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GX

Green Transformation

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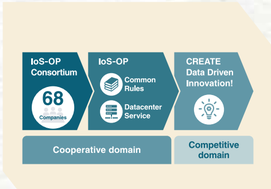

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SHIPBUILDING IN JAPAN 2023

JAPAN
Transformation

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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.

WIND POWER FOR CLEANER SHIPPING

More than 100 years have passed since wind powered sailing ships fell from their position as the main form of sea transportation. But now this technology from the past is once again being revived. In Japan, a ship with a hard sail system called "Wind Challenger", mainly developed by Mitsui O.S.K. Lines and Oshima Shipbuilding has been launched into the open seas.

A ship is alongside the shipyard quay. Even from a distance, a white structure stands out on deck. Approaching the ship, the logo mark of Wind Challenger and three companies, Tohoku Electric Power, Mitsui O.S.K. Lines and Oshima Shipbuilding can be clearly seen.

This new type of wind power propulsion system, Wind Challenger, was installed onto the 100,422-dwt bulker, *SHOFU MARU* built by the Oshima Shipbuilding. The vessel is owned by Mitsui O.S.K. Lines and carries coal for Tohoku Electric Power.

In recent years there has been a movement to use wind once again, which was used to power vessels for hundreds of years, to propel large size commercial vessels.

There are various types of wind propulsion methods for ships. For example, there is the traditional canvas soft sail used since the age of sailing ships. Then, there is the increasingly popular Flettner Rotor system in which a vertically erected cylinder on the deck uses the "Magnus Effect" to generate propulsion power from wind. There are also suction wind type and kite type technologies emerging.

Wind Challenger's biggest merit is its efficiency. As the sail is hard, the perfect wing shape can be maintained to use the wind very effectively.

Two technologies of the sails enabled the high efficiency. One is the use of Glass Fiber Reinforced Plastic (GFRP).

The use of light and strong materials enabled safe operation of the large structures on the deck and the sail can sufficiently use wind power.

One more technology is the telescopic and rotatable mechanism. The higher sail can catch

Sail Heights from 23m to 53m

WIND POWER FOR CLEANER SHIPPING

more wind. But, if the sail is too high, it can have the reverse effect and result in a loss of energy if there is a strong wind or head wind.

So, it is necessary to extend and shrink the sail. This is a unique feature of Wind Challenger, telescopic sail.

The sail on *SHOFU MARU* consists of four-stage sliding structures.

Wind Challenger sail can be extended up to about 53 meters height and convert wind power to propulsion force of ship. Under strong wind condition and during cargo operations, the sail is shrunk to about 23 meters height.

The sail can be rotated to the most appropriate angle up to wind direction in order to gain maximum propulsion force. When viewed from above the sail, its shape is like an airplane wing. The lift force generated by this shape can be converted to propulsion force of ship. Wind Challenger sail can generate maximum lift power when the sail receives quartering wind.

The sail can convert the wind power to propulsion force. Not only the following wind but also various wind directions can be turned into thrust except for wind from up ahead 50 degrees out of 360 degrees.


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Underway with Expanded Sail

When the ship receives backwind or is in anchorage, the sail is set "zero-lift angle". Lift force of the sail can be minimized at zero-lift angle.

The sail can be safely extended/shrunk and rotated automatically up to ever-changing sea and weather conditions. Integrated Automation System is on the bridge in order to check the sail condition timely.

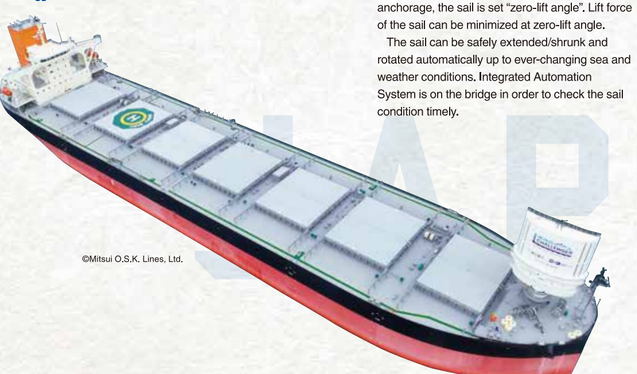
Basically, the sail is controlled automatically in the ocean. When the ship is in port, the sail is operated manually to secure safe cargo operation.

The size of sail has been decided not only maximizing propulsion force and strength of structure, but also considering the visibility. The sail satisfies all regulations of SOLAS treaty related to visibility from the bridge.

Compared with wood chip carriers and small bulk carriers with on-deck cranes, good visibility is secured.

To take maximum advantage of wind power, it is important to select the appropriate shipping course. So, Weather Routing System has been developed and installed to support finding the most optimized shipping route.

Conventional weather routing systems just use weather forecast information and select the optimized shipping route based on the arrival time, safety and other factors. However, there is possibility for the ships with Wind Challenger sails to enjoy more advantage of wind power in case the ships proceed shipping route with appropriate wind.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In Berth with Contracted Sail


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To suggest candidate shipping courses to crew on board, the dedicated Weather Routing System for ships with sails, which can calculate the optimized shipping courses considering sea and weather conditions to minimize fuel consumption, was developed.

Before the delivery of *SHOFU MARU*, explanation had been made to more than 30 parties, for example, coastguards, port authorities and pilot associations including Japanese and non-Japanese because no one had been operated the ship with such construction.

One month before the delivery, harbor master and two pilots of Newcastle Australia, *SHOFU MARU*'s first port of call checked ship's maneuver by using a simulator. They confirmed there are no problems to operate a ship with a sail under various possible sea and weather conditions.

According to preliminary simulation on the basis of a 100,000-dwt vessel with one Wind Challenger sail, the vessel can save fuel consumption around 5% between Japan and Australia and around 8% between Japan and North America due to frequent stronger wind.

The development of Wind Challenger began in the Autumn 2009. Mr. OUCHI Kazuyuki, an alumnus of Mitsui O.S.K. Lines and a special professor at Tokyo University at the time led and started an industry and university joint research project.

At the time, saving energy in maritime technology was a major concern because shipping companies' profit went bad due to fuel price increase. On the other hand, there were few persons in the world who seriously considered reviving sail technology.

However, concerned members in Wind Challenger project worked through for realizing sail technology with a view not only to save energy but also to reduce greenhouse gas emissions. They proceeded the basic research of the modern sail technology and carried out on shore test of the sail by using 40% scale model. Mitsui O.S.K. Lines and Oshima Shipbuilding took over this project from 2018.

Compared with 14 years ago when the development began, the demands for energy saving and environment conservation much more exceeded expectation. Now, the sailing technology is an effective solution.

For installation of Wind Challenger sail onto the vessel, IKNOW MACHINERY built the swivel base of the sail and Tokyo Keiki developed an autopilot system dedicated for a sailing vessel.

Azbil developed the full automatic control system for rotating and telescoping the sail. Innovative Composite Center in Kanazawa Institute of Technology, Kansai Design Company and GH Craft participated in the project as consortium members. Classification services were provided by ClassNK.

On 7th October 2022, the delivery ceremony for *SHOFU MARU* was held. Mr. Takeshi Hashimoto, President and Chief Executive Officer of Mitsui O.S.K. Lines said: "The main purpose of Wind Challenger project is to revaluate wind power which has been used for ship propulsion for many years. We have realized our long-time vision." Mr. Eiichi Hiraga, President of the Oshima Shipbuilding said: "From now on, we will deepen our technological capability through this project and contribute to realize low carbon / decarbonized society in several decades."

This is just the beginning of Wind Challenger project. The construction of a second vessel with Wind Challenger sail has been already decided. The biggest benefit of Wind Challenger sail is possible to reduce GHG emission immediately after installation.

The other benefit of Wind Challenger sail is possible to reduce fuel consumption. In near future, ammonia and hydrogen will be likely used for vessel fuel but they might be much more expensive than heavy fuel oil. It means fuel saving is much more important than present age.

Oshima Shipbuilding and Mitsui O.S.K. Lines aim to install Wind Challenger sails onto not only bulk carriers but also VLCCs and LNG carriers. Both VLCCs and LNG carriers have huge space on deck. At least 2 Wind Challenger sails can be installed on these vessels.

Based on feedback from *SHOFU MARU*, the project members are trying to improve the performance of the sail. At the same time, a smaller Wind Challenger sail (38m height) is designing for smaller vessels. Mass production of the sails is also being studied.

Furthermore, the challenge toward wind propulsion is continued.

Ensuring Navigation Bridge Visibility


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ONBOARD CARBON CAPTURE TECHNOLOGY MOVES FORWARD

Mitsubishi Shipbuilding, Kawasaki Kisen Kaisha and ClassNK took on the challenge of the onboard carbon capture verification project. The world's first demonstration has opened the door to realise the possibilities for its practical application.

Demo plant Room Installation

Seeking to reduce green house gas (GHG) emissions from ships research has been progressing on fuels like synfuels, ammonia and hydrogen which does not emit CO_2 when combusted. But there is one more option to achieve carbon neutral on ship. That is to move in the direction of capturing the CO_2 onboard the vessel.

Land-based technology has already been established for power plants, which separate and capture CO_2 emissions then store them underground. If CO_2 can be separated and captured onboard ships and temporarily stored, it will be possible to send CO_2 ashore at the port and store it semi-permanently in a reservoir or reuse it.

To realize this concept, Mitsubishi Shipbuilding, Kawasaki Kisen Kaisha and ClassNK moved ahead of the rest of world to take on the challenge of demonstrating onboard carbon capture technology.

Those three companies got a support from the Ministry of Land, Infrastructure, Transport and Tourism and began a two-year demonstration project called CC-Ocean (Carbon Capture on the Ocean) Project from August 2020. A small-scale CO_2 capture demonstration plant has been fitted on Kawasaki Kisen's 88,000-dwt Corona Utility, operated by Tohoku Electric Power Company, to verify the technology and develop requirements for onboard use.

The onboard CO_2 capture demonstration plant used the same chemical absorption method used for land-based plants. This involves separating and capturing CO2 from exhaust gas by using aqueous solution that is capable of absorbing CO_2.


Operation of demo plant by ship's crew

The demonstration plant consists of three main towers: an exhaust gas quencher, an absorption tower and a regeneration tower. Firstly, in the quencher exhaust gas discharged from the marine engine is cooled. Next, in the absorption tower, liquid absorbent poured from top contacts the exhaust gas and absorbs the CO_2. It is heated in the regeneration tower to release CO_2 with a high level of purity.

The development of this demo plant involved Mitsubishi Heavy Industries Group's comprehensive engineering capability. Mitsubishi Heavy Industries group has the biggest market share worldwide for its CO_2 capture technology. Its highly efficient exhaust gas capture technology is already commercially available for land-based plants. To make this technology suitable for use on ships Mitsubishi Shipbuilding, Mitsubishi Heavy Industries and its research and development center have combined their knowledge.

Although the technology has already been verified on land, to apply it to a vessel the differences in situation must be considered such as movement of the ship. It was important to stabilise the level of the absorbent liquid and to reduce vibration from the engine as well.

Safety measures were also key issue. As absorbent requires care in handling, guidelines for the use of protective clothing have also been prepared. Mitsubishi Shipbuilding, Kawasaki Kisen Kaisha and ClassNK repeated discussions and caried out a HAZID safety evaluation of the demo-plant and system to identify risks and fed them back into the design, such as measures to cope with the leakage of absorbent or pure CO_2. After confirming its sufficient safety, the onboard verification has started.

In August 2021 the demonstration plant was installed on the ship and sea trials started. In the first month engineers from Mitsubishi Shipbuilding were onboard to measure and analyze emissions and CO_2. They also performed instruction the operation and maintenance procedure of the plant to crew, including how to top up the absorbent. Then, from mid-September, the demonstration operation was performed only by the crew. The operation manual was updated during the trial and raised its quality for practical application. A shore-based support system was also arranged.

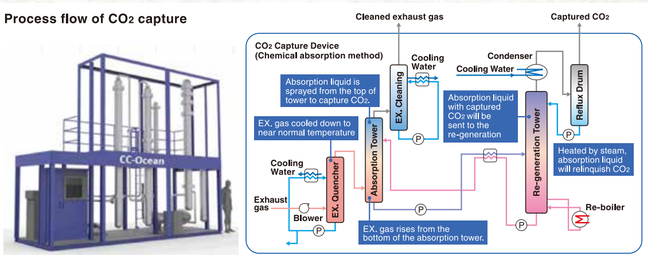
It was the first time CO_2 capture had been tested by crew during the commercial operation of a vessel. While carrying out their usual duties for five months, they performed unprecedented attempt to operated and measured the plant simultaneously. This could not have been achieved without their cooperation.

Onboard trial has been completed February 2022 and results of separation and capture of CO_2 from the exhaust gas has shown a CO_2 purity level of more than 99.9%, achieving the planned performance.

There were plenty of findings from the demonstration. There are many cases of CO_2 capture from natural gas on land, but very few from exhaust gas by heavy fuel oil. Through the project the effect of load fluctuations on the main engine and the impact of hull movement on CO_2 capture was also assessed as well as many operational knowledge.

The knowledge gained from the demonstration project will be used in the development for commercial use. A major step forward has just been taken towards new technology for the onboard CO_2 capture.

Process flow of CO_2 capture



The world's first fully electric tanker, *ASAHI*, which uses a high-capacity lithium-ion battery as its main source of power, was delivered in April 2022. The ship aims to reduce its environmental footprint and improve working conditions for crew.

ELECTRIC TANKER SOLUTION FOR ZERO-CARBON SHIPPING

Japan's essential coastal shipping industry is facing many structural issues, including labour shortages and an ageing workforce and fleet. In 2019, Asahi Tanker, Exeno Yamamizu, Mitsui OSK Lines and Mitsubishi Corporation set up e5 Lab. Inc to develop and popularize a zero-emission electric propulsion vessel as a solution to these problems and to aim at building new shipping infrastructure and services.

The project was named e5 because it aimed to achieve five key values in the shipping industry – "electrification", "environment", "evolution", "efficiency" and "economics" to provide secure and safe quality transportation services to society.

To realize the project, Asahi Tanker built an electric tanker for bunkering, one of its core businesses. The first ship, named *ASAHI*, was built by Koa Sangyo which has experience in building diesel-electric vessels with electric generators.

The construction of *ASAHI* aimed to reduce the shipping industry's environmental impact and improve working conditions for the crew by incorporating many of the latest technologies and ideas.

ASAHI is entirely powered by battery, and it is the world's first battery powered tanker. By making the vessel fully electric, it can achieve zero emissions of CO_2, nitrogen oxide (NOx) sulphur oxide (Sox) and soot.

The electrical power provided from a high-capacity lithium-ion battery drives the motor and propels the ship. The vessel is also entirely battery powered when it is stationary, during loading operations and berthing The capacity of the lithium-ion battery is 3,480 kWh, equivalent to the electrical power of 100 electrical vehicles or the electrical power used by 450 households in one day.

The battery room is located in the ship's bow on two levels, where the temperature is controlled and kept below 20 degrees Celsius to avoid overheating and ignition of the battery, and can be monitored and operated from the living area.


Smart Bridge System


Accommodation area is increased

As the battery is charged from shore, Asahi Tanker has provisioned an electric tanker charging station at the port of Kawasaki where the vessel is stationed. The power supply capacity of this station is 375kVA (kilovolt amperes) which is the first large-capacity charging system in Japan and can fully charge the tanker's battery in 12 hours when it is stationary at night.

The electricity for the charging station is also zero emission. The electrical power supply is derived from 100% carbon free renewable energy, reducing CO_2 emissions by around 400 tons, the equivalent of the annual electricity usage of 300 households.

Basic operation of bunkering vessels involves bunkering ships in the port area during the afternoon and returning to base at night. Though the ship is fully battery powered for normal operations, it has been fitted with a small generator and a tank containing 10 tons of fuel oil in case situations arise where the vessel cannot return to the base.

Another major improvement is the maneuverability of *ASAHI*, which is significantly enhanced compared to conventional ships. The steering equipment includes two azimuth thrusters and two side thrusters. These not only move the vessel forwards and backwards, but also sideways and diagonally, and even allows the vessel to turn on the spot, which has not been possible on bunkering vessels up to now.

In addition, the tanker has the first smart bridge system installed on a coastal vessel. The officer's seat is positioned in the middle of the bridge where, from a surrounding monitor, the battery and the propulsion system can be checked. Images from cameras fitted on the bow and stern of the vessel can be viewed in together with the radar, as well.

Moreover, the ship is fitted with Kawasaki Heavy Industries' Kawasaki Integrated Control System for integrated control of the thrusters which can be operated from a single joystick.

An automated loading system also plays a part in reducing the crew's workload. *ASAHI* employs a hydraulic butterfly type pipe loading and unloading system, using valves and pumps, which is programmed to automate the operation. By introducing an automated loading system operation, what previously had to be opened and closed manually while watching the operating meter above the pump rail, can now be done from the cargo control room under the bridge.

An explosion prevention tablet has also been introduced to operate valves and pumps, allowing remote operation from the deck.

The living area for crew has also been markedly improved. As the vessel is battery powered, there is no need for an internal combustion engine. The area saved from the lack of an engine room means that the accommodation area for crew has been increased, providing a living space that can be enjoyed by crew as if they were back at home. The spacious living area on the ship has overturned the image of cramped internal spaces in Japanese coastal ships. In addition, the comfort of the ride has been improved as the electrification has eliminated vibration, noise and the smell of oil onboard.

In coastal shipping, securing the employment of seafarers has become a major on-going topic. By improving the operational performance and reducing the burden of loading operations, the workload of crew has been reduced. Full electrification also reduces complicated maintenance that can only be carried out by experienced and knowledgeable engineers. The close attention paid to the ship's internal equipment and design has resulted in a vessel that crew will surely want to work in and help in securing seafarers.

Lastly, *ASAHI* also has a power supply system that allows it to transfer electrical power from its large capacity battery over to shore and can be used as a power supply in emergency situations such as a natural disasters.

The ship will offer a solution to various social issues and realize a sustainable coastal shipping industry.

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SEP *BLUE WIND* FOR LARGE WIND TURBINES

SHIPBUILDING IN JAPAN 2023

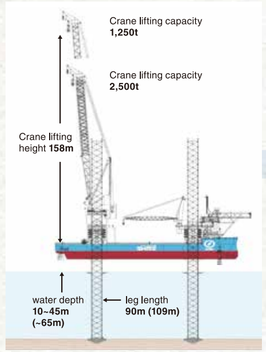
As Japanese wind farm power generation projects start Shimizu Corporation has built the self-elevating platform (SEP) vessel *BLUE WIND* at Japan Marine United. The vessel has with the largest class of crane, with a lifting capacity of 2,500 tonnes, which can install large-size wind turbines bet ween 14MW to 15MW. With this vessel Shimizu Corporation is aiming to be a major player in the construction of offshore wind turbines which are continually increasing in size.

Expectations are growing more than ever in the world that power generation from offshore wind farms can become a stable source of renewable energy with a large capability to produce electrical power.

There are two types of offshore wind turbines. The fixed bottom type are attached to the ocean floor and the floating type are placed on a floating structure on the ocean surface. Large scale offshore wind turbines attached to the ocean floor use an SEP for installation. After an SEP vessel arrives at the construction site four legs penetrate into the ocean floor and the hull is jacked up from the sea surface to allow it to operate independently of the ocean waves. The first stage of the offshore installation procedure is to install the foundation such as the monopile. Then the wind turbine tower, nacelle and blades are transported by the SEP and installed on the foundation.

Each year, in the offshore wind power generation market, the size of wind turbines is increasing. Since 2014, wind turbines have increased in size by on average 1MW annually to improve the power generation cost of offshore wind. This is why Shimizu Corporation decided to develop a large SEP vessel to ensure reliable and highly efficient large wind turbine construction.

Major characteristic of the *BLUE WIND* is the world class performance in the construction of wind turbines.



The *BLUE WIND* has a crane with a maximum lifting capacity of 2,500 tonnes, (1,250 tonnes with boom extended mode), and a maximum lift of 158 meters. Based on this she can install the foundation and also install a 14MW to 15MW class wind turbine. On her spacious 4,600 metre square deck she can carry, at once, all the parts – including tower, nacelle and blades for 7MW turbines, or three 12MW turbines. Even considering preparation days seven 8MW wind turbines can be installed in 10 days and three 12MW units in five days. Compared to conventional SEP vessels, where turbine need parts to be divided and transported, construction efficiency can be improved by 50% and a significant reduction in construction time and costs can be achieved.

The operational range of the crane installed on the SEP is a unique specialty. The crane has a working radius of 60 meters. In cases where there is an obstruction next to the quay the components of a large wind turbine can still be loaded from a distance. It is designed for a wide range of working environments in ports where wind turbines are loaded.

The vessel is also ready for the Japan's harsh natural and ocean. SEP vessels is to secure construction environments that are not affected by waves. The Blue Wave has 90m leg at present, and it can be modified to109m, allowing it to work at a depth of 10 meters to 65 meters. Even when the sea condition is rough and the waves are high, stable operations condition is secured o the Vessel. Japan's sea conditions are recognised as one of the most severe in the world, but even with long period waves of 10 seconds, and a maximum significant wave height of 2.5 meters, the Blue Wave can operate 85% of availability, much higher availability than other SEP vessels.

The safety of the vessel during earthquakes and the operation in minus 10 degrees Celsius environment have also been confirmed.

Another feature of the *BLUE WIND* is self propelled navigation, which has improved its workability. SEP vessels which have been built in Japan up to now are not self propelled, but the *BLUE WIND* has followed the self-propelled design which is common in Europe. The propulsion system has six thrusters, including thee 3,800kw units and three 3,200-kw units. It has a maximum navigation speed of 11 knots, twice as fast compared to barge type SEP pulled by tugboats. It is expected construction time can also be reduced because of the improved speed. Because the vessel has a higher performance than a tug boat for responding to rough meta ocean conditions. The further away the construction site is from the bese port the higher the vessel's ability is realized. The ship is also fitted with a dynamic positioning system to maintain its position. Construction of the *BLUE WIND* began in October 2020 at JMU's Kure shipyard and, after it was outfitted at JMU Amtech's Aioi plant, there at ten four months of operational training. By March 2023 it will be on site in full operational.

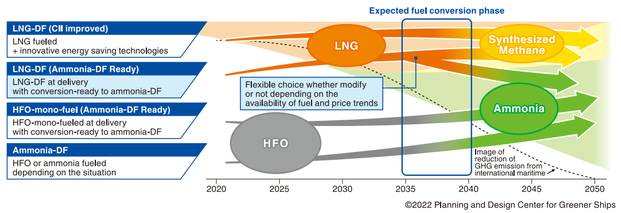
The name *BLUE WIND* emphasizes Shimizu Corporation's corporate color and the desire that the vessel sails across the oceans like the wind, and plays major role in the offshore wind power generation facility construction market. In response to the Japanese government's declaration that by 2050 it wants to be carbon neutral, many offshore wind construction projects will be realized. Also, in Europe, the US and Asia large scale offshore wind power generation projects will be started one after another. The world demand for SEP vessels is growing, and attention is focussing on large scale SEP vessels. Shimizu Corp will respond to the growing needs of offshore wind projects with newbuilding vessel.

Image of the construction work

©SHIMIZU CORPORATION

GSC IS DESIGNING

Through accumulating technology Japanese shipyards will provide the greener ships that are suitable for the new age of zero emissions.
The Planning and Design Center for Greener Ships (GSC) is developing the next generation of environmentally friendly ships by studying and analyzing future scenarios for fuel.



©2022 Planning and Design Center for Greener Ships

The GSC was established in October 2020 by initiative of major Japanese shipbuilding parties concerned as a core organization for the continuous planning and dissemination of advanced environmentally friendly ships. Currently 12 member companies including 10 shipbuilders has participated to GSC.

After its establishment GSC has conducted surveys on the future fuels for zero-emission ships including the trends in production and costs. Based on the results of the study GSC concluded that ammonia might be one of the promising candidates as a future zero-emission fuel.

Many international shipping companies are aiming to achieve net-zero greenhouse gas emissions (GHG) by 2050. GSC is developing the greener ships with consideration of the transition to net-zero emissions by 2050. One main scenario toward net zero which continues to be popular is the use of LNG as a transitional fuel, before later switching to ammonia, while the potential use of carbon neutral methane and carbon neutral methanol is also being considered.

In addition to this fuel switch scenario, the development of the next generation of ships is being tackled based on four ship concepts that take into consideration a flexible approach to the life cost of ships and changes in conditions.

The first concept ship - CII Improved LNG-DF - is an LNG fueled ship with innovative energy saving technologies which can improve Carbon Intensity Indicator performance.

The second - Ammonia-DF Ready LNG-DF - is an LNG fueled ship at the time of delivery, but it is designed to easily convert to ammonia in the future.

The third - Ammonia DF Ready HFO Fuel - is a heavy fuel oil mono-fuel vessel at the time of delivery but is ready to switch to ammonia.

The fourth - Ammonia DF - is a heavy-fuel oil vessel which can also run on ammonia depending on the requirements.

The first stage of the development was a panamax bulk carrier, one of the main vessel types in international dry bulk transportation, designed as an ammonia dual-fuel vessel which won an approval in principle (AiP) from ClassNK. Although progress has already been made on the development of large-size ammonia dual-fuel vessels, this represented the first time an AiP had been awarded to a panamax bulk carrier. Panamax bulk carriers are one of the main products of Japanese shipyards. This vessel type was selected as a starting point because it is highly difficult to design ammonia fuel arrangements considering the configuration of the internal spaces.

In the development consideration had to be given to the main issues of ammonia-fueled ships which are toxicity and corrosion. Adequate safety precautions were carried out by following classification society guidelines for the use of ammonia as a fuel. Another issue was that the energy density of ammonia is low, compared to heavy fuel oil vessels, so the fuel tank spaces are considerably larger. After carefully studying the capacity and location of the fuel tanks it was decided to design the ships with two 2,500-cbm tanks positioned on the decks of the ships. By doing so the impact on the cargo volume and voyage range was minimized, and the vessel was safe and easy to use. Consideration was also given in the design for possible use on larger ships, including capesize bulk carriers. On 20 April 2022 the LNG Ammonia Ready LNG fuel panamax bulk carrier was awarded an AiP from ClassNK.

For the time being the use of LNG fuel addresses the issue of lowering carbon emissions, but for the future transition to zero emissions, a switch to ammonia, or carbon neutral methanol is also possible. It was also developed as a solution that allows a flexible and efficient approach when the timing of the transition and the availability of new fuels is unclear.

For LNG fueled vessels there are LNG and heavy fuel oil dual fuel, and for ammonia fueled ships there is a NH3/heavy fuel Oil dual fuel ship type. With either type they have the same voyage range and cargo capacity as conventional heavy fuel oil ships.

Also, in order to reduce the conversion costs and downtime for vessels, parts that can use both LNG fuel and ammonia have been increased. In addition, to minimize and make the conversion work easier, consideration has been given to the standardization of the structure, location and size of the parts which require modification.

As well as bulk carriers the GSC is also developing tankers and containership designs. In addition, a study is also being carried out into methanol which is drawing attention as a potential future fuel.

By utilizing the basic design information developed by GSC, it is expected Japanese shipyards can smoothly progress with the product development of the next generation of environmentally friendly ships such as various types and sizes of ammonia fueled and ammonia ready ships.

Also, to realize a smooth fuel transition, the development of ship machinery and equipment is essential. In 2022, together with the Japan Ship Machinery and Equipment Association, a workshop was held with members of both associations. The purpose was to promote the understanding in the shipbuilding and ship machinery industries of achieving zero emissions and the use of new fuels on ships. Another goal was to promote the technical development of marine equipment and systems such as auxiliary equipment, pipes and instrumentation. In the six workshops held far 100 companies and 400 people have taken part in each meeting and deepened their understanding of ammonia, hydrogen, methanol and other various fuels.

GSC is taking a lead in making shipping carbon neutral by 2050.

AMMONIA DF PANAMAX BULK CARRIER

LENGTH(O.A)	abt.228.9M
LENGTH(B.P)	225.45M
BREADTG(MLD)	32.26M
DEPTH(MLD)	20.10M
DEADWEIGHT	abt.80,400MT
MAIN ENGINE	MCR 8,000kW
SERVICE SPEED	abt.14.2KNOTS
NH3 FUEL TANKS	2500m3 x 2sets

AMMONIA READY LNG DF PANAMAX BULK CARRIER

LENGTH(O.A)	abt.228.9M
LENGTH(B.P)	225.45M
BREADTG(MLD)	32.26M
DEPTH(MLD)	20.10M
DEADWEIGHT	abt.80,400MT
MAIN ENGINE	MCR 8,000kW
SERVICE PEED	abt.14.2KNOTS
CH4/NH3 FUEL TANKS	2500m3 x 2sets

THE GREENER SHIPS TO PROGRESS DECARBONIZATION

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TOWARD AUTONOMOUS SHIPPING WITH MEGURI2040

無人運航船プロジェクト MEGURI 2040 日本財団 THE NIPPON FOUNDATION

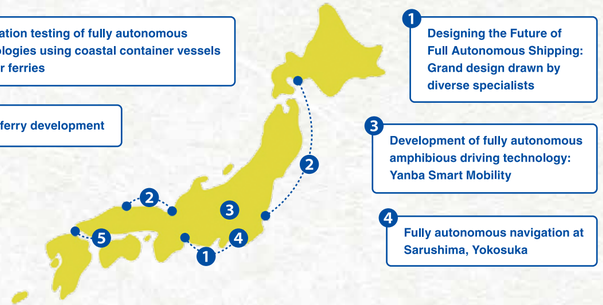
By March 2022 the MEGURI2040 Stage 1 fully autonomous ship project, sponsored and led by the Nippon Foundation, including 50 companies and five consortia from different fields, had successfully completed the technical development projects for six ships and demonstration tests on six routes. This project has opened the door to the age of the fully autonomous ship.

❶-1 Fleet Operation Center

❶-2 Container Ship

❷-1 Container Ship

❷-2 ROPAX



In Japan, the Nippon Foundation-promoted **MEGURI2040** demonstration project has, since 2020, been working toward the realization of the fully autonomous vessel.

The fully autonomous vessel systems installed on the six demonstration ships have successfully performed to the fullest extent in line with the type of ship and route conditions.

One of the demonstration tests, Designing the Future of Fully Autonomous Ship (DFFAS), involved a consortium of 30 different companies from various fields progressing the development under an open innovation format.

The demonstration trial involved the 95.23 meter long 749-gt container ship *SUZAKU* and a Fleet Operation Center (FOC) on land that could carry out autonomous operation and observation of the vessel.

The demonstration test took place on about 430 nautical miles round trip between in Tokyo Bay in the port of Tokyo, through which more than 500 ships pass through daily, and the also-congested Tsu Matsuzaka Port.

The results of the test showed that the vessel operated 97.4% of the time on the outbound journey, and 99.7% of the time on the return journey, on the fully autonomous ship system. The remote operation from the FOC was a success and functioned effectively.

The Mitsubishi Heavy Industries Group company Mitsubishi Shipbuilding and Shin Nihonkai Ferry conducted a demonstration test from Shinmoji in Kitakyushu City in the Iyonada Sea on a 222-metre-long ferry. The trial demonstrated turning and reversing movements, precise automated berthing and unberthing operations, and high-speed navigation up to 26-knots.

Through this project a fully autonomous operating system for large ferries was developed including sensors to detect other ships using infrared cameras, a remote engine monitoring system and a sophisticated cyber security system. From now on this will be a big step forward the automation of ships, contribute to the development of fully autonomous operation and is expected to be a major step forward toward realizing safer and more efficient seaborne transportation.

Also, a successful demonstration test for the fully autonomous operation of an amphibious vessel was carried out on the Yanba Dam on the Agatsuma River.

The **MEGURI2040** test involving Mitsui E&S Shipbuilding is detailed in the column on the right.

The Nippon Foundation **MEGURI2040** project, through the results of the Stage-1 demonstration tests, is aiming at realizing unmanned ship operations by 2025, and preparations are now being made for the Stage-2 project to begin.

❸ Amphibious Car-Vessel

❹ Small Tourism Boat

❺ ROPAX

MMS: Mitsui ship Maneuver control System

Obstacle Avoidance Navigation, *MIKAGE*

Among the companies taking part in the **MEGURI2040** test Mitsui E&S Shipbuilding took part in two consortiums.

From long ago Mitsui E&S Shipbuilding has been involved in navigational support systems such as the integrated ship navigation control system MMS, and the dynamic positioning system DPS as well as total control devices for various navigational technologies such as thrusters, rudders and propellers.

It has a high technical capability in the ship operation controls at low speeds. This technology is leading to the automation of operations within port areas such as berthing and unberthing.

When operating a ship in the port area at low speeds movement is limited and, in addition to the use of many operational devices at the same time, there are other factors causing considerable disturbance including sea depth, wind and waves. Among the issues, to ensure safety approaching the quay, it is necessary to precisely control the positioning, direction and speed creating a high level of difficulty in ship operation.

It is a mentally taxing task for the operator. As the impact of automating this process would be considerable, Mitsui E&S Shipbuilding focused on this area to develop a control system from an early stage.

Mitsui E&S Shipbuilding participated in The Nippon Foundation **MEGURI2040** Fully Autonomous Ship Program to develop an autonomous operation system for three demonstration ships and has successfully demonstrated technology, which is essential for the realisation of fully autonomous ship operations.

Firstly, it took part in a consortium promoted by Marubeni Corp and others demonstrating the fully autonomous operation of a small passenger ship. Mitsui E&S Shipbuilding applied its automated operation technology to the small passenger ship *Sea Friend Zero*.

The ship carried out fully automated operations over about one nautical mile including unberthing, sailing, collision avoidance and berthing.

For the first time in the world fully automated navigation from departure to docking was demonstrated on a small tourist boat.

After that it took part in a Mitsui OSK Lines led consortium which conducted a demonstration trial on a coastal container ship and car ferry for the development of technology for autonomous shipping, and took charge of rout following, automating avoidance maneuvers and in port operations and berthing and unberthing.

The demonstration trial on the 749-gt container ship *MIKAGE* took place over 150 nautical miles between the port of Tsuruga in Fukui Prefecture and the port of Sakaiminato in Tottori Prefecture. All operations from departure to coastal sailing to arrival, and including avoidance operations, were all fully automated.

It was the first ever example of the fully autonomous navigation of a commercial in-service container ship.

Also, the large-size car ferry *Sunflower Shiretoko* sailed between Tomakomai in Hokkaido to Oarai in Ibaraki Prefecture, a distance of 400 nautical miles and taking over 18 hours.

This set the world record for the longest ever distance and time for a continuous demonstration trail of an automated sailing. The ship left port at 10pm in the evening and sailed throughout the following afternoon and evening at a high speed of 23 knots continuously over 18 hours. In addition, considering access to the Tomakomai and Oarai ports are narrow, it was an extremely difficult challenge for the ship operating system, but it demonstrated precise and safe, and operation can be achieved.

In particular the port of arrival at Oarai faces the open sea and is exposed to wind, waves and current, and measures just 80 meters at the narrowest point, requiring very difficult maneuvers from the 180-meter-long Sunflower Shiretoko to dock.

Each of the three demonstration ships have considerable differences in their size and characteristics, but the demonstration tests confirmed that ship operations can be technically automated for many ships.

Mitsui E&S Shipbuilding will take the technical results it received from this joint project and its own independent research to upgrade and improve the performance of ship operation support system and commercialize the product by expanding its functions.

Berthing System in Oarai Port

The Ship Data Center (ShipDC) operates the IoS Open Platform (IoS-OP), a common infrastructure for centralizing and sharing data related to ship operations. ShipDC aims to promote the IoS-OP framework as a de facto standard to realize a fair and equitable global market for data sharing.

OPEN PLATFORM FOR DATA SHARING GROWS

The intention of IoS-OP is to provide a common infrastructure that allows stakeholders to share data about ship operation without compromising the interests of the data provider. It is made up of rules around the use of data and a data centre to store and provide operational data.

In the IoS-OP the aim is to have a "Cooperative Domain" linked to the distribution of data where participants cooperate, and a "Competitive Domain" where participants can focus on innovation and the development of new services. The "IoS-OP Consortium", a member organization of ShipDC makes common rules for data sharing, examines technical issues and supports business activity. As of January 2023, there were 68 member companies. These included 27 marine machinery manufacturers, 12 shipbuilding companies, 6 shipping companies, 14 digital, communication and IoT service providers and 9 classification society, research institutes, research association and others. The membership is not limited to the shipping industry and attracts participants from various industries. The activity is also not limited to Japan and the nationality of the participating companies is not an issue. Currently companies from Singapore, Denmark, the UK and South Korea are taking part.

One of the most obvious example of data sharing through IoS-OP is the use case of Ocean Network Express (ONE). In 2019, three Japanese shipping companies, NYK Line, Mitsui OSK Lines, Kawasaki Kisen have begun sharing of operational data acquired from the monitoring system installed in their container ships with their charterer, ONE, through the IoS-OP.

The number of ships which are sharing data through the IoS-OP is increasing. In 2020 and 2021 the three major Japanese shipping companies NYK Line, Mitsui OSK Lines and Kawasaki Kisen agreed to expand the number of ships providing data, and the number of registered ships increased to around 500.

Data ownership is one of the critical aspects of ensuring the transparency in the data sharing. To ensure the appropriate data management under IoS-OP the responsibilities of stakeholders in data collection and utilization are defined according to data ownership. In the IoS-OP, data ownership is defined as the authority to utilize data on an agreement basis, and the "Platform User" is the entity who has the authority. The roles are defined as the "Platform User" which is involved in data collection, the "Platform Provider" is involved in manufacture and sale of onboard data collection servers, the "Solution Provider" offers land-based application and analysis services, "Solution User" utilizes data to contribute to ship operations and the "Data Buyer" uses data for the benefit of their own company. Under these common rules the flow of data is promoted to the benefit all stakeholders.

Currently registered platform providers include Terasaki Electric, BEMAC, Furuno Electric, Alpha Ori Technologies and Mitsui E&S Shipbuilding. Solution providers include NAPA, ClassNK Consulting Service, NYK Line, Ocean Network Express, Tsuneishi Shipbuilding, Nautilus Labs, Nabtesco, Hitachi Zosen, Weathernews, Chugoku Marine Paints and seawise.

With the increasing combinations between the data servers and applications taking place on IoS-OP, in 2022 under IoS-OP Consortium a service was started to test and verify the connection between the onboard data server and application software. Based on this it has become easier to identify combinations of the onboard data servers and application software products that are compatible.

IoS-OP advocates the fair and equitable sharing of data, for example requesting that data will not be provided to a competitor company and realizing a structure in which data can be fairly shared with all stakeholders without causing a disadvantage. In addition, above IoS-OP the ShipDC provides an automatic conversion function to the standard name using the International Standard for shipboard machinery and equipment (ISO 19848) that reduces the burden of data conversion work.

In 2020 the international consortium Smart Maritime Network (headquartered in Ireland), made up of digital companies and others, decided to officially support the use of the ISO 19848 Standard data for shipboard machinery and equipment used in IoS-OP. Based on this the standard is expected to become more widely used.

There is an example of cross industry collaboration on ship operational data. The Japan Fisheries Information Service Center, which is involved in handling fishing industry related information, through IoS-OP received ship operational data from NYK Line and Kawasaki Kisen to improve the accuracy of understanding the current state of sea conditions for fishing and to start to use the information to make predictions about the future. By using data on sea temperatures, the aim is to better understand current and future fishing sea conditions. It could also help the economics of the fishing business by improving fishing catch and reducing fuel consumption, which, it might be expected, could even contribute toward a reduction in greenhouse gas emissions.

"We believe that we can ultimately contribute to your environmental issues and the pursuit of the safe operation of ships through IoS-OP," said President, Yasuhiro Ikeda.

Registered Providers

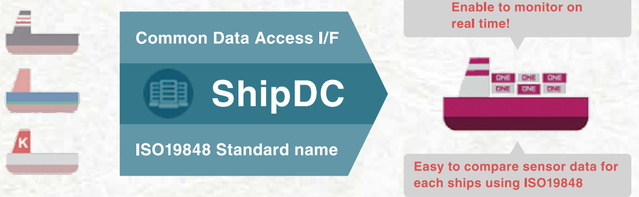
PP (Platform Provider) - Shipboard Data Collection Servers

TMIP	MaSSA-One	FOP	SMARTShip	Fleet Transfer/Monitor
TERASAKI	BEMAC	FURUNO	Alpha Ori	Mitsui E&S

SP (Solution Provider) - Shore Solution Services, Applications

Fleet Intelligence	ClassNK CMAXS	IBIS PLUS	Ship Data Viewer	Tsuneishi
NAPA	ClassNK Consulting	ONE	NYK Line	Tsuneishi Shipbuilding

Japanese Operators Share Data with ONE through IoS-OP



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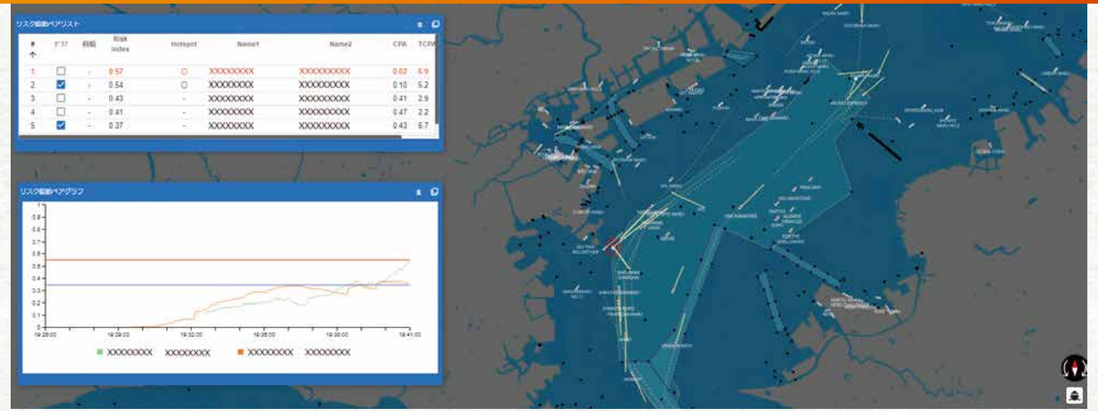
AI IMPROVES PREDICTION OF COLLISION RISK

As global seaborne transportation continues to increase major ship casualties are happening one after another. Especially in narrow waterways in and around ports, technology which supports traffic management and onboard watch keeping is needed. General IT vendor Fujitsu has established advanced technology that can accurately predict the risk of ship collision using its own specialization in data analysis and AI technologies.



Screen image of vessel collision prediction technology

In 2014 Fujitsu, which has developed across 180 countries, together with the Singapore Agency for Science and Technology and the Singapore Management University, established the Urban Computing and Engineering Centre of Excellence (UCE CoE). From 2015 onwards it set out to improve the safety of maritime transportation through the development of maritime traffic management technology.

To turn the outcome UCE CoE's development into a practical solution, between 2018 and 2019, Fujitsu joined with Maritime and Port Authority of Singapore (MPA) in a demonstration project in the Singapore Strait's Maritime Traffic Control Services, assessing the application of AI technology in predicting the collision risk between two ships.

In this trial, collision risk detection technology developed by Fujitsu's research and development to precisely measure collision risk, and dynamic risk hot spot technology which predicts the areas and time where the collision risk will be most concentrated, was demonstrated and the results were confirmed. A major challenge for the practical application was evaluating the precision of predictive technology. To do this several cases of collisions and near misses were selected from past traffic data in the Singapore Strait and compared with MPA traffic controllers' judgement in assessing danger and evaluating whether they matched. This showed that the technology could detect potential danger and send out alerts 10 minutes before an incident, that is around 5 minutes earlier than warnings that were put out by traffic controllers. It was also able to accurately detect collision risks that are often missed by humans.

Between December 2019 and March 2020, the next stage of development took place in Japan. The effectiveness of Fujitsu's collision risk prediction technology was verified at the Tokyo Wan Vessel Traffic Service Center, under the outsourcing of the Japan Coastguard. The results confirmed that Fujitsu's technology is effective in the early detection of vessels with a collision risk. It was also confirmed that by quantifying the collision risk, and by making traffic controllers aware of it, to a certain extent duties could carry on without to relying on their experience and skills. Between November 2020 and September 2021 at the Tokyo Wan Vessel Traffic Service Center Fujitsu demonstrated its technology after brushing up the results of its research and development. This technology took data the vessel's current position, its speed and direction and used AI to calculate the predicted risk of collision, this was combined it with an algorithm that calculates the degree to which the ship is following its course, to come to a more precise prediction of the risk of collision. This made it possible to provide alerts only in situations with a high risk of collision and changes of the course along a route would no longer be detected as dangerous steering. Under the conventional method alerts are frequently made at bends in the route. But, by using this technology, unnecessary and excessive alerts could be reduced by as much as 90% across the whole route. For busy marine traffic controllers which monitor collision risks such unnecessary alerts are a noisy distraction. If these can be reduced, then the workload of traffic controllers can also be significantly reduced.

From this domestic and foreign trials Fujitsu was able to confirm the effectiveness of the basic research and move on to developing a product. From 2021 the product was developed through the Japan Ship Machinery and Equipment Association under a product development grant from the Nippon Foundation. In May 2022 the "AI ship collision risk analysis software" was launched as a safe navigation support solution.

The concept of this product is the early detection of risk and supporting a rapid response for the avoidance of collision, and to contribute to an improvement in the safety of maritime traffic by reducing human error and the workload of the user. "It was difficult to have a qualitative sense of assessing collision risk, and evaluating its value on the user's business," said Kenta Usui, Manager of the Transportation Business Division, Social System who was involved in the product development. "To understand of the work of traffic controllers, and to fine tune the technology to support them, we received the cooperation of the MPA and Japan Coastguard, through the experience of traffic controllers and our discussions with them, and in analyzing the data, we came up with the technology," he said.

Senior manager Yoshiyasu Sone, who was also involved in the product development, said: "We struggled to combine the "truth," as understood through the experience and knowledge of traffic controllers, and the "truth" as understood through Fujitsu's big data analysis in a package," he remembered.

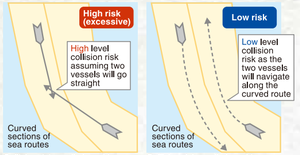
By completing the product in this way many benefits can be expected, including the realization of risk avoidance behavior from traffic controllers and watch keepers, contributing to a standardization of skills by crew and traffic controllers and a reduction in human error. Usui said a characteristic of the product is that "with the collaboration of data and the traffic controllers on site a quantification of risk that fits with human senses can be achieved." He added: "Through early detection it creates alerts in stages which are suitable to the situation while it supports the digitalization of the operation through precise AI," he said. Senior manager Sone added: "Several ship collision risk models can be created improve the risk evaluation, risk can also be ranked between 0.0 to 1.0 and, through a numerical rating of risk, traffic controllers which are monitoring multiple ships can prioritize the highest risk ships."

Looking forward Usui said: "From now on we don't only want marine traffic controllers to use this but also, by extending it to onboard watchkeepers, from both land and sea we want to provide comprehensive risk management." The policy is to brush up the technology based on feedback from customers and others.

Fujitsu has successfully achieved its initial objective: to use its strength in AI and advanced technology to develop a product to support safe navigation. Its technology not only realizes safe navigation but also connects to major issues such as the declining birth rate and ageing population and labor shortages. It can also help achieve a sustainable society and economy. Fujitsu will continue to take on the challenge by spreading the benefits of its IT technology widely throughout the industry.

Evaluation by operation controller at the Tokyo Wan Vessel Traffic Service Center

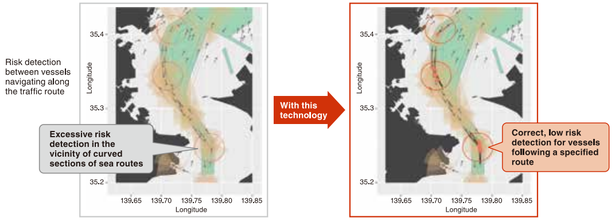
omparison of conventional collision risk prediction with new technology



Collision risk prediction with conventional technology

Collision risk prediction with new technology

Screen comparison image of collision risk prediction



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IoT FIX FOR SHIP BLACKOUTS

In shipping when a blackout or other breakdown occurs at sea, responding quickly can be a matter of life and death. General electrical manufacturer BEMAC has converted its switchboards to IoT systems to ensure a quick response to when there is a breakdown of power distribution and other such problems at sea.

Suggested restoration procedures

BEMAC is based in Ehime Prefecture in Japan's largest maritime city of Imabari where the country's marine industries are concentrated. As a general electrical manufacturer it is involved power distribution and control systems for large ships and the design, manufacture, electric work and maintenance of all types of electrical equipment.

BEMAC's main product is the main switchboard. The main switchboard drives the engine generator, controls its electrical power and distributes it to electrical equipment throughout the ship. It is the manager, so to speak, of the power distribution system. So, when there is a problem with the power distribution system, such as failure to start the engine generator, BEMAC is the first to receive enquiries.

On a ship when there is a breakdown of the power distribution system, in the past an engineer was sent out, but since the Covid-19 pandemic, movement was restricted and free travel was no longer possible, making it difficult for BEMAC to respond. The cope with this situation, when there is a blackout and other problems, BEMAC created an application for condition monitoring and preventative maintenance by allowing the ship's crew to see and analyze data while onboard.

With the support of the Japan Ship Machinery and Equipment Association the development took place between 2020 and 2021. This development included a data collection unit, which collects power distribution data, an application which displays data, and other information, and a function through which AI is used to predict machinery breakdown.

The final product was an application that included both a blackout diagnostic and power distribution system trouble shooting application at the same time. Based on power distribution data, the problems cause is automatically diagnosed and troubleshooting is proposed to resolve the issue. Also, data before and after the problem occurred can be stored, so the user could check on previous failures.

By using this application onboard crew can analyze the problem while looking at the data. Also, when there is a blackout BEMAC engineers onshore can be contacted by email and, through the application, the shoreside personnel can view the same data as the ship's crew to analyze the cause and offer remote advice.

The development was a success because BEMAC is involved in the switchboard and can view the whole power distribution network. Also, in the development, BEMAC's accumulated experience up to now was brought to life. Over many years it has recorded problems and included it in a data base. By analyzing these numerous cases it was able to include many examples of trouble shooting in the application.

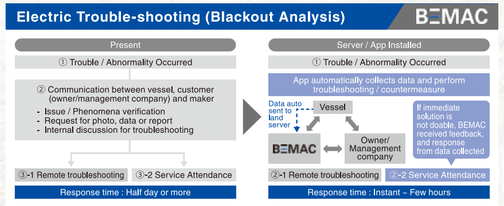
Manager Atsufumi Takegata, who was involved in the project, emphasized: "Our company is not only involved in providing switchboards, it also handles electric work and a wide range of after service. These points also helped us to enhance the troubleshooting."

Commenting on the application Hajime Jinno, Chief of the IT System Group, added: "We are planning an upgrade next." The plan is to progress by including a function that will predict problems with the power distribution. The main theme of the challenge will be combining the judgement of AI technology and the feeling of people at the actual site. Looking to the future Hiroyuki Kawasaki, Manager of the IT System Group, said: "This will not be limited to troubleshooting of the power distribution system, from now on we also want to work with the generator engine manufacturers and others to expand the range of fixing defects."

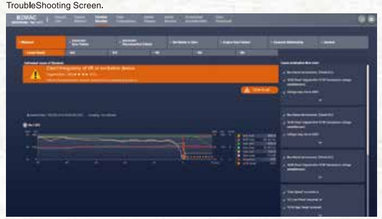
BEMAC has raised the development concept of "MaSSA (The Maintenance System for Soundness Sailing Ability)" which is advancing technology toward the target of creating a ship which supports safe navigation whatever the conditions.

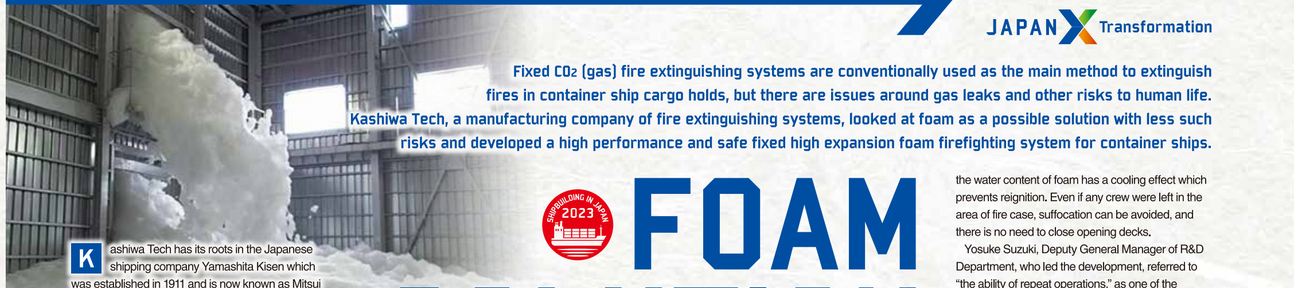
The development so far is part of this. "While making applications one by one we want to reduce ship down time and ultimately achieve the 'ship that does not stop,'" said manager Kawasaki.

Supported by THE NIPPON FOUNDATION



TroubleShooting Screen.





Fixed CO_2 (gas) fire extinguishing systems are conventionally used as the main method to extinguish fires in container ship cargo holds, but there are issues around gas leaks and other risks to human life. Kashiwa Tech, a manufacturing company of fire extinguishing systems, looked at foam as a possible solution with less such risks and developed a high performance and safe fixed high expansion foam firefighting system for container ships.

FOAM SOLUTION FOR CONTAINER SHIP FIRES

Kashiwa Tech has its roots in the Japanese shipping company Yamashita Kisen which was established in 1911 and is now known as Mitsui OSK Lines. In 1947 it started out selling carbon dioxide fire extinguisher as its main business.

Since then, the company has been established as a comprehensive manufacturer of marine fire and disaster prevention product involved in the design and development of fire extinguishing and environmental protection equipment.

Under the International Maritime Organization's SOLAS Convention fixed fire extinguishing equipment in cargo holds is restricted to gas fire extinguishing systems using carbon dioxide gas - and equipment using inert gas - or alternative fixed fire extinguishing system which has the equivalent level of effectiveness. However, currently only gas fire extinguishing systems are provided.

As for gas fire extinguishing equipment one main structural risk has been identified by shipowners. When a fire breaks out in the cargo hold the use of CO_2 gas can leak in the gap between the hatch cover and the hatch coming and the concentration of CO_2 cannot be maintained enough to the extinguishing ability.

But Kashiwa Tech, which specialises to use the foam in fire extinguishing, started to look at its effectiveness as a possible solution. Also, following a number of disastrous containership fires there was a strong call from shipowners to apply foam fire extinguishing systems to container ship holds which also encouraged the development.

A key to the development of the equipment was how to evaluate an equivalent level of performance as a gas system. So, Kashiwa Tech requested Class NK for the cooperation and they began joint research in 2017. As well as demonstration tests and trials based on simulating fire conditions in container holds, Computational Fluid Dynamics (CFD) was also used to simulate and analyse the foam flow. HAZID meetings with shipyards, shipowners and other experts were held and the equivalence with gas fire extinguishing systems was confirmed.

In the subject high expansion foam firefighting system, the foam generators are fitted to the ventilation ducts onboard, which works as the ventilation system and the foam firefighting system as well. Patents for the product have been issued in both Japan and South Korea and are under review in China. In recognition of equivalence with gas firefighting systems, Approval in Principle have been obtained from classification societies as ABS of the USA, Lloyd's Register and Norway's DNV.

Jiro Otagaki, Technical Adviser, said: "A subject of the development was to prove that in a loaded condition the spread of foam into the container hold including the space between containers would be sufficient." Because it was difficult to conduct full scale tests, CFD simulation was practiced analyzing foam flow. Another difficulty was to set the parameters for analysis, "we recorded the video of foaming process made by a small size foam generator and requested the experts to estimate the foam spread, and set the calculation parameters based on the video," he said. Finally, through such struggles upon the hard work, a simulation similar to the real experiments has been created.

Foam firefighting system has the advantage of high fire extinguishing performance and human safety, the water content of foam has a cooling effect which prevents reignition. Even if any crew were left in the area of fire case, suffocation can be avoided, and there is no need to close opening decks.

Yosuke Suzuki, Deputy General Manager of R&D Department, who led the development, referred to "the ability of repeat operations," as one of the product's special features. Gas fire extinguishing system can be operated basically only one time, but foam firefighting system can be loaded with foam liquid more than five times of the protection areas' volume, resulting in more operations repeatable. And the system size and footprints are compact, therefore, the frequency of the maintenance work is much less.

In the product development process, the company's in-depth knowledge of high expansion foam firefighting system worked effectively. And the involvement of the member who was an expert from a shipping company, familiar with container ship structure, also benefitted the development.

Saburo Yamagata, Managing Director cited an episode. "One ship crew, when he witnessed the results of the fire extinguishing test, said 'I'm very relieved. From now on there's no hesitation to press the switch of the firefighting system.'" Yamagata told it was really impressed. Mr. Otagaki emphasized: "We expect the reduction of the disastrous fire accidents through the application of this foam firefighting system."

Simulation of Foam Flow in Container Hold.