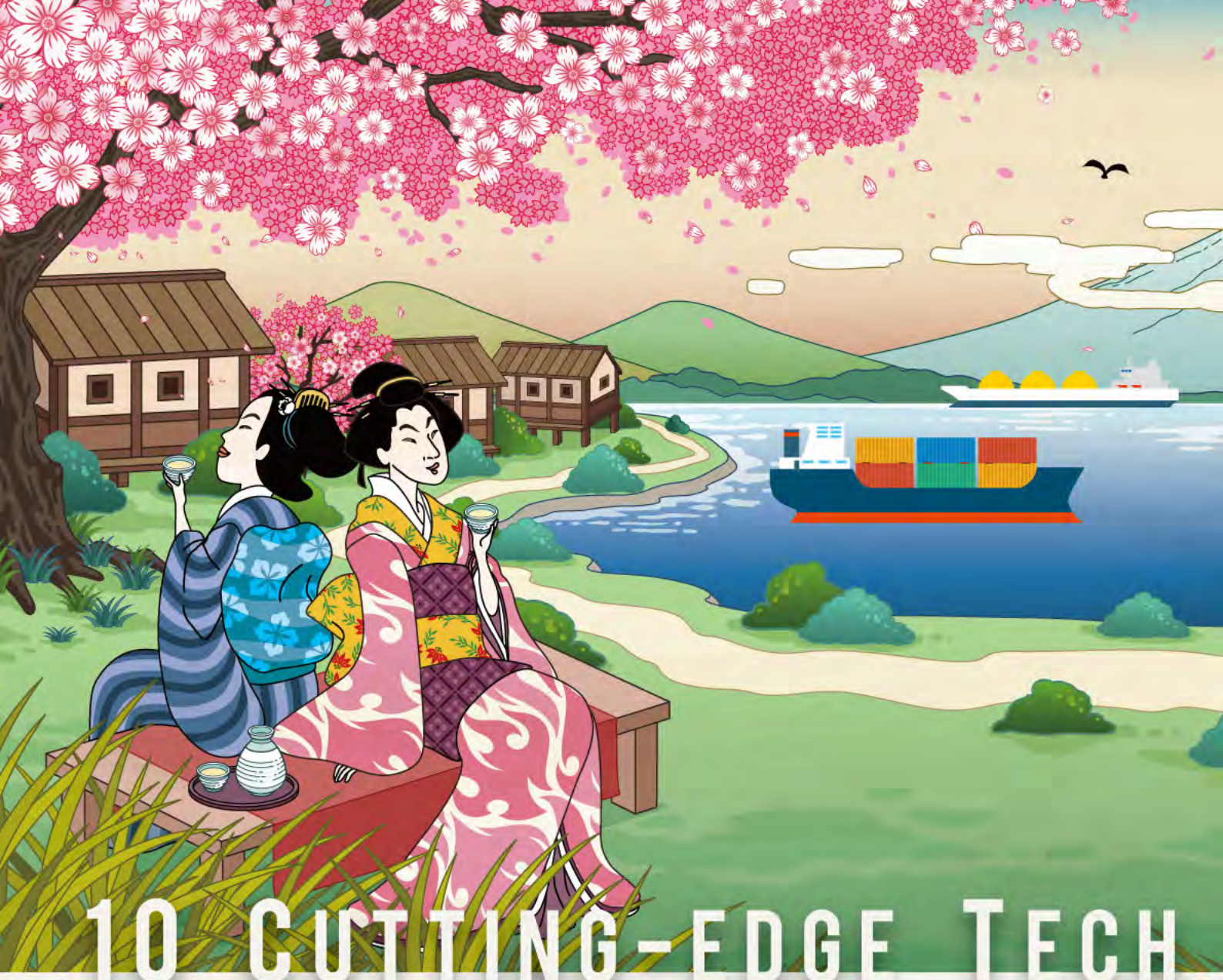

10 CUTTING-EDGE TECH

Japanese Shipbuilding and ship equipment industry

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To help manufacturers develop and realise new products, Japan Ship Machinery and Equipment Association has received support from the Nippon Foundation and is now providing business assistance to them.

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ZERO EMISSION AND AUTOMATED SHIP NAVIGATION REALIZED IN NAGASAKI

The *e-Oshima* is a small ferry powered by a lithium ion battery with an automated ship navigation system installed onboard. It is a vessel that has taken on the challenge of both automated ship navigation and zero emissions.

Passengers travelling on the *e-Oshima* were surprised at just how quiet and speedy the vessel was. "It really is quiet," and "It's much faster than I thought," were the sort of comments heard from passengers after sailing on the vessel.

Oshima Shipbuilding completed the *e-Oshima* in 2019. The ship does not use an internal combustion engine but, an onboard battery provides the electrical power for propulsion and all other power requirements such as communication and navigation equipment and lighting. While sailing it does not have any emissions, including carbon dioxide (CO_2) or nitrogen oxide (NOx) and others, making it a zero emission vessel. The ship uses two 300kWh lithium ion batteries supplied from global battery maker GS Yuasa. In addition, it is fitted with two Kawasaki Heavy Industries azimuth propeller systems and a main switchboard from Fuji Electric Company in combination. A unique feature of the ferry is the use of a direct current (DC) grid system realizing a more compact installation and highly efficient use of power.

Battery pack

Recharging takes place from a specially designated pier when the vessel is alongside. It takes around 2.5 hours to charge the battery if it is completely flat.

By using a high performance inverter system, in combination with the battery powered propulsion system, a seamless acceleration is achieved. The ship also has advanced manoeuvrability.

Oshima Shipbuilding uses the *e-Oshima* to pick up shipowners for naming and delivery ceremonies at its own shipyard. Shipowners board the vessel and, after the naming ceremony, can sail alongside their newbuilding and observe the yard and ships under construction from the window or the promenade deck.

One more feature of the vessel is its automated ship navigation function. The automated ship navigation technology, which has recently been drawing the attention of the world, has been applied on an experimental basis to the ship. There are three main automated sailing features on the vessel. The first is the automation of routing and speed control. The crew create a route plan and set the

waypoints, or the final waypoint, and the arrival time. Based on these settings the automated ship navigation system fixes the automated pilot's route and the propulsion unit's speed.

The second is the automation of the collision avoidance system to prevent collisions with other ships. Based on information from the Automatic Radar Plotting Aid (ARPA) and the Automatic Identification System (AIS) the ship can identify vessels sailing around its route and automatically navigate to avoid collision. The third is that the ship can also collate data from electronic charts and navigate to avoid grounding.

The *e-Oshima* also has a system to assist berthing operations. It is a system which overlays data on the ship's wake, its movement vectors, bow and stern movements and speed and distance from the berth on an electronic chart.

This automated ship navigation system was developed from MHI Marine Engineering's navigation support system Super Bridge X. A risk analysis of the system was conducted by ClassNK.

The vessels wake is shown on screen during automated operations

In Japan shipping companies, shipbuilders and machinery manufacturers are cooperating in progressing a number of research and development projects to realize automated ship navigations. *e-Oshima* is one of those projects. The automated ship navigation system used on this vessel has been selected by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) as one of the demonstration projects. Through real operations the systems usability from the seafarer's point of view will be improved along with other matters, then it is expected the knowledge will be incorporated into industry guidelines.

Oshima Shipbuilding specialises in the construction of bulk carriers for the international trades. Every year it builds around 40 bulk carriers, but it does not build small ferries like the *e-Oshima*. However, based on its management philosophy to consider the world environment, Oshima Shipbuilding has been tackling the development of the next generation of environmental technology. For example, projects such as developing an LNG fuelled bulk carrier and "Wind Challenger", to use of wind power in the next generation of sailing ships, are progressing. The next challenge of achieving the zero emission ships led to the all battery powered vessel. Oshima Shipbuilding started to discuss the potential of battery ships internally in January 2017 and sent a research team to America and other countries.

As a result, the future "e-mobility" project was confirmed and in 2018 it was decided to start the design of a battery powered ship. With the cooperation of battery makers, the necessary equipment was investigated. As there were no rules on the use of batteries on ships, there was an exchange of views with the MLIT and the ship's specifications were decided.

At the launch ceremony, Oshima Shipbuilding representative Sho Minami was joyful when he said: "This ship is not just a ship built by us. Our young employees have been central to the project and, borrowing the power of all Japan, we have been able to complete this vessel."

In the future the aim is that through the use of solar power to fuel the ship's battery, it will become a "totally emission free vessel." The ferry *e-Oshima* looks like becoming a symbolic vessel in the new age ahead.

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INTERVIEW

ONBOARD CARBON CAPTURE
MITSUBISHI SHIPBUILDING

The world maritime industries have started to work toward 50% reduction in greenhouse gas (GHG) emissions by 2050. Mitsubishi Shipbuilding's onboard carbon dioxide (CO_2) Carbon Capture and Storage (CCS) system with methanation is among the candidate solutions being trailed.

— How is Mitsubishi Shipbuilding tackling GHG reduction technology?

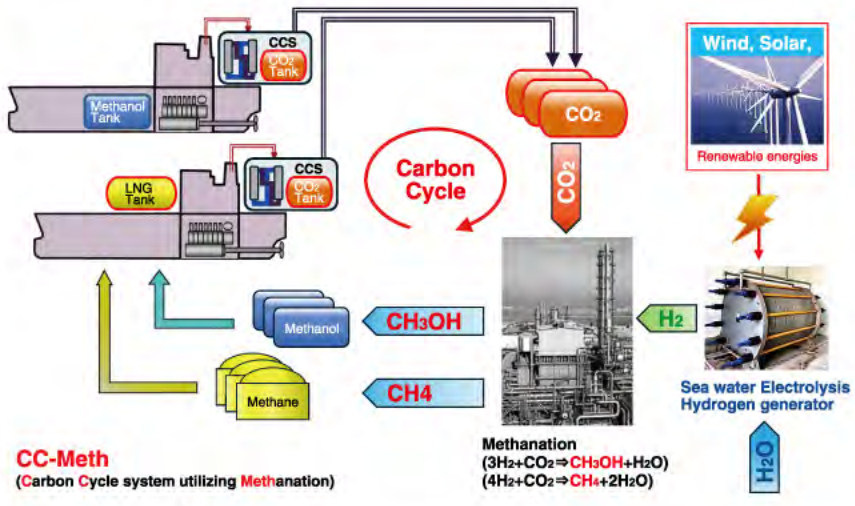
"In 2018 the IMO decided on its GHG strategy, but our company has been seriously progressing with research aimed at halving emissions, or even designing emission free vessels, since 2017. A 50% reduction of emissions, or zero emissions from entire industry cannot be achieved by using existing technology.
The solutions to this challenge are wide ranging, but can be broadly split into two areas. One is to use a propulsion system with carbon free fuels such as hydrogen and ammonia. Another is to continue to use fuels containing carbon, but to capture the carbon emissions in a continuous cycle. We started by thinking about these two approaches. The former approach is not an issue for a shipbuilder as our major functions are fabrication. We don't own fuel processing technologies. Rather, the engine makers play key roles in the research and development of using decarbonized fuels such as hydrogen, ammonia, biofuel and others at the moment. It will be at the later stage that shipbuilders work on risk assessment or the integration of propulsion systems using these fuels. So, first we focussed on the latter approach to reduce GHG, which is an area we supposed that we could bring in additional value as a shipbuilder. Firstly, we researched methanation and onboard CO_2 capture technology."

— Why did you choose methanation?

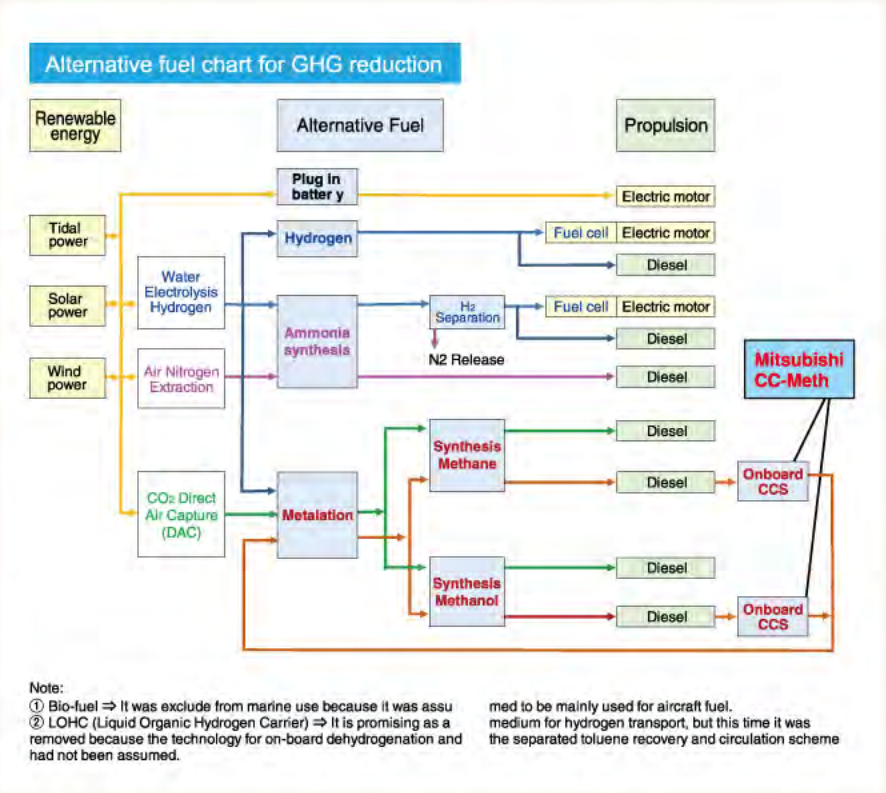
"Each GHG reduction technology has pros and cons. The optimal solutions also differ depending on ship type,

Takashi Unseki,
Chief Engineer

Concept of Mitsubishi "CC-Meth"



voyage distance and the surrounding infrastructure.
For example, batteries can achieve zero emissions but the energy density and power output is low. Thus they are good solution for near short voyages, but not suitable for long distance voyages. For containership and VLCC vessels, which need a large power output and trade in long distance voyages, using methanol or ammonia as fuel looks to be a realistic solution to cut GHG. Hydrogen has an extremely low temperature of minus 253 degrees centigrade, while ammonia is toxic making them difficult to handle. In contrast methane and methanol have already been used as marine fuels, so they have already been combusted in diesel engines, and there is some experience in how to handle these fuels, making them easier to deal with."



Note:
① Bio-fuel ⇒ It was exclude from marine use because it was assu med to be mainly used for aircraft fuel.
② LOHC (Liquid Organic Hydrogen Carrier) ⇒ It is promising as a medium for hydrogen transport, but this time it was removed because the technology for on-board dehydrogenation and the separated toluene recovery and circulation scheme had not been assumed.

— Why can you achieve zero emissions with methanation?

"The concept of methanation involves using wind and other renewable energy sources to generate electrical power to produce hydrogen which, through a catalyst, reacts with CO_2 to create methane or methanol. As carbon is being captured and reused, using this synthetic methane as fuel is regarded as being CO_2 neutral.
We developed a concept combining methanation technology and Onboard Carbon Capture and Storage system, and named as *CC-Meth* (Carbon Cycle system utilizing methanation). With this concept, as well as using methanation fuel as a marine fuel, CO_2 captured from exhaust gas through a liquid amine absorption method is liquefied and stored in a tank on deck.
Captured CO_2 is offloaded at port and again used in a reaction process with hydrogen to create methanation fuel. This is a scheme using proven existing technology where CO_2 is not emitted into the atmosphere but reused onboard a ship."

— What has been the result of the design and feasibility study of this system?

"Firstly, we came up with concept designs for VLCCs, bulk carriers, domestic cement carriers with CCS systems and calculated the payback scenario. In the case of VLCC, we found out that the application of CCS system will give such impact as 5,000 extra light weight and 50% extra CAPEX. The payback period will be around 20 years under certain conditions, for example, the price of renewable electrical energy would have to be around $ 5c per kw, a fuel tax of around $200 to $240 per tonne, or a carbon or emissions tax of $20 to $24 per tonne of CO_2.
On the other hand for small vessels the size of the system would be too large in comparison to the size of the ship and the ship price would also double so, even if conditions changed, it would be impossible to recover the investment.
So, the other solutions, such as fuel cell power systems or batteries would be suitable for small ships"

— Capturing carbon also involves equipment and cost

"This concept design has been performed under the cost estimation of the land-based carbon capture equipment, so future cost reductions from mass production in marine use were not included. Also, at this stage, there are a lot of necessary conditions that have not yet been established such has a fuel tax or carbon trading.
However, we have shown a trial calculation of a CCS solution that combines existing technologies and clarified economic conditions. This leads to a concrete discussion to realise this model as one of the GHG reduction scheme from shipping industries.
In fiscal 2019 the concept design of a carbon capture system on a 20,000-teu containership will be carried out. We understand as onboard CCS solution is just one possible candidate. Apart from that our company is also looking at developing the design concept of ammonia fuelled panamax bulker. We will keep tracking all sorts of technologies to meet the needs of our customers whatever they might be."


Kazuki Saiki,
Deputy Manager

Online training system "INFINITY Training" using xR technology

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JRCS's Digital Innovation Lab

JRCS Co. Ltd is well known as a marine equipment maker involved in the manufacture and sales of electrical power distribution systems, control and measurement instruments for ships. Its products have been installed on more than 7,000 ships around the world, supporting efficient and safe navigation. In 2018, on the occasion of its 70th anniversary, it targeted a major shift from an electrical systems manufacturer to a digital business and set a new target of becoming a leader in digital innovation.

INTERVIEW

Koichiro Kondo
Managing Director

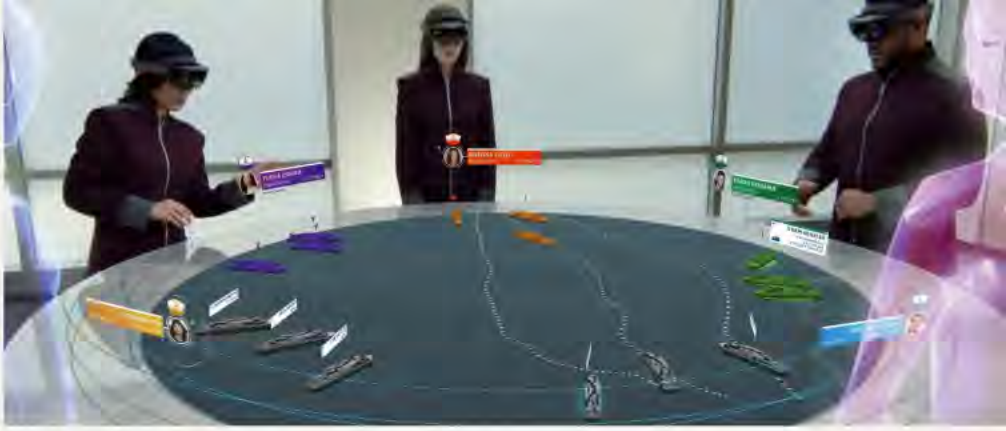
Q: What is the current situation of the JRCS Digital Innovation LAB?

A: Development is progressing smoothly. Firstly, we introduced the remote training system *INFINITY Training*. It is a market where customers' needs are high and it will have a huge impact on the industry. After that we developed the remote onboard machinery maintenance support system *INFINITY Assist*. By remotely assisting with onboard work the system can also help make up for onboard skills shortages. We expect that this will be a digital solution which greatly transforms onboard and machinery makers' working practices. As a further advancement of technology we are also planning a remote ship operation system called *INFINITY Command*.

Q: Is the final aim to develop automated shipping?

A: Yes. As we cannot provide autopilot and other systems we need the cooperation of a business partner. So we can use our sensor data, visual information and other information toward automated ship operation we also need to prepare an information input and output structure and interface. By using a digital twin it will also lead to the capability to monitor

JRCS aims the realization of autonomous navigation



To advance the digital transformation of the maritime industries JRCS established the JRCS Digital Innovation LAB. At the JRCS Digital Innovation LAB has taken on the challenge of combining its accumulated technology and knowhow with product data, and the latest digital technology, to develop and supply the optimal solutions to customers.

The JRCS Digital Innovation LAB, under the company's digital service brand *INFINITY*, is cooperating with leading digital businesses to develop remote crew training and land to ship maintenance support systems. In the future its ambition is to work with other companies toward building solutions for remote ship operation and independent ship navigation.

As part of this project JRCS tied up with Microsoft Japan in 2018. Under the cooperation it is taking on the development of technology that mixes the real and virtual world to create a mixed reality (MR) "HoloLens" goggles for seafarer training. It is also working on combining MR with artificial intelligence (AI) to assist in ship maintenance during operation and working toward independent ship operation.

The first major step in the project was the establishment of a remote training system, called *INFINITY Training*, using the HoloLens goggles in April 2019. By installing Microsoft's translation function the service allows Japanese and non-Japanese seafarers to participate in remote training at any place and time.

Following that, in the second stage of the project, a remote maintenance service called *INFINITY Assist* was developed. *INFINITY Assist* uses MR, IoT and AI technology to remotely support seafarers in the onboard maintenance of machinery and contribute to safe navigation. JRCS commercialized its own high voltage distribution network maintenance application in 2019, and in 2020, is planning to expand its contents. The company is aiming to develop the system into a shared maintenance platform in the future which other companies can also supply.

The mid-term objective of the project is to be able to provide a land-based ship operation solution, called *INFINITY Command*, in preparation for automated ships. It is aiming at beginning the service from 2025. The project is based on a future world in which the ship's master does not board the ship but instead a digital captain controls several ships from a land base.

The JRCS Digital Innovation LAB, through the *INFINITY* project, intends to cross national boundaries to set up cooperation with other companies. JRCS is progressing digital transformation and innovation as part of the theme of turning the maritime industries into an industry of the future.

Digital Innovation LAB

Safety Remote Maintenance

the condition of ships from land.

Q: What is the role of JRCS in the digitalisation of the marine industry?

A: For example, in Japan, every sector has its own distinct technology. Our company wants to create an open platform structure that will gradually allow partners to participate. In the past our company only looked at electrical networks and control systems but we want to broaden our scope to offer visual recognition and ship operation applications.
From July 2019 we launched a new development project in the US.

Q: How do you secure personnel with digital skills?

A: Even if we utilise the resources of outside partners we ourselves must have a flexible approach to digital technology. It is not easy to secure personnel with digital skills but we are trying. After recruitment we can even train digital skills to new employees. Also, when it comes to recruiting engineers, it is important for us to improve our brand image. As products increasingly move toward software, we cannot be seen simply as a hardware manufacturer of products such as electrical systems. Going forward we want to be known as a brand that thinks out-of-the box and comes up with ground-breaking ideas.

Atsushi Sora
Digital Innovation LAB
Chief Digital Officer (CDO)

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Installation of structural supports on upper deck

TSUNEISHI'S NEW LR1 TANKER IS LIKE A "BIG MR"

The TSUNEISHI SHIPBUILDING newly developed 77,000-dwt product/chemical tanker is interchangeable with the established Large-Range (LR1) product tanker. But the new design has also introduced the concept of the large-size Medium-Range (MR) tanker.

Among bulk carrier sizes the 82,000-dwt type is called a Kamsarmax. TSUNEISHI SHIPBUILDING was the first to name this ship type in 2002. At the time all panamax bulk carriers were built to a length within 225 meters.
But, after a detailed marketing of world ports, Tsuneishi discovered that an even longer hull could still access most ports. So, Tsuneishi extended its panamax design by four meters to 229 meters and announced the arrival of a new design capable of entering the Republic of Guinea bauxite port of Kamsar. The design became a hit and Tsuneishi's new Kamsarmax design has gone on to become an industry standard. More than 300 Tsuneishi Kamsarmax bulkers have now been built and the design holds the largest share of the world market for this vessel type.

Now Tsuneishi has once again launched to the world a new design that has the potential to open up a new market. The design is a new type LR1 product tanker. Like the Kamsarmax the key word to describe this design is pioneering.

Existing LR1 tankers trade naphtha between the Middle East and the Far East and supplement the role of the LR2 tanker. The trade's cargo lots are set as 25,000 mt x 2 + 10% equalling 55,000 mt.

Because the trade is largely fixed, most LR1's have a cargo capacity of 87,000 cubic meters, a length of 229 meters and 32.2-meter beam. The LR1 can be said to be a mature design. But, Tsuneishi noticed that some MR tanker operators were saying, "We want to load even more cargo into the MR product tanker." However, the MR product tanker trade is very different to that of the LR1 product tanker. It transports European and United States gasoline, and diesel from the US to Europe. There is also an MR trade from North to South America and around the Middle East.

From this the new LR1 tanker design concept that Tsuneishi has developed can also be described as an enlargement of the MR tanker, or a "Big MR."

MR trading routes

LR trading routes

Firstly, the new LR1 design, like existing MRs, has been built to carry a variety of cargoes. It can carry oil products like gasoline, naphtha and diesel oil, as well as crude oil cargoes. It can also carry vegetable oil, and IMO type II and type III chemical cargoes. In common with MR designs it has also employed an independent pump system. LR1 and LR2 tankers typically employ a pump room style, but Tsuneishi's new design, like MR tankers, has an independent pump for each of its 12 cargo tanks and two slop tanks. It has been designed to carry up to six different cargoes.

Structural innovations have also been used on the within cargo tanks. Generally, in LR1 tankers, structural elements to maintain strength are placed within the tanks. But in this design, like MR tankers, the structural elements are connected to the upper deck, with a corrugated bulk head within the cargo tank. Because of this hull structures do not overhang into the cargo tanks. This makes tank cleaning easier and reduces cargo residue. This design also realizes a more flexible operation of the vessel.

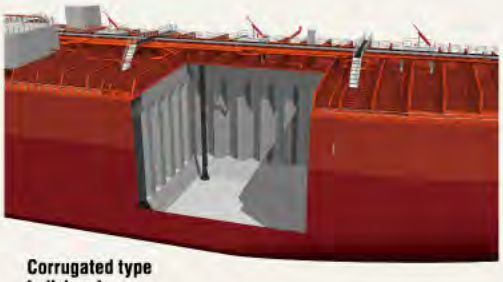
At the same time the new design LR1 vessel has been equipped with the versatility to enter a variety of ports. Using the MR tanker as a benchmark, it has a wider beam and shallow draft which has increased capacity while, at the same time, allowing the LR1 design to enter all the ports used in the traditional MR trades.

Consideration has been given to port draft restrictions and the height of the cargo manifold. The new LR1 design's draft and depth has been set at the same level as the MR tanker with a 13.3 meter fully loaded draft and a depth of 19.3 meters. As there is virtually no trade passing through the old Panama Canal docks the beam has been widened to 38 meters to allow a larger cargo capacity.

It is not just a case of the vessel being capable of entering the traditional MR ports, the cargo capacity has also been increased compared to previous MR tanker designs and the traditional LR1 tanker. In the design of the vessel a cargo capacity of 92,000 cubic meters was set. Tsuneishi's designers got a hint from the car industry on how to increase cargo capacity. In Japan in recent years the "Tall Wagon" car design, which reduces emissions but increases internal space, has become a hit. It is a car design which has reduced engine room space and moved the fuel tank to increase the internal volume. TSUNEISHI SHIPBUILDING took this into consideration and set about reviewing the fuel tank, engine room and other machinery arrangements to increase the size of the LR1 cargo tanks. As a result it has achieved advanced cargo space efficiency. When the new LR1 design's length x beam x depth is taken into consideration it has achieved a cargo space efficiency of 55%, which significantly surpasses the industry average for an LR1 tanker of 50%.

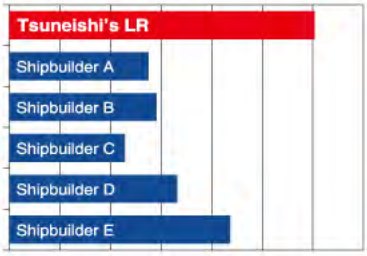
Plenty of energy efficiency technology has also been incorporated in the design. As well as an optimized hull form, a Tsuneishi designed fin (MT-FAST) has improved propulsion efficiency by 4%. An energy efficient propeller, (TOP-GR), a reaction rudder, and an accommodation unit with low air resistance were employed. A fuel efficient G60-type main engine was installed. The result was it achieved a 35% improvement on the energy efficiency design index (EEDI) standard that was created for newbuildings to reduce carbon emissions. The efficiency standard of the new LR1 design is even enough to clear the upcoming EEDI phase III standard.

TSUNEISHI SHIPBUILDING launched the first of the new design LR1 tanker, the *Orange Victoria*, from its Chinese shipyard TSUNEISHI GROUP (ZHOUSHAN) SHIPBUILDING in March of 2019. Other shipyards have now developed their own wide beam shallow draft LR1 tanker designs but TSUNEISHI SHIPBUILDING has the lead on this trend. Tsuneishi aims to continue as the market leader by continually improving its LR1 design.



Corrugated type bulk head

Cargo Capacity/LBD



Energy saving hull fitting MT-FAST

Ship hull forms have evolved step by step but there has been very little change in the design of rudders. A group of people who challenged this situation by asking "can't the propulsion performance by newly developed rudder be improved?" have now come up with the world's first gate shaped rudder.

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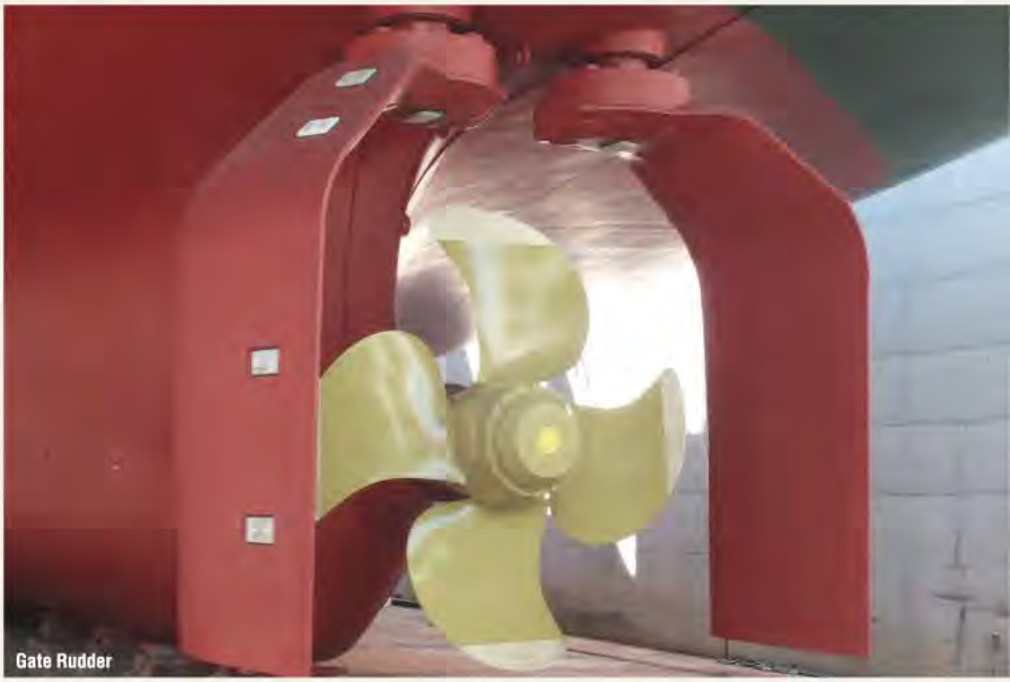
A GATEWAY TO INNOVATIVE PROPULSION SYSTEM

Japan's first specialist rudder is now drawing considerable attention as a subject of research in the shipbuilding field. The name of this device is the Gate Rudder, which Japanese ship-owners, shipyards, foreign engine makers and oil majors are all now considering.

As the name suggests the Gate Rudder is consists of two uniquely shaped rudders placed in parallel either side of the propeller, which reduces resistance of rudder and creates thrust to improve the fuel consumption. And also, at slow speeds, by changing water flow of the propeller, in combination with a high-powered bow thruster, berthing and unberthing performance can be improved considerably. Further a stern thruster is then no longer required. Vibration and noise can be reduced because of reducing the required thrust of the propeller as main source by generating thrust from the rudder, and of equalizing the non-uniform flow into the propeller disk area by placing a rudder either side of the propeller. The benefits of the Gate Rudder are quite wide. For example, as the rudder and propeller are integrated, a ship can be compact. By moving the propeller toward the rear, the main engine room can also be placed at the stern. As a result, without changing the size of the vessel, cargo space can be increased. Removal of the propeller and shaft is also easier.

The company that took on the challenge of developing this technology is Kamome Propeller Co., Ltd. established in 1924 in Tokyo which is a comprehensive manufacturer and service provider involved in the development, manufacture and sales of ship machinery, propulsion and maneuvering systems, now based in Yokohama and tackling the development of energy saving products.



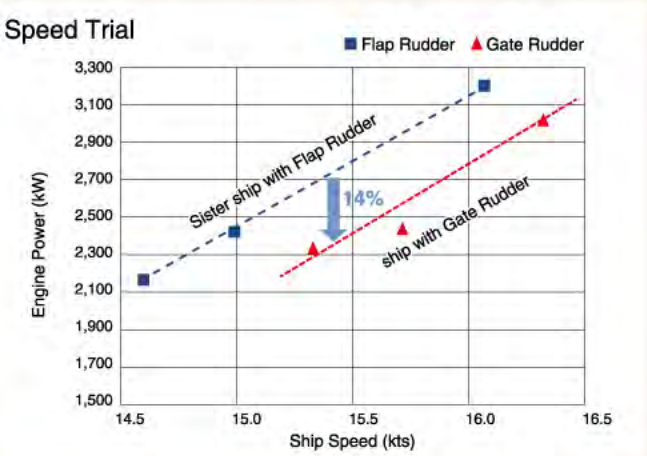
Gate Rudder

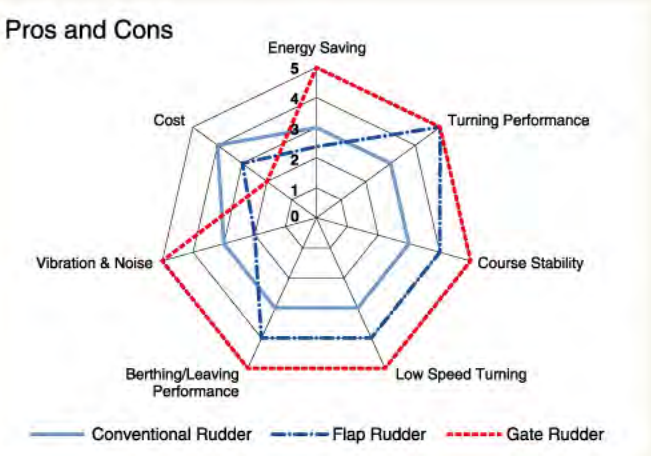
Originally, rudders were equipment using lift forces to change the direction of the ship. The basic principle of placing the rudder in the area where the flow of water is the quickest, behind the propeller, has not changed in the last 200 years. However, a rudder which protrudes from the ship's stern also acts as a brake creating resistance.

Technology has advanced, and ship's hull form has developed, but improvements in the main rudder have remained elusive. Within the shipbuilding industry it has long been held that major improvements in performance cannot be expected from the rudder.

But there were some people who questioned the industry's common knowledge and asked the question "Can the performance of the rudder really not be improved upon?" Kamome Propeller also went along with that line of thinking and joined in the challenge of developing a new type of rudder. The result was it completed an integrated system of propeller and rudder which was to become the Gate Rudder, the world's first new type energy saving rudder.

The development project began in 2012 by Chairman Sadatomo Kuribayashi of Kuribayashi Steamship Co., Ltd. who brought the idea of the





hollow rectangular type rudder to the National Maritime Research Institute (NMRI). From his own experience as a yachtsmen company chairman Kuribayashi has some familiarity with how things were in the age of sailing ships, when rudders not only played a part in changing the direction of the ship, but also in providing propulsion. Strathclyde University visiting Professor Noriyuki Sasaki, now technical consultant at Kamome Propeller, was at NMRI at the time and with his partners began conducting trials.

The rudder shape was revolutionary but at first it was installed in the traditional place behind the propeller. The results were not so good as expected, but the opportunity was taken to develop a new rudder and the momentum of the project began to pick up. As the trials and discussions progressed, the idea to locate the rudder to the side of the propeller was proposed by NMRI, while company chairman Kuribayashi suggested dividing the rudder shaft and operating each rudder plate independently in an improvement of the design. The idea to have the integrated propeller and rudder system was then born. Professor Sasaki said: "There was an understanding that if the rudder is not behind the propeller it will not be effective. It was necessary for the research to reverse that thinking and look at it from an original view point."

It was the world's first attempt to develop a new type rudder. Kamome Propeller and Kuribayashi Steamship group company Kay Seven Co., Ltd., with the support of The Nippon Foundation, began a project for two years including actual ship test from fiscal 2018. Many young engineers from Kamome Propeller were assigned to the project. Kuribayashi Steamship and Yamanaka Shipbuilding Co., Ltd. and others were also involved in working together toward the realizing the product.

As this was a rudder which had not been built before, a few miscalculations were made. For example, it was decided to test the rudder on a containership and tests on the efficiency of the rudder and propulsion system were carried out in advance. Professor Sasaki estimates were for energy savings of around 8% but model tank tests showed zero savings. Company chairman Kuribayashi did not believe the result. Later it was realized that, as this was a new type of rudder, it is not possible to use the existing testing and estimation procedures. At the time some of the partners for research group doubted the usefulness of the system but Professor Sasaki said, "it will be ok," and progressed with the research.

Six years after the outset of the project in 2017 Kamome Propeller, Kay Seven, Yamanaka Shipbuilding, navigation equipment maker Tokyo Keiki Inc. took on the challenge of sea trials. The Gate Rudder was fitted onto 416-teu containership *Shigenobu* operated by coastal shipping company in Japan Imoto Lines, Ltd. and its basic reliability was confirmed.

The earlier miscalculation turned out to be a happy one. Compared to the sister ship Sakura, built one year earlier, Shigenobu showed a 14% improvement in energy saving comparing higher than the estimate.

In fiscal 2018, to collect a full year's data, an experienced engineer was put on Shigenobu to test all performance data and in-service monitoring began. The vessel outperformed the previous year averaging a 33% improvement in energy savings. By repeating these experiments, the various benefits of the Gate Rudder were confirmed.

Professor Sasaki bravely predicted: "In three or four years time, considerable numbers of the gate shape twin rudder will come onto the market." As for the future development on he said: "First we need to improve the manufacturing." From now on developing high accurate design methods along with testing and analysis on a variety of vessels is planned, following the survey planned for the 499GT cargo ship of Kuribayashi Logistics System to be built this summer. There are still a lot of unknowns about the Gate Rudder, and crew on ships where it has been tested have said there are merits still to be uncovered. "I expect there are still uses which have not been realized yet, I'm looking forward to it," said Professor Sasaki. Sasaki and the Kamome Propeller members have bright eyed optimism and say they are looking forward to the future.

Supported by
日本財団
THE NIPPON FOUNDATION

Development team of Gate Rudder

日本海事産業は今

FLEXIE BRINGS NEW VERSATILITY

The first car carrier was built in Japan in the 1960s. Since then car carriers have gradually developed and changed shape. The new FLEXIE concept has again evolved car carriers into a new shape.

At port the letter A on a bright blue hull catches the eye. Onboard a team of stevedores park brand new cars one after another. This is a new 6,800 car capacity car carrier developed by Mitsui OSK Lines, Minaminippon Shipbuilding and Japanese machinery manufacturers that has been calling on ports since 2018.

The new concept FLEXIE is not a ship that sticks to one route, it is a ship designed to trade to a variety of ports. In recent years car carriers do not just carry cars but also a different sizes and shapes of vehicles and equipment including construction machinery, agricultural equipment, railway stock and others. Also, in line with the trends of the day, these shapes and sizes change over time. For this reason if car carriers deck heights are optimized for low cars they will not be able to load high sided vehicles. On the other hand, if the number of high-level decks is

increased then, if low cars become popular again, it will create a void space and waste cargo capacity and create inefficiencies. So, the FLEXIE design has been developed to be highly adaptable car carrier that can cope with whatever the cargo combination and whichever trade it is engaged in.

The specialty of the FLEXIE is that it has six floors of "liftable" decks. With this a number of deck patterns can be created. For example, if a large number of low cars are loaded the deck height can be lowered to just two meters. If a pattern is used where all the decks are required to be raised, then they can be lifted to a maximum height of 5.6 meters. Car carriers built up to now have limited cargo space for construction and mining machinery but in the FLEXIE design they can be loaded into three different floors.

The vessel's rampway can also take weight of up to 150 tons, and to load long cargoes the rampway's slope has been lowered and widened. It can load railway carriages with a length of up to 80 feet. The design does not take up the crew's time either. There might have a large number of liftable decks but they use a remote controlled car lift system to reduce operating time. This reduces mistakes helps to safe of preloading operations.

The vessel's size is also a unique feature. In recent years most car carriers are built to a wide beam post-panamax size. The FLEXIE maintains the length of current car carriers at 199.9 meters but the width has been reduced to a panamax beam of 32.2 meters. This gives the vessel the flexibility to operate in the world's car carrier trades and ports.

Even with a smaller panamax beam the FLEXIE design has increased cargo capacity to 6,800 cars compared to 6,400 to 6,500 for existing designs. This has been made possible by the large number of liftable decks which have been increased from the conventional 12 floors to 14 floors. The height of the cargo holds has increased slightly, but, including the antenna, the height of the car carrier has not changed compared to conventional car carriers. It clears the standard height of existing car carriers with an air draft of 38 meters.

Also, the hull construction has been reconsidered and the ship has been built without bulk heads. That means there are no barriers within the cargo holds making cargo loading much more efficient and increasing the number of cars that can be loaded. The slope within the holds has also been reconsidered to improve loading efficiency further.

The fuel consumption per car transported has also been improved by 13.7% compared to existing ships. The ship also uses a numerous state of the art energy efficiency devises. A spherical bow shape, jointly designed by Mitsui OSK Lines and Mitsui Zosen Akishima Laboratories, has also been used. The ship's bow has a round shape while the stern is tear shaped to reduce air resistance. The water flow around the propeller has been optimized to improve propulsion efficiency. The latest propeller propulsion fin (MIPWING) has also been used along with low friction coatings on the hull bottom.

For safety digital data communications technology is being trailed. Augmented reality technology, jointly developed by Furuno and Mitsui OSK Lines, has been used for the first time in navigational displays on an experimental basis. Surrounding vessels, land marks and scenes shot from cameras on the bridge are displayed to provide visual supports to watch crew and aid ship navigation. This technology is likely to feature in the automated ship of the future. A remote operational support systems have also been introduced. Crew helmets have been fitted with cameras and the images can be displayed on onboard dedicated computers or land based remote monitors which can issues instructions. Crew can also carry hand held small screens and input information into a dedicated onboard computer allowing them to communicate.

A virtual reality ship visit system has been introduced. Without visiting the ship, those in charge of loading, crew and even customers can check the ship's bridge, cargo area and engine room and bridge by using computer monitors or special goggles.

Also, based on vibrations, technology which can detect faults with machinery before problems occur has been introduced. The technology has been jointly developed by Mitsui OSK Lines and Asahi Kasei Engineering Corporation.

The first ship built to the FLEXIE design was the *BELUGA ACE* which was launched in March 2018. It won the Ship of the Year and other awards. A ship which pursues the through flexibility is bringing added value to the shipping industry.

Adjustable deck height using a lift car


Low wind resistance hull form

Rampway for long and heavy cargo


Deck structure

日本海事産業は今

Oda,
CEO & President

DEVELOPING THE UNSTOPPABLE SHIP

Technology research and development into automated navigation is progressing throughout the world. But, the theme of general electrical machinery maker BEMAC Corporation's project is slightly different. Its goal is to develop navigational systems with the capability to maintain the continuous sound operation of ships. It utilises big data and artificial intelligence to develop technology to achieve the "ship that never stops."

In 2018 BEMAC announced the research and development guidelines for the Maintenance System for Soundness of Sailing Ability or *MaSSA*. The idea was to develop a system that can detect the causes of accidents or breakdown before they happen to avoid damage and, even if a breakdown does occur, to have the function of self repair and support continuous operation. While automated ship development focuses on unmanned ships and developing efficiencies *MaSSA* is placing an emphasis on the pursuit of reliability.

BEMAC CEO & President Masato Oda said: "In the first place the most important thing is for a ship not to lose its navigational capability, so raising this research and development target is easy to understand I thought." If a ship that never stops can be realised then it opens a route toward the totally independent ship. "However the hurdles to achieving this are extremely high. Cars can soon be repaired at the street corner garage, but ships are different. To support navigational capability ships must be able to self repair," he added.

It is rare for Japanese companies to raise such an ambitious target in this way from the outset. The Japanese approach to research and development is to develop realistic achievable technology, one by one, and there is a strong tendency to place an emphasis on process. But, CEO & President Oda had a growing sense of danger as European companies, one after another, set the goal of unmanned or completely automated vessels. "There are many companies in Japan that already have the necessary technology for vessels that can sail independently. Despite that, if things carry on as they are, they will fall behind. We are emphasising the big objective of achieving a ship that will not stop, and want to bring together Japanese technology."

To achieve this great concept the first step is centralizing ship data. To do this BEMAC is linking with the maritime industries and putting its effort into preparing the infrastructure for the collection of data. Japan ClassNK's subsidiary Ship Data Center took the world lead in establishing a base for the joint ownership of data through the Internet of Ships Open Platform (IoS-OP). BEMAC is a member of this consortium and, as a platform provider, in 2019 developed an onboard data collection server, known as the BEMAC IoT Data Server. The BEMAC IoT Data Server is an onboard server that complies with the international standard ISO19847/19848. The server does not only collect ship information to be shared with a land based platform, it also has other merits for its application such as additional functions that can grasp the operational situation and support navigation.

Tokyo Data Labo

This independent solution is the *MaSSA-One* ship support solution. *MaSSA-One* is intended to have a structure that is applied through three stages. The first is the IoT data server function to collect engine room and navigational data, next is to understand the situation through an evaluation of machinery condition and energy demand and route information. Lastly, it detects every risk and offers navigational support through risk avoidance and the recovery of the healthy function of machinery.

In 2020 the first stage will see the release of a monitoring application for the engine. This application is a tool that allows crew to soon check the most important data for them in various ways from the ship data. Its characteristic is its visibility and its operability. By 2021 the release of a support application, utilizing AI technology, is planned. The support application will have functions that can be applied to machinery trouble, human error and route selection.

"We will consider together, along with our customers, how we will use the accumulated data," BEMAC CEO & President Oda said. One theme is how to improve onboard work and make it more efficient through digital technology. If through the digitalisation of ships human error and other trouble can be solved, then cost and time too can be saved, and the end result will be improved reliability and reduction in crew.

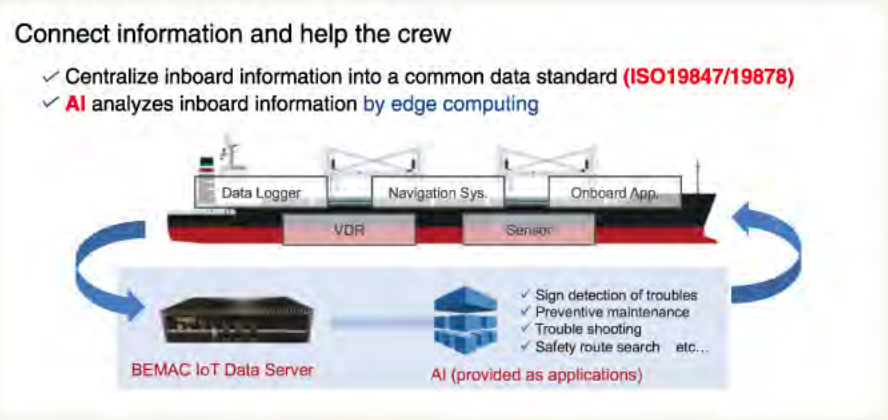
In 2018 BEMAC, to establish the structure of the project, set up as a development point the Tokyo Data Labo. The Tokyo Data Labo has become a command centre handling the development of new business models, the overall structure of technology and basic design. Hard and soft development takes place at the main company development department, the development of applications is headed by BEMAC's partner company FutureRays.

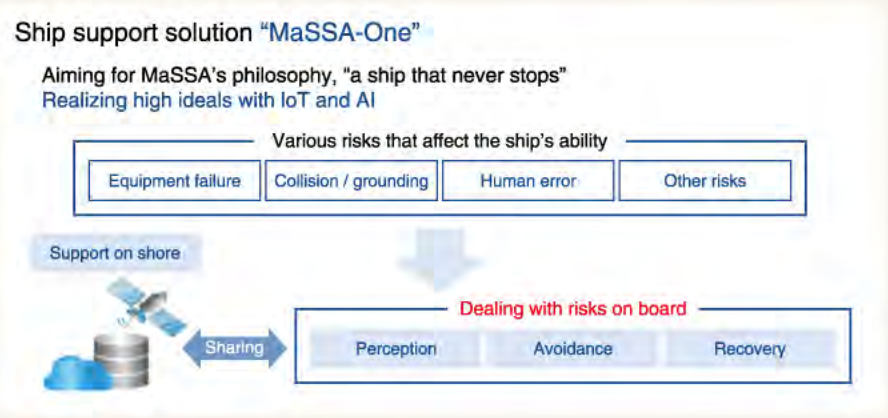
As a ship electronics maker BEMAC has knowledge and technology. Tokyo Data Labo General Manager Makoto Murakami said: "All data is an electric signal. As a ship general electrical maker we thought that if we don't do it then who will do it?" As a machine learning engineer over 20 years Murakami has become involved in all types of data activity. But, he says that compared to other industries, for the use of ship data, "the level of difficulty is very high."

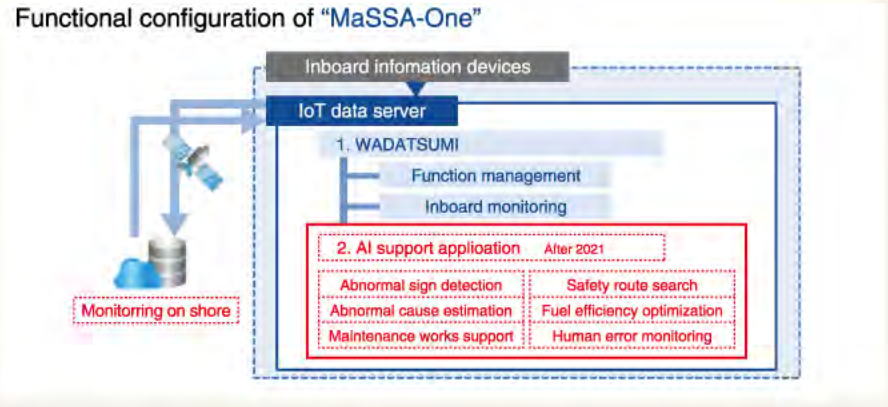
Murakami, General Manager

In shipping the situation is that the data that is available to an engineer is only for a specific ship and, one by one, the engineer must carry out the work of selecting data. General Manager Murakami is working toward the use of original techniques to collect data, creating a clean environment where activity can take place, leading to product development. He said: "The use of data is not technology to protect the market share of manufacturers, it is to a way to bring out new value." As for customers, he adds, he would like them to consider "for what reason are they collecting data and to come up with a more concrete intention and then consult with us engineers." The clearer the intention the easier it is to pin down the necessary data and the sensors required to be fitted and, from the economical point of view, a more efficient approach can be taken.

It is becoming an important theme in the world maritime industries to identify the activities that ship's data will be used for. BEMAC is, through the early creation of a digital platform in Japan, machine learning and other activities using its knowledge to take on the challenge to develop the world's first ship that "never stops."







日本海事産業は今

A LEADER IN BUILDING REEFERSHIPS

A reefership with a record breaking size of 880,000 cbft has been built in Japan. Through advanced insulation technology and hull designs demanded by the reefership sector Japan has taken the lead in this market.


Cargo holds

Fruits such as bananas, kiwi and grapes, which colourfully decorate the dining table, are transported by refrigerated cargo ships. As well as fruits, these reefer ships transport vegetables, fish, meat, fresh produce and processed foods, requiring refrigeration or freezing, around the world supporting our daily diet. There has been an increase in the transportation of refrigerated cargo by reefer containers but, in the Southern Hemisphere there are many ports which cannot handle containerships, so there is a demand for large reefer ships that can load and transport cargo in their cargo holds in bulk form.

The key to constructing reefer ships is

installing insulation which requires a high level of technology and skill. So, there are only a few shipyards in the world which are capable of constructing reefer ships. Among them is Shikoku Dockyard which has the experience of building 74 reefer ships.

Shikoku Dockyard used its experience to build the world's largest reefer ship, the 880,000-cbft *Cool Express*. Until that ship was built the largest reefer ship was the 650,000-cbft type, and that too was built by Shikoku Dockyard, which has been breaking its own records in terms of reefer ship size. The floor space of the *Cool Express*' cargo holds equates to around 34 tennis courts measuring around 8,900 square metres. Cargoes are loaded into cargo holds at a temperature of from plus 15 degrees to minus 25 degrees centigrade. Most of the cargoes are fruits which are loaded in boxes and placed onto pallets. The height of the cargo holds is higher than ships built up until now at 2.5 metres. The number of boxes stacked onto a pallet have also increased from eight levels to nine levels. Also, on the return voyage, a variety of cargoes including containers, vehicles and general goods can be loaded and transported in its holds.

As the number of containers which can be loaded on deck has also been increased, a custom built spherical shape lashing bridge has been developed and employed. The number of containers that can be loaded on deck has been increased from three tiers to four tiers. The weight of containers that can be loaded has also been increased from 25 tonnes to 30 tonnes. A dedicated crane has also been fitted to the stern of the vessel to load containers on the aft deck.

As well as increasing the amount of cargo that can be loaded the maintenance of the optimal temperature has also been achieved. Insulation has been fitted in all areas of the cargo hold including walls, floor and ceiling. Within the holds an insulated construction has been created using panels filled with glass wool or urethane foam. In the insulation installation process detailed coordination was necessary, including consideration of the insulation design, the selection of materials – including a high volume of woodwork – the production management of insulation works at the construction stage and fire prevention.

There was not only a complete insulation, but also a system to control refrigeration and freezing was also installed. The cargo holds are divided into nine different thermal insulation compartments and each compartment has two cooler rooms which are equipped with two air cooling devices so that the temperature in each compartment can be uniformly controlled. Also, a system to maintain the freshness of fresh produce has also been incorporated. A controlled atmosphere system has been installed which can control the oxygen concentration by adjusting the injection of nitrogen gas. For containers, a modified atmosphere system that controls oxygen concentration at all times through nitrogen gas injection is also being used. A nitrogen gas (N2) generator has also been installed on the ship.

To build the world's largest reefer ship it was also necessary to improve the hull form. A versatile ship hull form had to be designed which would allow an increase in the cargo volume and at the same time the ship to trade within the limits set to the world's leading ports and waterways. Also, as the ondeck container-cargo had been increased, it raised the centre of gravity of the vessel, and it became important to ensure ship's stability.

For that reason a wide beam shallow draft design was used with a fully laden draft of 10.2 meters. This allows the design to even navigate the shallow waters of South America and West Africa's river basin. Its wide beam also gives good ship's stability.

Another feature of frozen or refrigerated cargoes is that they must be transported quickly at high speed to arrive at the port of destination. With the use of a sharp shaped bow and shallow draft and a highly efficient propeller the vessel can realise high speeds.

Above the bow of the *Cool Express* a cover has been fitted to form a unique shape. By fitting this uniquely shaped bow in with the ship's frame line the aim is to reduce pitching and the improve the vessel's performance in wave conditions. Also to improve the ship's versatility it has been built to ice class 1B standard so the vessel can navigate to cold climates and in ice conditions.

To meet the latest environmental regulation on emissions a hybrid type sulphur oxide SOx emissions scrubber has been fitted to the vessel. To meet noise and vibration regulations the accommodation area has been completely separated from the engine room and engine casing. Despite using a more powerful engine than in previous reefer ship series the noise in the accommodation area has been greatly reduced.

To support voyage optimisation the NK-NAPA Green System is being used. The ship's navigational situation, cargo hold, engine room, alarm and other condition can also be monitored in real time at the shipowner's office through the use of a sea to land communications system.

The *Cool Express*, by taking on the challenge of building the world's largest reefership with a high level of versatility, has opened up and pioneered a new potential for the reefership market.

日本海事産業は今

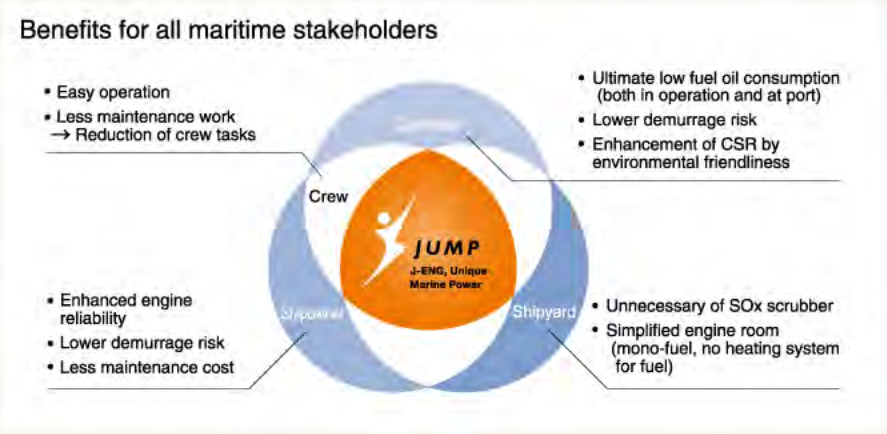
Japan Engine Corporation (J-ENG) has combined their original technology into the world's first MGO mono-fuel engine, which will solve matters that ship owners and operators are confronting with. They propose their ecological and economical MGO mono-fuel engine as a solution to emission of sulphur oxides (SOx) and nitrogen oxides (NOx). Also, this Engine can even be your counterplan against the Energy Efficiency Design Index (EEDI).

USING MGO MONO-FUEL ENGINE LEADS TO SOLVE ENVIRONMENTAL MATTERS

IMO (International Maritime Organization), as a strategy to prevent air pollution, is introducing regulations to control sulphur oxides emissions from ships. Toward this J-ENG is proposing the *JUMP (J-ENG, Unique Marine Power)*, with the mono-fuel MGO latest environmental protection type engine UEC-LSJ, at the core of this solution. The MGO mono-fuel engine, combined with J-ENG's advanced technology, complies with the SOx and NOx regulations and achieves a considerable reduction in fuel costs compared to existing engines, while also contributing toward a large improvement in the EEDI.

As a result of a strengthening of the SOx emissions regulation very low sulphur fuel oil (VLSFO), with a sulphur content of less than 0.5%, has replaced heavy fuel oil as ships' main fuel. To comply with the recommendations J-ENG is recommending that ships, especially those with small to medium-sized engines, use the MGO mono-fuel engine. MGO maybe more expensive than VLSFO but J-ENG's president Ken Kawashima explains: "Thanks to the MGO mono-fuel engine's lower fuel consumption, as long as the price difference between MGO and VLSFO is within 10%, it has a cost advantage over the life cycle of the vessel"

Furthermore, he adds: "As the MGO mono-fuel engine meets all the requirements of NOx and SOx regulations, and achieves a high EEDI level, it also contributes toward improving the ship's competitiveness." J-ENG is recommending its MGO mono-fuel engine to meet the NOx regulation because, compared with other solutions, the fuel consumption performance is higher. When NOx regulation was tightened from the Tier I to the Tier II fuel consumption have had been sacrificed. To meet the NOx Tier III regulation ships will have to either be installed with a Selective Catalytic Reduction (SCR) or an Exhaust Gas Recirculation (EGR) unit to reduce NOx emissions further, and fuel consumption performance has once again been sacrificed. Generally, there is a trade off between reducing NOx emissions and fuel consumption, and it has been thought, that to



achieve a reduction in NOx fuel consumption will always worsen. However, EEDI requirement are also being raised in stages to control carbon dioxide (CO_2) emissions from shipping. Amid increasing regulations aimed at reducing greenhouse gas emissions, a worsening of fuel consumption performance from ships, is a problem that is unacceptable both from the environmental and economical point of view.

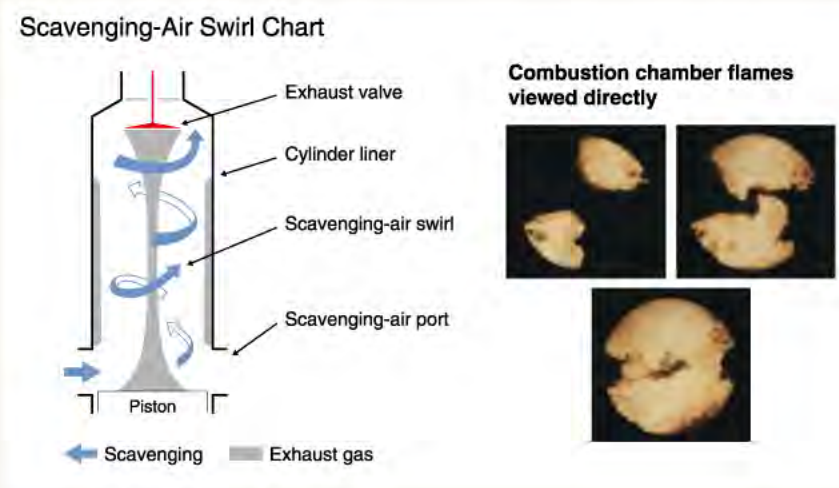
J-ENG has the only licensor covering design, production, sales, service with a global network, its mission is to propose solutions to environmental regulation. It is putting its efforts into offering to the world an engine with widely improved fuel consumption performance.

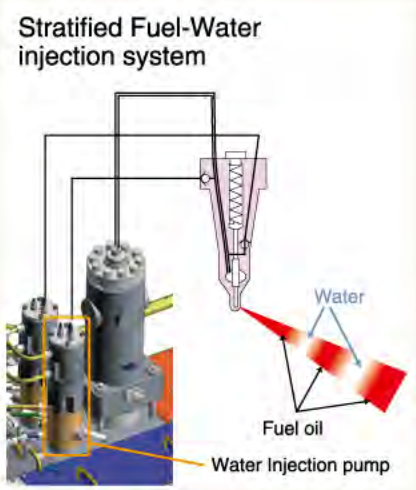
With the cooperation of Onomichi Dockyard Co., Ltd., and the support of the Nippon Foundation, it has been progressing with the development of the MGO mono-fuel engine. The basic concept of the new type engine is to pursue fuel consumption efficiency on a zero basis. MGO was chosen above VLSFO because of its stable product quality and availability. Also engine room operability, including the main engine, and ease of maintenance was also taken into consideration. VLSFO is also a new fuel category and, depending on its condition, there are concerns that it could cause fuel and engine problems. There are supply issues and handling also requires meticulous care. On the other hand, MGO is already an established marine fuel oil and its quality and supply chain already established. By using MGO exclusively, there will be only a single fuel system needed, and the fuel heating system that is required for using VLSFO, will not be necessary. Since there is a single fuel system, and there is no need for heating the fuel. Therefore, ship space can be used more effectively and, as a result, the operational, maintenance, economical aspects all improved. The single fuel system requires no change over of fuels, which means, it will become a potential solution for the anticipated independent and automated ships in the future.

To achieve the super low fuel consumption the UE engine's advanced technology high efficiency combustion and advanced injection technology has been used. As an engine that prioritises fuel consumption, stratified injection technology has been applied to clear the NOx Tier II emissions requirement, without the usual trade off between fuel consumption and reducing NOx emissions. The NOx Tier III levels have been achieved by using J-ENG's low pressure EGR and low pressure SCR. By combining these technologies in the MGO mono-fuel engine it can be expected that, compared to conventional engines using VLSFO fuel, fuel consumption can be reduced by around 10% (based on the calorific value of the fuel).

The MGO mono-fuel engine is the latest in the J-ENG's UE brand. The first engine was completed in December 2018. The first engine (5UEC50LSJ-EGR) has already accomplished 300 hours of continuous testing to verify its performance and reliability.

Meeting environmental requirements has become a huge financial burden for shipowners and operators. J-ENG through its engine and unique technical approach is offering a friendly solution to both the environmental issues and the lifecycle costs.





日本海事産業は今


Top side tanks in cargo tanks


Most of the upper deck is flat

NEW DESIGN ADDS TOP SIDE TANK TO CHEMICAL TANKERS

Ensuring the stability of liquid cargoes with a high specific gravity in tankers is an important issue. Hongawara Shipyard has come up with an innovative idea to resolve this problem. It involves installing a top side tank, that is commonly used in bulk carriers, on chemical tankers.

Tomono-ura in Hiroshima prefecture is a historic port town that is as pretty as a picture and attracts tourists from around the world. Hongawara Shipyard is located in this small town which has a 1,000-year history. The shipyard builds between 10 to 12 coastal ships annually including general cargo ships, tankers, ferries, cement carriers and tug boats. Each ship is made to order according to the shipowner's requirements on trading route, port conditions, cargo load, speed and crew numbers.

As a shipyard with a reputation as having a high level of design capability it has developed an idea for a new type of chemical tanker.

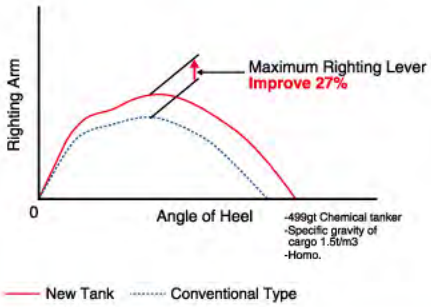
In 2017 Hongawara Shipyard was approached by an owner with a newbuilding plan for a 499-gt sodium hydroxide solution carrier. But, in the early stages, the project hit a wall with stability regulations. Small ships, which carry liquid cargoes with a high specific gravity like sodium hydroxide solution, find it difficult to clear new rules on stability. If an attempt is made to pass stability regulations with standard hull dimensions, then the cargo load will have to be reduced. But if cargo load is maintained then the design will exceed limits on the ship's beam.

Company president Makoto Hongawara is a naval architect who decides on the ship's main dimensions and configurations. He repeatedly, on a trial an error basis, attempted to come up with various dimensions that would meet the stability regulations.

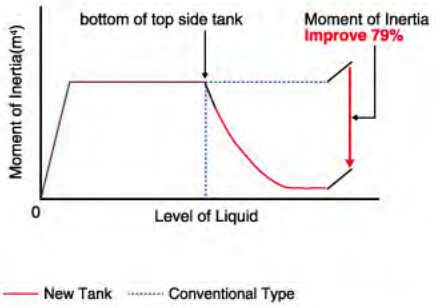
Then he suddenly came up with an idea. "Bulk carriers use top side tanks in cargo holds to prevent cargo breaking up, couldn't the same method be applied to chemical tankers?"

The free surface effect of liquid cargo has a large effect on tanker stability. If the upper part of cargo tanks is narrowed to make a triangular shape, then the liquid cargo space would be reduced and cargo movement could be limited. So, he thought, if a top side tank is placed in the upper part of the

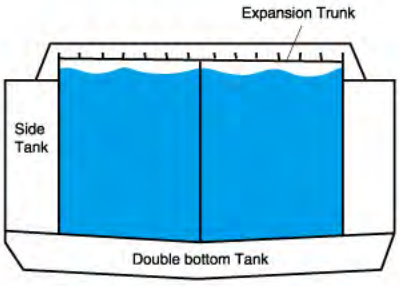
Stability Curve



Moment of Inertia of the Free Surface



Conventional Chemical Tanker



cargo tank, as in bulk carrier designs, then this shape could be realised.

When the calculations were made the results looked good. In current design cargo tanks, because the cross sectional area is square, the cargo load is increased but that raises the centre of gravity. But, if it is a cargo hold fitted with a top side tank the higher the liquid level the smaller the area for liquid to flow. When the cargo tank is 95% fully loaded the surface area is reduced, preventing the centre of gravity from rising. Graphs illustrating a comparison of stability in existing ships compared to the new design were drawn up. They showed that the new tank style improved stability by 27% compared to existing designs.

"While meeting requirements on the ship's dimensions, gross tonnage and cargo load we cleared the stability rules. I thought we can propose this design as a new ship type," company president Hongawara remembered.

There were other benefits to the top side tank design. In conventional tankers in operation, liquid cargoes can move, a condition known as sloshing. This movement causes cargo to strike the cargo tank's walls, in some cases, causing it to crack. But in Hongawara's new design, because the surface of the liquid cargo is restricted, movement of the liquid cargo is limited and that reduces the danger of damage to the cargo walls. As there is reduced cargo movement crew comfort is also improved.

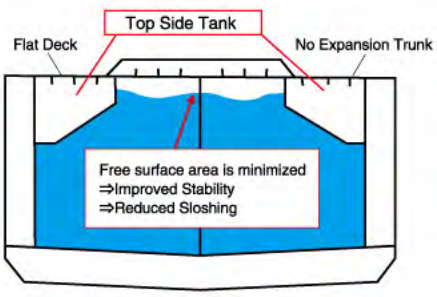
There is one more major merit to the use of a top side tank. In chemical tankers built up to now, structural support materials are placed on the upper deck plate of cargo tanks. But in the new design the support materials are all enclosed within the top side tank, reducing the amount of cargo tank support materials on the upper deck plate. Pipes can also be moved from the upper deck within the top side tanks. There is also no need for an inflatable trunk. Most of the upper deck is left flat improving the movement of crew around the ship and improving work efficiency.

In May 2019 the 499-gt chemical tanker *Etsuzan Maru No.8*, the first to use this tank configuration, was launched. Next, in June, the second such ship, the *Tokuho Maru*, was launched. The third in the series is scheduled to be delivered in 2020.

The new type tank is perfect for high density liquid cargoes. As well as sodium hydroxide solution there is also the prospect that it will be effective for the transportation of other cargoes including magnesium hydroxide, phosphoric acid and sulphuric acid.

Hongawara Shipyard has decided to develop a chemical tanker smaller than 499 gt to be deployed in the transportation of these cargoes. Hongawara Shipyard has already received a patent for this design of cargo tank. Company president Hongawara says: "We would like to meet all the needs of shipowners through order-made ships."

New Chemical Tanker




President Hongawara

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The "Takarabune," or treasure ship, comes from Japanese mythology and symbolises celebration, the goods it carries are all used are for joyous occasions and to bring luck. In this picture it carries rice bundles, which represent the commodities modern ships transport, scrolls are like ship design plans, the fan represents natural energy and the lucky mallet drums up new ideas and innovation and powerful creativity.