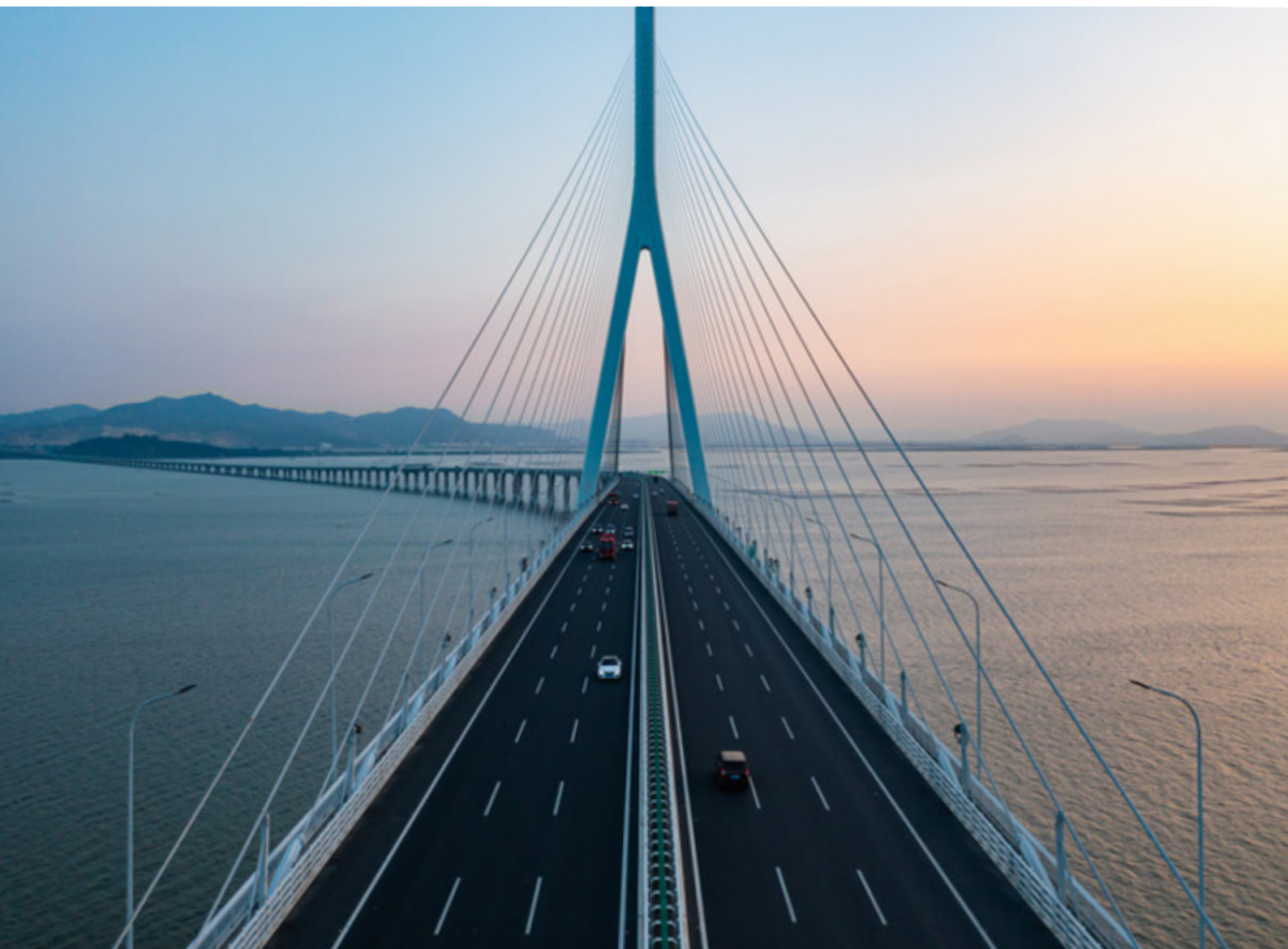


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GENERATIONS

EXPANDING HORIZONS



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Redefining the role of humans in the age of automation

Dr. Yemao Man, Senior User Experience (UX) Researcher at ABB's Corporate Research Center in Västerås, Sweden, challenges the prevailing narrative that human error is the primary cause of accidents in the technical world. Seeing human errors as a symptom of deeper systemic issues, he emphasizes the importance of human-centered design and offers a fresh perspective on the integration of UX in business in an increasingly automated world.



Dr. Yemao Man,
Senior User
Experience
Researcher,
ABB Corporate
Research Center

Tell us about your work and how you became interested in UX?

Basically, our laboratory is the users' own world. We conduct extensive research via field studies, observing and interviewing operators and other key stakeholders in their environments. We explore how they interact with equipment, software systems, and even each other, aiming to uncover unarticulated needs and identify pain points. Then we generate actionable insights to improve design or create novel concepts for visioning the future.

My interest in UX began when I was studying Computer Science and Engineering. UX and human-centered design are an intriguing field at the intersection of cognitive science and technology. I completed my PhD in Human Factors (HF), a social-technical discipline that studies the interactions between humans and other elements in a system.

UX and human-centered design are an intriguing field.

UX is a continually evolving continuum of those interactions, influenced by design and closely linked to emotion and engagement. In the marine domain, the time I have spent on ethnographical studies on vessels has significantly deepened my understanding of how design impacts user cognition, satisfaction, safety, and efficiency in industrial settings.

Conceptual design:
visioning future
ship bridges
(Image generated
by Yemao Man
with Gen AI using
dedicated prompts)



What are some non-technical aspects of Human Factors?

A core part of our research is identifying barriers to task execution. Is it due to lack of knowledge of the system in question, miscommunication, or a badly designed user interface?

The role of human interactions within organizations is a critical part of HF. Our focus is on enhancing communication to minimize misunderstanding, and we achieve this by closely examining how individuals collaborate and coordinate their efforts.

Training is very important. As technology advances, the need for appropriate training becomes more apparent. Relying on extensive manuals for user education is often ineffective. Can we use other ways to encourage more active learning? I think this is an important area of research. One promising direction is the application of augmented reality (AR) technologies. By making training more interactive and engaging, AR can facilitate experiential learning, allowing operators to assimilate knowledge more effectively through augmented hands-on experience.

How is UX different for automation technology?

The integration of automation technology into technical systems represents a significant shift in user-system interaction dynamics. Unlike many consumer-oriented technical applications, automation assumes a greater role in decision-making. This transforms the user's role into a more supervisory or managerial one, which can lead to significant cognitive challenges and user engagement issues.

A critical aspect of UX research is to understand user behavior in response to automation failures or unexpected system behavior, and how design should cope with that resiliently.

Trust plays a fundamental role in our approach to understand human-automation relationship, and it is influenced by many factors, including individual factors, information visualization, and interaction design. Additional considerations for automation technology include the necessity of proper training and adherence to ethical design principles. Ethical design is especially important in ensuring that technology does not introduce biases or unfairness into the system. For example, a performance ranking system that displays an operator's performance alongside their peers could raise ethical and psychological concerns.

As long as there are humans in a system, there will be errors.

Do you think people fear automation?

I have conducted a lot of interviews in which people have expressed their concerns about high-level automation, particularly regarding job security. Some managements seem more interested in using technology as a substitute for human labor rather than as a tool to enhance and support human performance.

While there is speculation about a jobless future, to me such a reality seems distant. Nowadays a lot of activities that have high knowledge barriers, such as writing, can be performed by AI. These systems are flexible and efficient, but unlike human beings they lack inherent goals or values. These are things that make us fundamentally different from machines.

I really don't believe machines will take over our world. Our focus shouldn't be solely on creating powerful technology in isolation. Instead, the future should be envisioned as a synergistic partnership between humans and machines, where we complement each other's capabilities. Technology should support human endeavors without replacing the human element – I think this is fundamental to our society and values.

—
UX researchers in ABB's UX research team (from left to right): Emmanuel Brorsson, Mowei Yang, Dawid Ziobro, Shreeya Sate, Petra Bjorndal, Yanqing Zhang, Yemao Man



What are common misconceptions about Human Factors?

One of the most frequently heard misconceptions is that humans are not reliable, slow, forgetful, and easily stressed, thus forming the weakest link in systems. This often leads to the argument for replacing humans with advanced technology. However, this view overlooks the fundamental and unique strengths that humans bring to complex technical systems.

Researchers in an area of study within HF, called joint cognitive systems and resilience engineering, advocate for viewing humans not as potential liabilities, but as essential contributors, enhancing a system's adaptability and resilience. We humans possess unique abilities to anticipate, adapt, and respond effectively to unexpected situations. A good example is the Apollo 13 incident back in 1970, in which NASA astronauts and ground crew, using their ingenuity and adaptability, crafted a life-saving solution using the available resources, landing the craft back on Earth after a rupture in an oxygen tank put the mission in jeopardy.

Human adaptability does come at a cost, which is the potential for errors. However, these errors should not be viewed as "bad apples" but rather an intrinsic part of an evolving social-technical system. The key is not to replace human operators, but to create systems that enhance and support human capabilities. We should not strive for rigid design that eliminates human errors at all costs, but for design that allows the system to absorb errors and still function safely.

How should HF/UX be considered in a business scenario?

It is important to consider the benefits that HF and UX research bring to a business. For a company trying to develop a user-friendly product, clear and transparent communication with end-users is crucial.

A characteristic of current automation technology is the use of complex pipeline diagrams or user interfaces. People often struggle to understand how the outputs are generated. They are unsure whether they should trust the technology, due to a lack of understanding of the underlying process. Addressing the transparency of these processes for end-users is a key focus in HF studies. We need to think about ways to effectively explain results to end-users who are experts in their own domains, not in machine-learning, statistics, or mathematics. When presenting AI-based recommendations, it is essential that operators comprehend the rationale behind those calculated results.

This goes beyond simple interface design, which is often mistakenly equated with HF and UX. We must have a holistic system perspective to understand what is going on in the field, and then translate those findings into design insights. This approach can significantly influence business, particularly with emerging trends like generative AI and the industrial metaverse, which have the potential to disrupt conventional business models. Understanding their impact on HF is crucial for devising better design strategies.

There is a saying in HF that “good ergonomics makes good economics”. While this might not be immediately visible in the short term, its long-term value is undeniable.

Do businesses generally invest enough resources in HF?

There is definitely room for improvement in how we view the impact of our work in HF and UX research. The focus is often on tangible business outcomes like top and bottom lines. Managers frequently ask UX researchers about the revenue potential of their work. Yet, UX is a complex social-system construct that cannot be simply quantified. It is similar to trust in design, because it is also challenging to measure the direct impact of design on revenue in quantifiable terms. I believe there should be a shift towards cultivating a human-centered mindset in business because putting the needs of customers at the center of business operations will eventually lead to higher customer satisfaction and long-term success. Over time, the profound impact of UX will become evident.

Human-centeredness focuses on innovating around users’ needs and challenges. If we embrace a technology-centered approach, which is prevalent in many industries, then we prioritize what can be sold to users based on available

technology. I think this will backfire in the long run. You have to start with the user experience and work back towards the technology – not the other way around.

There is still a lot of that needs to be explored in the terms of HF, and that requires engaging with real end-users in real-world scenarios in a scientific manner. Our synthesized insights stem from deep engagement with end-users through rigorous user research methods, including observation, interviews, and even shadowing. This enables us to empathize effectively. We identify stress-inducing situations, critical information needs, and gather feedback on interface sketches. After fieldwork, we spend hours reviewing videos, analyzing notes, and figuring out how to convey these invaluable insights to product designers.

Is attributing incidents to human error without further explanation an old-fashioned approach? Are we now looking beyond human error?

This narrative around human errors being a primary cause of accidents is still prevalent in the technical world. It gets us nowhere because it implies that human beings are inherently error-prone and supports the argument for technology replacing them. We should not overlook the broader context in which errors occur. Human errors should not be seen as a cause, but rather a symptom of deeper issues within a socio-technical system.

Human errors are often the result of systemic problems such as design flaws or inadequate training, poor communication, or unrealistic workloads. An organizational culture and leadership style that views errors as learning opportunities and catalysts for systemic improvement can significantly increase the chances of proper support during mishaps and help to mitigate risks.



Conversely, organizational issues, such as the pressure to outpace competitors by rushing production without prioritizing high safety standards, can silently contribute to system failures during the risk incubation period.

I think we should dig into how organizations can learn from errors and become more resilient. The focus should not be on the unrealistic goal of eliminating human errors entirely. As long as there are humans in a system, there will be errors. Instead, the emphasis should be on designing systems that can mitigate the impact of such errors. Leadership should be crafted to support a safety-conscious and human-centered culture, fostering an environment where individuals feel empowered to contribute to the improvement process. This approach will encourage a more reflective and growth-oriented organizational ethos. •

Insurers look to a future with uncrewed vessels

As autonomous technologies are moving into the realms of commercial applications, marine insurers are getting to grips with what this new breed of vessel will mean for them. Generations asked Mark Harrington, Commercial Director of the Shipowners' P&I Club, which launched the world's first autonomous vessel policy in 2018, how uncrewed ships can reduce risk and enhance safety in future.



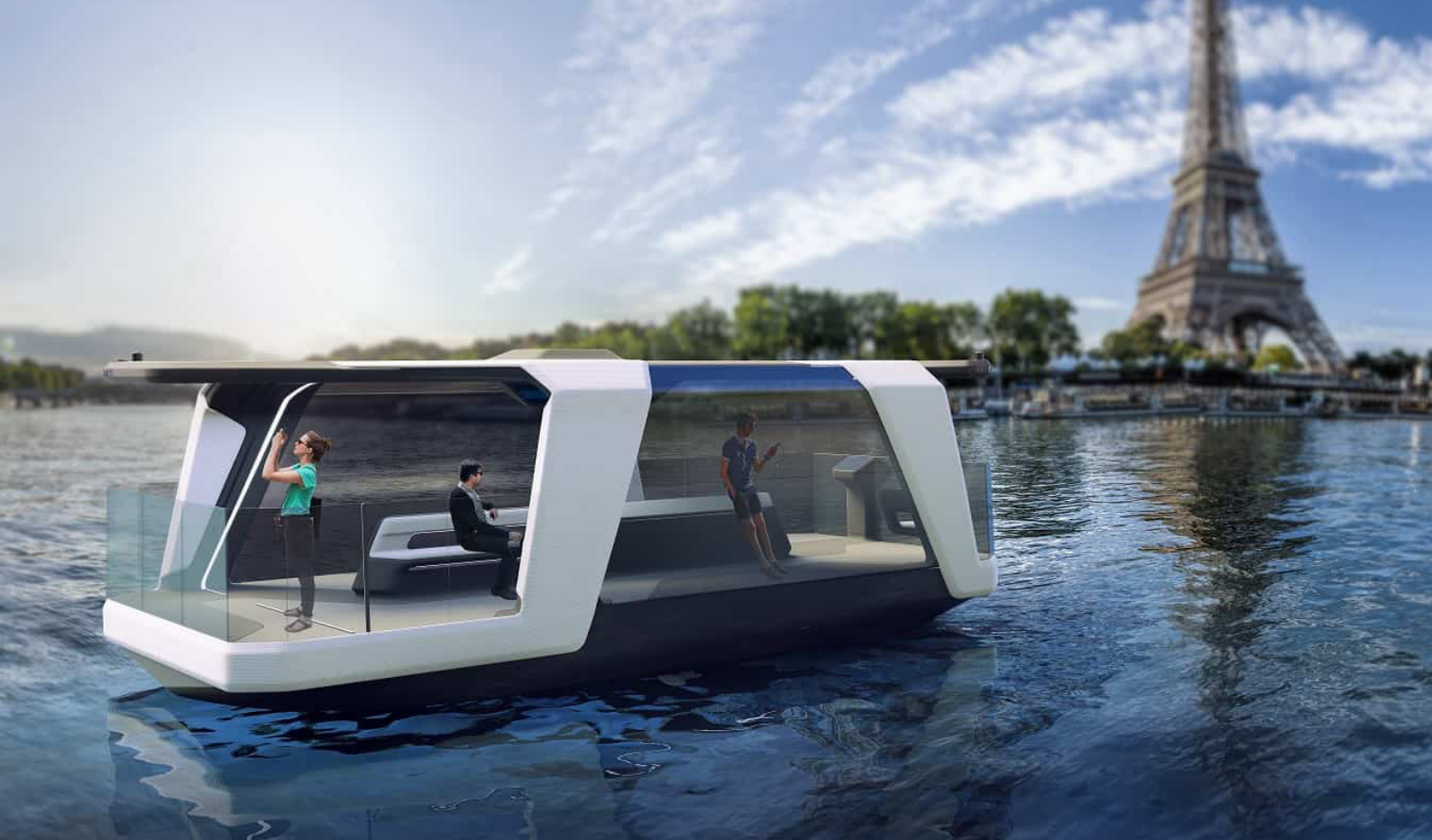
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Mark Harrington,
Commercial
Director,
Shipowners'
P&I Club

Harrington says experts consulted by the Shipowners' Club do not expect large, uncrewed vessels to be commonplace before 2040, given the required changes in international regulations.

However, small, uncrewed craft are already in the water, and this is what the club is commencing with into the autonomous ship market. These specialist craft, known as autonomous surface vessels (ASVs), are less than 24 meters (79 ft) in size. Typically monitored and controlled from a remote location which can be either on another vessel or ashore, these vessels are used to clean up rivers and beaches, as well as to inspect construction sites. So far, the club has not had a single claim on the 80 uncrewed crafts it covers. Their autonomous vessel policy is 'all risks' with a limit of up to \$500 million and includes cyber insurance.

"Admittedly these are lightweight, low-risk vessels, but because there is no need to have people on board doing these jobs, hazards are obviously reduced. In short, less people equal less claims. As P&I insurers most of our claims are people-related but we haven't seen any technology failures either," says Harrington.

Projects are in the pipeline for uncrewed vessels over 24 meters and "there will be a need for P&I cover for even larger vessels in the coming years, which we find very exciting. According to our projections, larger fully automated vessels could potentially result in claims savings of 25 percent and 43 percent in \$ incurred," he adds.



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Render of the
autonomous ship
on the river Seine
(Image credit:
Innovation Origins
– MidJourney)

“P&I is a traditional product with a 168-year-old history. Things have changed a lot in that time, but the cover has stayed pretty much the same. It’s exciting to think about what kind of services we need to provide for this new era of vessels. There will be situations we don’t even know about yet and current risks that may be on a different scale.

“But then we are underwriters, so we have to be prepared to take calculated gambles. Many companies rely on us to provide solutions to cover new risks. Risks change and this is just another example of that.”

Benefits must be balanced with risks

Harrington recently outlined some of the benefits and risks of autonomous vessels during a presentation at the International Union of Marine Insurance (IUMI) in Edinburgh. According to him, some of the ways in which uncrewed vessels could reduce risk and enhance safety are through collision-avoidance technology, real-time weather data, improved data recording and stricter regulatory requirements.

At the same time, he says, these, and many other benefits, should be balanced against just as many potential risks, including technology failures, public perception, cyber-attacks, job losses and fire.

How quickly the autonomous market will develop depends on how much companies can invest in this market and change their practices, as well as how the world will change, says Harrington, noting that ports and infrastructure will have to change to adapt to uncrewed vessels.

“But the P&I industry will need to provide solutions so that people can invest. Investment cannot progress if we don’t provide financial security in the form of insurance. Because this is a new and evolving area, there is a lot we just don’t know, but then P&I has always been reactive in terms of how many claims we get,” he adds.

Something Harrington sees as crucial when it comes to autonomous technology on vessels is communication between the P&I community and the maritime industry.

Many companies rely on us to provide solutions to cover new risks.

“We want to know about your near-misses that don’t result in claims. We are insurers, not technology experts. So as much information as we can get from technology experts the better, and vice versa. Send us questions and details of things that go wrong so we can get a broader indication of what we should be charging and prevent others from suffering the claims you almost had.”

Ships at sea
(Image credit: One
Sea Association)



Pricing is all about expanding knowledge

Harrington adds: “When aspects of P&I have changed in the past, the price starts somewhere, but over time, and with claims experience, we hope to provide greater stability in pricing, better loss prevention, and the right policy. We’re in touch with a lot of people and we see a lot of publications. The more knowledge we have, the more we can adjust our pricing. What operators of both uncrewed and other vessels want is stability in the premiums and the more we know, the more we can offer that.”

Harrington concedes that uncrewed large oceangoing container ships or tankers “will be way past my underwriting career” and wonders whether uncrewed cruise ships will ever be accepted by the public. “However, we want to be ready and there to provide the insurance, however autonomous technology plays out.”

In the meantime, he is looking forward to the 2024 Paris Olympics, which will offer a glimpse of the autonomous future in the form of an uncrewed electric ferry along the Seine River. This 3-D printed vessel will be used to transport athletes and visitors from around the world. As Harrington says, “the autonomous market is only ever going to grow”. •

Spearheading the emerging autonomous market



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Kalevi Tervo,
Global Program
Manager,
ABB Marine & Ports

Kalevi Tervo, Global Program Manager at ABB Marine and Ports, agrees. “Although we may have to wait a long time for autonomous ocean liners, autonomous technologies are already being applied in various ways on these large vessels.

“For example, safety is being increased and risks reduced with systems that use autonomous technology in one way or another, such as automatic braking assistance (crash stop) and advanced automatic maneuvering control. Then there are collision avoidance, docking and lookout assistance systems also in use.

“So, in practice, in addition to actual autonomous (short-distance) ships, these systems are spearheading the emerging autonomous market up to level 3, ie, conditional automation, according to the levels of automation defined by One Sea. It's exciting to see how the market will develop.”

Breaking down barriers in the South African shipping industry

As the CEO of South Africa's only 100 percent black ship-owning company, Durand Naidoo does not believe in barriers. He finds ways to step around them. His business also boasts the highly unusual feat of being 51 percent black female-owned.



—
Durand Naidoo
CEO
Linsen Nambi

When Naidoo started Linsen Nambi in 2010, it was in response to an obvious barrier: there were no South African C-suite executives in the shipping industry.

“I was working for Maersk-owned Safmarine in Johannesburg at the time, and Maersk was leading it from Copenhagen. I looked at the South African shipping companies running the industry and saw there were branch managers, sales managers, marketing managers, but all the territory managers were expats. I felt like there was a ceiling. The only way I could become a CEO was to start my own company.”

Naidoo became captivated by the shipping industry at university, after supplementing his accounting degree with maritime and transport economics. He approached his former accounting classmate Thuso Mhlambi, now CFO at Linsen Nambi, to start a company together.

“We began by offering business consulting services to the shipping industry in the areas of marine surveying and shipbroking. But we soon realized that in the services industry, we were at the mercy of the market, so we started to think about becoming asset owners.”

Partnered with a women's organization

The company now has over 100 employees and three business units: bunkering, marine surveying and shipbroking. Together with Women in Oil and Energy South Africa (WOESA), the company acquired the bunkering division of South African shipping, freight and logistics company, Grinrod in 2018. It gained three



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Linsen Nambi
bunker measuring
equipment
(Image credit:
Linsen Nambi)

modern bunker tankers in the ports of Durban and Cape Town under contract to oil majors BP, Engen and Chevron. Khumo Ntlha, CEO of WOESA became Social, Ethics, Transformation and Sustainability Director.

While bunkering is still Linsen Nambi's core business, the other two business units are coming to the fore. "We've become particularly more active in marine surveying. In South Africa, it's an ageing sector that has not transformed. Also, warehousing companies have found that the pool of marine surveyors in the market lack the depth of knowledge and skills required.

"We looked at our business and realized we have over 100 experts in marine logistics because we bunker every type of vessel including RoRo, dry bulkers, tankers, container carriers and reefer cargos. Being floating storage, we also understand an element of terminal operations.

"Looking at this from a shared value perspective, we decided to make our seafarers partners in the marine surveying business by providing them with training and knowledge. This created an economic spillover to products and services that we could sell as a business. We're presently testing the products in the market."

Naidoo says he wants Linsen Nambi to remain entrepreneurially oriented and use opportunities for investment in infrastructure in South Africa. This is all part of the shared value philosophy that fuels his drive to get over the hurdles.

Government and private sector must work together

“The major challenge in South Africa is that our ports are run by the state, so things move slowly because we have to wait for the government to enact legislation. At the same time, our society is not individualistic as in other parts of the world. It’s built on collective needs and understanding.

“The government wants to address pressing societal needs while the private sector is driven by profit. Current statistics show that the top 10 percent of income earners in this country spend eight times more than the bottom 40 percent, so there is significant inequality. This is not sustainable going forward. Government and the private sector need to come together to look at both the needs of society and those of the business environment.”

Linsen Nambi’s acquisition of the Grinrod bunkering division was financed through the South African Industrial Development Corporation to facilitate the economic participation of black women and youth in the shipping industry.

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Two Linsen Nambi vessels bunkering the largest passenger vessel in the world, Queen Mary 2 (Image credit: Linsen Nambi)



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Linsen Nambi
tank barge
Southern Valour
(Image credit:
Linsen Nambi)



However, this type of transformation still has a long way to go in the country's maritime industry. At present there aren't any merchant-going South African shipping companies and most of the 13,000 ships that call at South African ports are foreign-owned.

Still, Naidoo is positive about the societal changes his company is making, particularly concerning women. At present 12 percent of the Linsen Nambi workforce is female and Naidoo is bent on increasing this number. He is proud of the fact that over 50 percent of the staff at head office in Durban are women.

More women would bring innovation

"When we started the business, we had only one or two female seafarers. We decided to address this imbalance by hiring from the bottom up so that there would be mentoring, coaching and one-on-one motivation. We want to convey that while our women don't see female officers on board, it is within their reach.

"My understanding is that when a woman works on board a vessel the environment does not provide mentoring and encouragement on a one-on-one basis." He is quick to add that as a man he is not really qualified to talk about women's experience, but "I think the perception of women is because they don't see other women in officer positions, they don't feel it's possible for them to progress."

In a country where unemployment is high, Naidoo feels work at sea offers "a dignified livelihood" to women in a global multicultural industry. "By not having them on board vessels, we are missing out on an entire skills base. Then you have a very narrow view in the industry, based on men in the market. With more women, I think there would be more innovation."

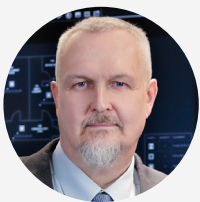
As Naidoo sees it, there are still several obstacles to overcome for the South African shipping industry to grow.

“For a long time, the mental barrier has existed that the shipping industry is not open to South Africa. But with the advent of Covid and recent shifts in world politics, people are starting to realize we need our own shipping industry.

“We are the only 100 percent black ship-owning company in the country and sadly, I don’t see the situation changing. Not only does the shipping industry here have high barriers to entry, but assets are extremely expensive. You need long-term contracts to mitigate against the risks of owning these assets and you need access to affordable finance. The cost of finance in South Africa is high and companies are reluctant to provide long-term contracts.

“We have a few major banks here that control the entire market and their appetite for risk is low. At the same time, we have legislation that makes it difficult for new entrants in banking and finance to come onto the market. The government is trying to grow the industry but until we solve this issue of funding and finance, we aren’t going to have a growing South African shipping industry.”

Nevertheless, people like Naidoo are working at it, breaking down one barrier at a time. •



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Eero Lehtovaara,
Head of
Regulatory and
Public Affairs,
ABB Marine & Ports

Eero Lehtovaara, Head of Regulatory and Public Affairs at ABB Marine & Ports points out that celebrating diversity pioneers such as Linsen Nambi is in the spirit of ABB’s Global Diversity and Inclusion Strategy 2030. ABB has recently adopted the United Nations (UN) Women’s Empowerment Principles in order to promote gender equality and women’s empowerment in the workplace, marketplace and community.

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The goal must be to provide a safe workplace for women so that ultimately society as a whole is safe for everyone. Kudos and best of luck to Durand Naidoo in his quest for more diversity and inclusivity in the South African shipping industry.

Riding the waves of change

The maritime industry has long been dominated by men. Old nautical superstition even held that women on ships were bad luck. Thankfully times have changed but, despite progress, gender stereotypes, unequal opportunities, and workplace discrimination persist.



—
Nompumelelo
Ngubani,
Chief Mate,
Linsen Nambi

Still, women like Nompumelelo Ngubani (30) are thriving at sea. As a chief mate for Linsen Nambi in South Africa, with ambitions to become a master, she sees a bright future ahead.

Ngubani joined Linsen Nambi last year as an able seafarer after serving a cadetship with another company. She got the job while waiting for her oral ticket and, once that was in the bag, she was promoted to chief mate.

“I thought work at sea would suit me because I like to interact with different cultures and to travel. Since maritime studies are male dominated, nowadays there’s a lot of encouragement for women to work in the industry in South Africa. After school I decided to take this opportunity and do maritime studies at the Durban University of Technology.”

As chief mate she is responsible for deck maintenance, inspection of life-saving equipment and firefighting equipment, and assisting the master with navigation. She must also ensure the safety of the crew and vessel, help with cargo operations and upkeep of crew certificates, as well as compliance with international safety management, monthly orders and reports.

I really enjoy being in a more responsible position now.

Dress was a big change

“It wasn’t easy at first when I was an able seafarer. There are certain jobs that require male power, so sometimes the men had to give me easier jobs and I felt that wasn’t fair. If you’re in the same position, you should do the same job.



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Nompumelelo
Ngubani
(Image credit:
Linsen Nambi)

“But I found the men to be quite understanding and I looked for other jobs. There are so many jobs on board that you can do that don’t require strength. It’s also important to keep active and stay fit,” says Ngubani.

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There’s a process in maritime; you can’t stay in one position, you must learn, improve, and move up.

Adjusting how she dressed was a big change. “As women we like to do our hair and nails. I wear a helmet all the time, so I can’t worry about my hair and the overalls aren’t very flattering. But it’s okay because you can forget about all that stuff and just do your job.”

“When you are seagoing it’s not so easy to see your family but that’s true for men as well. I don’t have a husband and children, but it will be harder if I have a family. Work at sea is difficult for men and women, both physically and mentally, and the environment on deck can be challenging,” she says.

However, she is thankful for the support she gets from the company. “We have had people coming to talk to the crew about gender-based violence and Linsen Nambi runs programs for us on everything from finance to wellness and stress management. There are also professional counsellors available to us.”

Work hard, be strong and patient.

Ready for more responsibility

Ngubani enjoys the clear career progression in the maritime industry. “It’s easy for women to get jobs in the industry now, but at the same time it’s not easy because there’s a stringent career process that needs to be followed. Some take maritime studies at university without being aware of the process they need to follow to get to a higher level,” she says.

“I really enjoy being in a more responsible position now. The responsibilities make me learn and grow and I’m gaining management skills. At the same time, there are also consequences for negligence, so whatever I do, I must do properly.”

Despite the pressure, she wants even more responsibility, aiming to get enough sea time to apply for a master ticket and then to apply to be master of the vessel. “There’s a process in maritime; you can’t stay in one position, you must learn, improve, and move up.”

Although Ngubani agrees working at sea is not a popular choice for women, she thinks it’s very rewarding. “There are so many different departments on a vessel that you don’t only learn for your position. You interact with all sorts of people from electrical engineers to engine-room staff, so you get a lot of diverse and varied experience.”

Asked what advice she would give to women who want to work in maritime, she replies:

“Work hard, be strong and patient. Listen to those who know more than you and absorb as much information as you can. There are a lot of people with a lot of experience on board ships. Ask and learn so that you can grow.”

Offshore wind market gathers momentum across Asia-Pacific

China is already the largest offshore wind market in the world, and the rest of the Asia-Pacific is gearing up to follow. Generations sat down with three local offshore wind experts – **Edgare Kerkwijk**, Board Member of the Asia Wind Energy Association (AWEA) in Singapore; **Alf-Kåre Adnanes**, Regional Division Manager AMEA at ABB Marine & Ports, based in Shanghai; and **Khaleef Khan**, Local Division Manager, Offshore, ABB Energy Industries, in Singapore – for a discussion on the market outlook and their interests in the region.



—
Edgare Kerkwijk,
Board Member,
Asia Wind Energy
Association

What is the state of play for the offshore wind market in the Asia-Pacific and how will it evolve?

Edgare Kerkwijk:

I would say that countries in the region are at four different stages of development. China is a market on its own and has surpassed most of the others to take the lead. With almost 40 gigawatts of capacity already installed, China is expecting to install a further three or four times this figure in the coming years. So far, the Chinese have been very internally focused, but we are now seeing the first signs of local companies exporting their expertise – turbines or vessels, for example – to other countries.

The next group of countries includes Taiwan, South Korea, and Japan, where construction of the first offshore wind farms has either been completed or is well underway. Taiwan is leading the pack, with quite a few gigawatts of capacity already installed. More auctions are underway and the market is set to grow in the coming years. Taiwan has also developed quite a bit of its own supply chain and is looking to export its expertise to other markets. Meanwhile, South Korea and Japan have both held their first round of auctions, and construction of the first wind parks is underway.



The third group of countries comprises the emerging markets of India, Vietnam, the Philippines, and Australia. Various projects and tenders have been announced, as have government policies, but construction has not started yet. Australia has announced around 50 projects, but these will take time to materialize because, as is the case with the other countries, there is still a lot to be figured in terms of grids, ports, logistics, and off-takers for the electricity, etc.

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China is a market on its own and has surpassed most of the others to take the lead.

Bringing up the rear are Bangladesh, Indonesia, and Thailand. So far, there has been very little discussion about offshore wind development in these countries. But developers will likely become increasingly interested in projects as all three countries face serious impacts from climate change and their governments will have to find ways to transition to renewable energy. Here, offshore wind is a more viable solution than, for example, solar farms because of the higher energy yield. In addition – and this goes for the whole of the Asia-Pacific – the plethora of very densely populated areas make onshore renewables infrastructure much harder to install.



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Alf-Kåre Adnanes,
Regional Division
Manager (AMEA),
ABB Marine & Ports

Alf-Kåre Adnanes:

I agree with Edgare's analysis, but my take is that the market is booming and will only get bigger. At ABB Marine & Ports we are deeply involved, working with shipowners, shipyards, and designers in developing the current and next-generation fleet of vessels to support the market expansion. Turbine installation vessels are the 'jewel in the crown', followed by other types of construction support vessels (CSVs) such as heavy-lift crane vessels, cable layers, dredgers, maintenance vessels – you name it. We need a whole new fleet to meet demand. Some can be repurposed from traditional (oil and gas) offshore vessels, but most are specialized vessels that will need to be tailor-made. We are applying our expertise to support designers not only in physically optimizing the ships themselves, but also how they are operated, controlled, and remotely coordinated.

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At ABB Marine & Ports we are deeply involved, working with shipowners, shipyards, and designers in developing the current and next-generation fleet of vessels to support the market expansion.



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Khaleef Khan,
Local Division
Manager,
Offshore,
ABB Energy
Industries

Khaleef Khan:

Basically, it is the trajectory of cost-per-megawatt ratio that drives the market demand. With positive momentum, we can be sure that more projects are going to materialize much faster. As Edgare points out, we already see this happening in the likes of Vietnam, the Philippines, South Korea, Australia, Japan, and Taiwan.

Offshore wind is a viable technology on par with other new technologies, such as hydrogen production and solar power. We may see how a combination of these will play an integral part of the regional energy transition.

Our Process Automation Energy Industries division at ABB is focused on providing solutions for offshore wind substations, either subsea, floating, or fixed to the seabed. We also provide electrification, automation, control, and digital solutions designed specifically for offshore wind. Supporting our Marine & Ports division with standardization of solutions for offshore vessels is also part of our mandate.

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Offshore wind is a viable technology on par with other new technologies, such as hydrogen production and solar power. We may see how a combination of these will play an integral part of the regional energy transition.

To succeed globally, Asia-Pacific must excel across multiple domains. What can organizations do to accelerate this growth?

Khaleef Khan:

Asia-Pacific is at the forefront of both demand and supply right now. We see more of components for several European and US projects being developed and built in the region, which has become a prime mover in the supply chain. Interestingly, while the offshore oil and gas market was expected to flatten, there has been a push for higher levels of investment in this space. Developments in LNG, which is a transitioning fuel in the energy transition, are also happening in parallel with offshore wind and other green energy projects.

However, Asia-Pacific as a prime mover is also being subjected to a lot of strain on supply chains with demand from projects all over the world. These countries must step up supply-chain investments because they are in a strong position; the infrastructure is there, as is the expertise and skills and talent market. More investment by companies to diversify their manufacturing base in the region will really boost the market. Production of the equipment and services needed for wind-farm installation – millions of tons of steel, turbines, high-voltage equipment, and the whole distribution network – is by and large centered in Asia-Pacific, spearheaded by China.

Asia-Pacific is at the forefront of both demand and supply right now.

Edgare Kerkwijk:

When the industry first started to develop, we saw a lot of European maritime companies moving to the region to get a slice of the action. Fortunately, maritime stakeholders in Asian countries also started to look at offshore wind, partly driven by slow growth in the oil and gas sector. That has changed in the past few years with renewed activity in oil and gas, so companies now have to decide which area to focus on. We have seen some companies flirt with offshore wind, but then move back to oil and gas because there is less price pressure in that market. Others have offshore wind as a secondary focus and this is beginning to grow.

I believe more local companies should actively develop expertise in this space, not least because a lot of regional governments are introducing localization rules to boost homegrown input. These require companies to provide the vessels and cables required for wind-farm development, or to undertake construction, so there is a lot of growth potential.

Alf-Kåre Adnanes:

On the issue of localization, governments want to create value and new jobs within their borders. That is totally understandable. However, only focusing on this aspect can slow down overall market development because they also need international expertise.

While companies like ABB need to adapt to localization requirements, we must also maintain and develop our global competence. At the same time, we need to be much more present in the countries where development is taking off. We cannot run everything out of Europe or Singapore.



How can international partnerships boost Asia-Pacific's offshore wind market potential?

Edgare Kerkwijk:

Rather than international partnerships, I would argue that we need to see improvement in regional partnerships. If you are an offshore wind vessel owner or crew member in Europe, for example, you might be in UK waters in October, Dutch waters in November, and Danish waters in December. The supply chain in Europe is pan-regional; we don't have many borders or limitations on people moving around to work. In Asia-Pacific there are a lot of regulations around what kind of vessel or crew are allowed into certain countries.

However, a regional supply chain does seem to be slowly evolving. For example, people with experience in Taiwanese waters are now working in Japan or South Korea. But a lot more needs to be done. Because in offshore wind we have this cost pressure on construction, it doesn't make sense to have vessels that can only work in Japan or Taiwan or wherever. It is in the interests of the industry and market efficiency to be able to access the best and lowest-cost resources they have.

Khaleef Khan:

I would think that there is room for improvement in how different organizations, technology players and other stakeholders can collaborate in this region to make progress in this space. As offshore wind technology is evolving, more development needs to happen through collaboration, after all, no one single party can do this alone. It would be more beneficial to find ways for the industry to leverage each other, bringing the whole industry to a level of critical mass where all parties can monetize the technology faster.

As offshore wind technology is evolving, more development needs to happen through collaboration, after all, no one single party can do this alone.

Alf Kåre Adnanes:

Partnerships can come in different guises such as joint ventures, loose partnerships, and forums to share experiences and best practices. All are essential, both international and regional. I have been involved in several forums focused on offshore technology. Gathering experts with different backgrounds and competencies is very useful. The whole industry can move faster together.



Is the political landscape favorable to the development of the offshore wind market in Asia? How can governments step in to meet the challenges?

Edgare Kerkwijk:

Governments across the region are keen to develop offshore wind technology. They see it as a good solution for the energy transition and a potential new source of employment. But they need to understand that offshore wind installations are not built in a day. They usually require the cooperation of a lot of different government ministries.

Nowadays, a typical offshore wind project is not 50 megawatts, it is often a gigawatt or more. Power needs to get onshore, into the grid, and to the load centers. This requires massive coordination. Sometimes governments announce projects too quickly without having fully figured out how to put all the pieces together. Offshore wind policies typically take five to 10 years to implement.

It is also important for governments to talk to each other and come up with appropriate policies. Europe has done very well in this regard, but unfortunately inter-governmental organizations are not that strong in Asia. But if countries work together, they can create a regional industry in which they support each other. Whether there is the political will to make this happen remains to be seen.

Alf Kåre Adnan:

I doubt that any one country in the region can create an entire offshore wind ecosystem by itself, with the exception perhaps of China. Cooperation and sharing common goals is the best way forward. It makes sense for countries developing offshore wind technologies not just to target local consumption, but also export opportunities in the global market. Regional governments should consider these wider business implications.

Moreover, investors need a predictable long-term picture to be willing to invest the large sums of money required. They need to know that the energy they produce, say five years down the road, can be sold at acceptable terms and prices. This framework must be initiated by governments because it is a new field that demands political support.

Khaleef Khan:

Asia is progressing with good fundamentals, but the question is really how to ensure all of them are consistent, complementing each other and ladder up to broader goals. Getting this right will be important, especially when projects in this space involve a diverse representation of companies, which have different requirements. There must be collaboration to generate design standards and to create synergies such as power sharing agreements between countries and less localized grids. We have seen some progress in this space, The rules are in the early stages of development, and our aim is to refine them to be foolproof, ensuring their validity not just for the next five years but for decades to come."

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The offshore wind market will help scale up Asia's Energy transition (Image credit: Adobe Stock).



Final message for our readers?

Alf-Kåre Adnanes:

I am a big believer in the transition to renewable energy and offshore wind is the easiest place to start, in Asia-Pacific as elsewhere. It is probably not enough to reach emissions targets alone, but it will be a significant part of the future energy mix globally. We already see increasing enquiries from shipowners for our support to optimize ship designs. There is also a huge drive to make these developments efficient both in terms of cost and operational productivity.

It is probably not enough to reach emissions targets alone, but it will be a significant part of the future energy mix globally.

Khaleef Khan:

While big projects play a crucial role in our energy transition journey, let's not overlook the significance of celebrating wins in smaller fields. We see this evolution in the oil and gas space to reduce the carbon footprint of offshore installations; for example, eight to 10 turbines providing power for one platform. This is a promising new application area for offshore wind. It's the accumulation of these incremental successes that propels us forward on this progressive journey toward a sustainable future.

Edgare Kerkwijk:

The offshore wind industry in the Asia-Pacific is providing a lot of opportunities for many stakeholder sectors. We've seen fantastic growth in the last couple of years and new countries coming onboard. However, it is important that these countries look at what has been learned elsewhere. The industry has been around in Europe for 20 years and the process of getting started will be more efficient if they seek input from those with more experience in this technology. •

A dynamic new blueprint for Japan's challenging shipping industry

During a recent visit to Tokyo, Saara Kuusisto, VP, Head of Sales, Marine Systems, and Mahesh Krishnappa, SVP, Head of Local Division Singapore at ABB Marine & Ports, sat down with Yasumasa Suetsugu, CTO of e5 Lab Inc., a consortium convened by the Japanese Shipowners Association (JSA) to research and develop renewably powered vessels, to discuss the challenges facing Japan's domestic shipping sector and e5's vision for decarbonizing the fleet and transforming the ecosystem.



—
Saara Kuusisto,
VP, Head of Sales,
Marine Systems,
ABB Marine & Ports

The Japanese economy today faces the same challenges as other countries, namely high inflation, slowing global manufacturing demand and geopolitical turbulence. "It's fair to call this a recession even. In international shipping there is overcapacity, which is very visible in low container shipping rates, and the difficult operating environment is creating financial pressure across the board. For a cyclical industry we're in a trough, but what goes down must go up again, so personally I'm optimistic," says Kuusisto.

Meanwhile, the Japanese government has pledged to achieve net zero greenhouse gas (GHG) emissions by 2050, setting the country on course to become carbon-neutral in just 30 years. Japan boasts the world's third-largest merchant fleet and in October 2021 the JSA also espoused its commitment to achieving net zero, in line with IMO targets. It believes that research and development of new zero-emission ships, new fuels and infrastructure will create a new source of competitiveness for the shipping industry. In terms of the merchant fleet, it estimates that an average of 100 vessels per year will need to be built, requiring an investment of some USD 10bn annually and extensive co-operation between supply-chain stakeholders including shipyards, energy industries, ports, cargo owners and trading companies.



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Image credit:
Adobe Stock

"How we will get there is still an open question," says Krishnappa. "Japan is looking at both ammonia and hydrogen as potential fuels in its decarbonization roadmap, but there are a whole host of challenges to solve in terms of availability and safety. These can be overcome locally but the big unknown is if other countries will develop the same infrastructure. It's a global challenge that requires cross-border collaboration lest we end up with a fragmented patchwork of solutions."

Coastal shipping lifeline

Meanwhile, as an archipelagic country with a population of 123 million Japan also has one of the world's biggest domestic shipping fleets. "Short-sea cargo and RoPax logistics are an essential link in Japan's transport infrastructure chain and this domestic fleet also requires rapid decarbonization," Kuusisto says.



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Mahesh
Krishnappa,
SVP, Head of
Local Division
Singapore,
ABB Marine & Ports

However, decarbonizing is not the only challenge. Domestic shipping is suffering from an acute human resources shortage amid a long-term decrease in the Japan's productive age population. "The average age of seafarers working in domestic shipping is 55 in Japan and there is significant attrition through retirement, just like in Finland. As well as a high turnover rate, many seafarers quit the industry during the pandemic, exacerbating the problem. It has become very hard to source the young people the industry needs. There is a huge gap between supply and demand," Krishnappa says.



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Yasumasa
Suetsugu,
CTO, e5 Lab Inc.

Suetsugu emphasizes that Japan's international and the domestic shipping markets are very different animals. "Together with government R&D sponsorship, Japan's global shipping companies have the wherewithal to plot their own path to sustainability. But the domestic shipping industry requires fundamental structural reform to become sustainable, not only environmentally, but also in terms of commercial growth. The status quo is not sustainable and our mandate at E5 Lab Inc is to create a new paradigm to make the industry clean, efficient and profitable for the future."

The E5 Lab consortium was originally launched in 2019 and brings together Asahi Tanker Co, Exeno Yamamizu Corp, MOL, Mitsubishi Corp, Idemitsu Kosan Co Ltd, Tokio Marine & Nichido Fire Insurance Co Ltd and Tokyo Electric Power Co in an open innovation platform. Covering shipbuilding, ship owning and operating, marine insurance and technology, the partnership's name reflects its five 'focus points': electrification, environment, evolution, efficiency and economics.

Electrification champion

"There are 5,500 ships in the domestic market and 3,500 will need to be replaced within the next 10 years," says Suetsugu. "We identified electrification as the easiest way to achieve our environmental ambitions while reducing crew workload through progressive robotization of ship operations."

He pinpoints three core pillars to accelerate the transition. The first is physical standardization both in ship designs, electrical systems, smart cockpit and major equipment including automated cargo handling. "This is the backbone of E5's ROBOSHIP electric vessel (EV) concept, which is designed from scratch and can be scaled across standard vessel types and sizes. Through modularization and having the same powertrain and power management configuration on all new ships we can reduce both capital and operational costs, increase productivity at yards and equipment manufacturers, enhance after-sales maintenance, and drive value for shippers. The potential to export next-generation ship packages will be an extra benefit."

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Image credit:
Adobe Stock



ROBOSHIP powertrains will feature batteries in combination with diesel generators and permanent magnet shaft generators, but adapted for new fuels, as well as auxiliary energy sources such as solar and wind, in future. "Ammonia and hydrogen propulsion is still some way off; we need practical electrification solutions that work right now," says Suetsugu.

The plan is also to implement a standardized software platform and common broadband network that will facilitate shore to ship communications, including remote diagnostics and smart navigation.

We see more of a hybrid future.

Streamlining operations

"All these standardized solutions will make ROBOSHIPS simpler to operate and reduce the level of experience needed versus conventional ships. We anticipate, for example, that the 499-gt tanker class will require just three seafarers to operate. This will reduce the number of seafarers required across the fleet," Suetsugu adds.

As an aside, he notes that although E5 is researching autonomous technologies to support on-board tasks currently done by humans, autonomy is not a goal in itself. "We see more of a hybrid future. We will still need a reasonable number of crew onboard for a long time yet to ensure safety."

The second pillar is radically reducing the domestic fleet age profile. "In the conventional model, ships involved in domestic shipping have an average lifespan of 25 to 30 years. We want to change this cycle to around seven years tops, whereafter the ships can be sold for a good price to operators in the Middle East or elsewhere in Asia. This rolling renewal will enable rapid uptake of the latest design innovations and technologies so fleet performance remains optimal," he says.

E5's third ambition is to standardize and centralize the industry within an entirely new business model embracing ownership, management, manning and education, insurance and finance. "Japanese domestic shipping is dominated by many small owners with either one or two vessels that they also manage. It's a very low-margin business and they lack resources to replace ships with expensive one-off newbuilds. There is also little incentive to introduce digital tools given the cost and training required. So, we have a situation where all these small owners cannot continue to operate old vessels safely, they can't hire young seafarers because the talent pool isn't there, and they don't have the cash to make investments," Suetsugu says.



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Image credit:
Adobe Stock

Monopoly risk

In addition, many of these small companies are typically led by individuals who are themselves getting on in years and, in some cases, are close to giving up. "Yes, some could merge or sell their assets to one of the bigger players who do have these capabilities, but that is unsustainable as it runs the risk of concentrating capacity in too few hands. We want to avoid the creation of monopolies," Suetsugu says.

The three pillars where all the complementary elements work together to form a virtuous ecosystem will help small owners get financial traction by reducing costs. "This completely new commercial approach is essential for electrification to work at scale. Numbers justify everything. We are discussing this with the government but it's not a wholly new idea. This approach was first mooted 20 years ago but owners were hesitant. Today the situation is different and the need for a mindset change is urgent," Suetsugu adds.

Ship ownership and ship management must be completely divided and centralized for maximum efficiency. "We must also centralize training of seafarers with new schools offering simplified training in standardized systems, as well as create new domestic licensing rules specially tailored for electric operations and a high degree of automation."

Long-term collaboration required

Forging long-term relationships with shipbuilders and system vendors will be essential. "The relationship between ship owners, yards and suppliers is often one of love and hate. They are typically transactional relationships based on single ship orders. When the ship is delivered that's usually the end of the relationship. Not being ship owners, the big difference with E5 is that to succeed in designing this new holistic domestic shipping ecosystem we need a strong commitment from yards and standardized offerings from manufacturers as part of the support structure. With fixed, reliable suppliers in place, we can then connect the other dots. This is the kind of collaboration and trust we are cementing with ABB, for example."

Krishnappa applauds the impressive scope of E5's ambitions. "It's a massive shake-up but I think it's achievable with the buy-in from all stakeholders. The projected scale of electrification demands new technology requirements and we are well placed to help in three fundamental ways. Firstly, our discrete base solution can be scaled to different power ratings and made future ready using, for example, fuel cells. We can increase power volume using standardized modules."

Should we simply change the fuel, add equipment like sails, or completely redefine the concept of ships and carve out a new era?

Milestone projects

Secondly, ABB can apply its extensive hybrid and electric solutions experience in the shortsea segment, including its involvement in two high-profile projects in Japan under the ROBOSHIP umbrella. "Together with E5 Lab and IHI Power Systems Co we developed systems for both the fully electric-powered tugboat Taiga, delivered to Tokyo Kisen for operations in Tokyo Bay this summer, and for the world's first two hybrid-electric biomass fuel carriers on order for Asahi Tanker Co for bunkering operations also in Tokyo Bay. These vessels represent a big milestone as the projects were completed despite the pandemic. Our remote diagnostics team in Singapore are supporting operations of both vessels, enabling the owners to minimize crew numbers and reduce maintenance costs," Krishnappa says.

Remote diagnostics form part of ABB's market-leading global service offering and Krishnappa notes that when, in future, domestic ships are sold after seven years to other countries, ABB can continue to support these vessels remotely, benefitting the new owners.



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Image credit:
Adobe Stock

“The collaboration with ABB has been beyond our expectations in delivering world-leading technology promoting efficiency, safety and reliability for these coastal vessels in line with specific size and weight reductions,” says Suetsugu.

Kuusisto agrees that standardized solutions are increasingly important in an industry where traditionally there has been a lot of tailoring for individual ships. This applies especially to the very price-sensitive cargo segment. "It is the key to cost-efficiency," she says. "And when Suetsugu-san says long-term relationships are E5's top priority, we can certainly promise that ABB will still be here 20, 30, 50 and more years in the future. As a partner in decarbonization we take pride in our solutions developed inhouse on the journey towards net zero."

In conclusion, Suetsugu notes that "humanity has been enriched by the evolution of ships – from oar-powered boats to sailing ships to steamships to diesel. Many are now asking what comes after diesel? Should we simply change the fuel, add equipment like sails, or completely redefine the concept of ships and carve out a new era?"

Nobody has the answer yet, he says. "But if we are to take on a challenge, I want it to be towards an exciting future, and electrification is a necessary requirement. The system should be as simple as possible – I believe this can be the backbone of the new future of ships." •



Q2/2024

041–047 We live in a diverse world, why shouldn't we work in one?

048–054 ABB broadens digital portfolio to serve shipping clients with weather routing services

We live in a diverse world, why shouldn't we work in one?

Over the last 15 years, Magda Kopczyńska has occupied a series of increasingly influential policy-making positions in the Brussels landscape, culminating in her present role as Director General of the Directorate-General for Mobility and Transport (DG MOVE). She spoke to Generations about the importance, or inevitability, of diversity and inclusion in a fast-changing world – not only in maritime, but the entire transport sector.

You are clearly motivated to empower women working in the transport sector and particularly in maritime. What would you like to see happen?

As a professional, the moment you start getting into higher management positions, you immediately look around and question if your working environment reflects everyday reality. What works for women, what doesn't, and what can we do about it?

If we want balanced, well-functioning workplaces across all transport sectors, inclusiveness needs to be understood and applied much more widely. By that I mean not just men and women, but all shades of gender awareness and identity, nationality and culture, age and types of experience. We should celebrate diversity.

Transport is traditionally very male-dominated, and empowering women to find their space and perform is still a work in progress. Women now represent around 1.2 percent of the global seafarer workforce, which is a huge increase since 2015, but only because we started at such a low level. The objective explanation is simply that the nature of seafaring requires spending a lot of time away from home.

With the right corporate, national and EU policies, it's perfectly possible to have a more balanced proportion of women and other groups. It will take additional steps to encourage women to take up jobs both at sea and ashore, but I believe most decision-makers support it.



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Magda
Kopczyńska,
Director
General of the
Directorate-
General for
Mobility and
Transport (DG
MOVE) says 'not
having diverse
representation is
simply outdated
and means you
give up on the
parts of society
that can bring
both skills and
positive ways of
thinking'.
(Image credit:
DG MOVE)

Do you think greater diversity can help the industry become more sustainable?

Most people immediately think of sustainability in terms of the environment, but to my mind it means much more. The transport sector is facing all sorts of challenges related to talent shortage, technology development, and the need for new business models. Maritime in particular has gone through some real adversity, starting with the 2008 financial crisis, then COVID and not least geopolitical instability. We need to be agile to meet such challenges, and as various economics studies clearly show, the more diverse your team, the better prepared you are.

On the talent issue, Europe fares better than the global average, with women accounting for 20 percent of its seafarers. This figure includes onshore employees, which is important because we know that in the future, onshore and onboard work will be more integrated as automation and digitalization increase.

The availability of more onshore jobs will likely encourage more women who want to work in shipping but not necessarily at sea. The same is also true for people from different backgrounds and those with reduced mobility.

What can politicians and industry do to encourage more diversity?

One small victory is that very few people now question that diversity has to happen. Everyone I talk to on both the industry and workers side acknowledges we need to do more to promote and assure female participation. The European Commission has made a conscious decision to make money available for inclusion projects.

For example, the WESS project (Contributing to an Attractive, Smart and Sustainable Working Environment in the Shipping Sector) implemented by the European Community Shipowners Association (ECSA) and the European Transport Federation (ETF) suggested six core best practices that companies should align on, including a minimum target for women in management positions and – it may sound trivial, but certainly isn't – ensuring equipment is ergonomically suitable for women. It's better if social partners from either side formulate these measures together before we start looking at legislation.

The younger generation especially really knows what they want. If we want them to commit to transport, we need to offer an attractive workplace, also in terms of career progression, reskilling and upskilling.

In addition, in 2017 we put in place the Women in Transport platform that brings together 30 employer and worker organizations from across the transport sector to share experiences, good practices, and knowledge on these issues.

The outcomes include the EU-funded Fair Winds collaboration between Swedish shipping organizations to ensure zero harassment and discrimination in the workplace. Harassment is unfortunately an issue in every sector that lacks balance in terms of gender and minorities. You can't hope for an inclusive working environment if there are members who don't feel safe. Although it's now more prevalent in the media, simply talking about these issues isn't enough. We need to see commitment and determination on the part of industry, supported by regulators, to make sure it doesn't happen.

The Women in Transport platform also supports the Honours for Diversity & Inclusion in Maritime, which was launched by the Belgian chapter of WISTA (Women's International Shipping and Trading Association) together with other stakeholders. An important award ceremony took place during the Brussels Conference on Wellbeing of Seafarers on International Women's Day on 8 March. I really applaud the Belgian presidency of the Council of Europe for putting this topic in the spotlight.

We also have the Diversity Ambassadors Network launched in 2022 that now includes some 80 ambassadors who appeal directly to transport industry leaders to explore what needs doing. Their next conference will be in June. So, all in all, there's quite a lot going on.

What is the key to overcoming lingering prejudices?

There's no easy way. It requires a change in mindset, and years before people enter the working environment. It boils down to education and the overall perception of the transport sector. Working in transport isn't perhaps a dream job for many young people these days. Obviously as a seafarer you're away from home. But even driving a long-distance train or flying planes involves being on the move a lot. The sector as a whole still doesn't project the right image. This needs long-term planning because if you don't have a positive image, you won't get positive people wanting to work for you.

Interestingly, we did a study several years ago where we looked at the attractiveness of transport modes among young people from 18 to 35. Maritime came last, after truck driving and train driving. The only one that was perceived as okay was aviation, which I think was largely due to the glamorous image of pilots. But the fact that transport isn't seen as an attractive, fun workplace is something we have to change.

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Gustavo Abdiel Aguilar-Miranda, founder of the 'I exist too' global forum on improving LGBTIQ+ rights in the maritime industry, launched in Panama last year. The forum won an Honour for Diversity and Inclusion in Maritime as best new initiative, alongside Costa Cruises for best improvement of diversity and inclusion in the workplace, and the 'Women Offshore' for best initiative against harassment. The awards were presented during the Brussels Conference on the Wellbeing of Seafarers, hosted by the Belgian Presidency of the Council of the European Union on International Womens Day on 8 March. (Image credit: Belgian Presidency of the Council of the European Union / Vlad Vanderkelen)



The younger generation especially really knows what they want. If we want them to commit to transport, we need to offer an attractive workplace, also in terms of career progression, reskilling and upskilling. Now with the focus on decarbonization, companies realize they will need a wider set of competencies. And in order to recruit the right talent, they will have to be attractive as an employer and root out those lingering negative attitudes.

Ideally there should be more female officers, but that will take time.

How can the maritime sector improve its perception?

The poor perception of maritime is also because it's less known by the average citizen than the other transport modes. Unless you go on a cruise or take a ferry, you'll probably never set foot on a ship or even in a port. We really need to show how important transport and especially shipping is for our daily lives and the economy. It's also a question of promoting best cases and best practices. In maritime we need healthy competition when it comes to working conditions. As a global sector, it is regulated through the MLC convention, but as is often the case with international frameworks, it only offers minimum standards. The shipping industry knows my stance; when it comes to people, reducing budgets won't work. I'm not talking about top-down regulation here, but the industry has to be aware that if you want to attract different types of people, you need to ensure the right conditions are in place – not least at sea.

One company with which I have talked extensively about what needs to be put in place said something very interesting. They realize that for a woman to feel safe onboard vessels, she needs at least another woman present, to provide support and to confide in. Ideally there should be more female officers, but that will take time. This type of approach sends the right signal to young women considering seafaring as a career.

How can shipping in particular increase its visibility among the wider society?

Firstly, positive stories don't make for gripping news, which is why you mostly hear about shipping in the mainstream media when bad things happen. Secondly, there have been a few examples of dubious employment and environmental practices worldwide, and the approach of some shipping companies to the war in Ukraine, have not been helpful. We have to acknowledge that.

For some in the shipping industry, it is convenient to be invisible. Visibility, on other hand, brings responsibility. Happily, many of my interlocutors are ready to front that responsibility, but they tend to complain that few people really care,

because ships are out at sea most of the time. Out of sight, out of mind. But I actually think people do care. Many stories, both good and bad, do get attention now on social media.

Shipping has to be ready to embrace the outcome of more visibility, which can put both in the spotlight.

Will digitalization and automation encourage greater diversity?

Digitalization is a positive thing, full stop, in my view. In terms of improving diversity, there will be more onshore jobs, making it easier to accommodate diversity, for example by employing mothers. But technology doesn't create the workplace, decision-makers do. Automation and new digital technologies like AI aren't a magic pill, but they do present an opportunity for change.

Job requirements will shift; those who are ready to adapt will come out better, and the transition is already happening. For example, the ETF wants to make sure that workers are offered opportunities to upskill so they can continue to thrive alongside new technologies. I am optimistic because there is added value in keeping people who know your business, but offering them new skills.

And when it comes to adapting, one thing I'd like to stress is that women generally are pretty capable. Any mother – or stay-at-home dad for that matter – will tell you that running a company pales in comparison to running a household!

Automation and new digital technologies like AI aren't a magic pill, but they do present an opportunity for change.

Research indicates that diversity is good for the bottom line. Do you see it as an economic imperative?

We like to talk a lot about resilience these days. Resilience for private-sector companies means you're prepared for and can withstand whatever comes your way. I like to think that in the 21st century, not having diverse representation is simply outdated and means you give up on the parts of society that can bring both skills and positive ways of thinking. Simply put, we live in a diverse world, why shouldn't we work in one too?

Are there organizations you'd like to applaud for their contribution to promoting diversity?

WISTA for one deserves huge credit for moving from the margins to center stage over the last 10 years. They're great at getting the right people to represent

their cause. The ETF and ECSA are doing a great job, and I will be pushing them to do even more. I'd also like to flag up the World Maritime University in Malmö, Sweden, who've done very well promoting strong women at their conferences and events, also from countries you don't normally associate with women in maritime, in Africa, the Caribbean, South America. Then there are all the business leaders who are committed to diversity in their own backyards – too many to mention, but their combined efforts deserve recognition. Generally, things are going in the right direction, maybe not as fast as we'd like, but it's just a matter of time.

What's your personal motivation being in a position of authority in Brussels?

I've been privileged to work in an international environment here at the EC, developing transport policy, for almost 15 years. Diversity is a natural part of the fabric, and indeed my own fabric, which makes it easier to cover all the ground, take all points of view into consideration.

EU policies address a diverse society of 450 million people – nationalities, gender, age, everything. But they also impact many other people worldwide. The more inclusive we are, the better our policymaking. We can't preach anything that we don't do ourselves, especially in our international development cooperation. Credibility matters! •

ABB broadens digital portfolio to serve shipping clients with weather routing services

The recent acquisition of DTN's shipping business, one of the leading providers of weather routing services to global shipping, is a key step in ABB Marine & Ports' long-term maritime digital strategy.

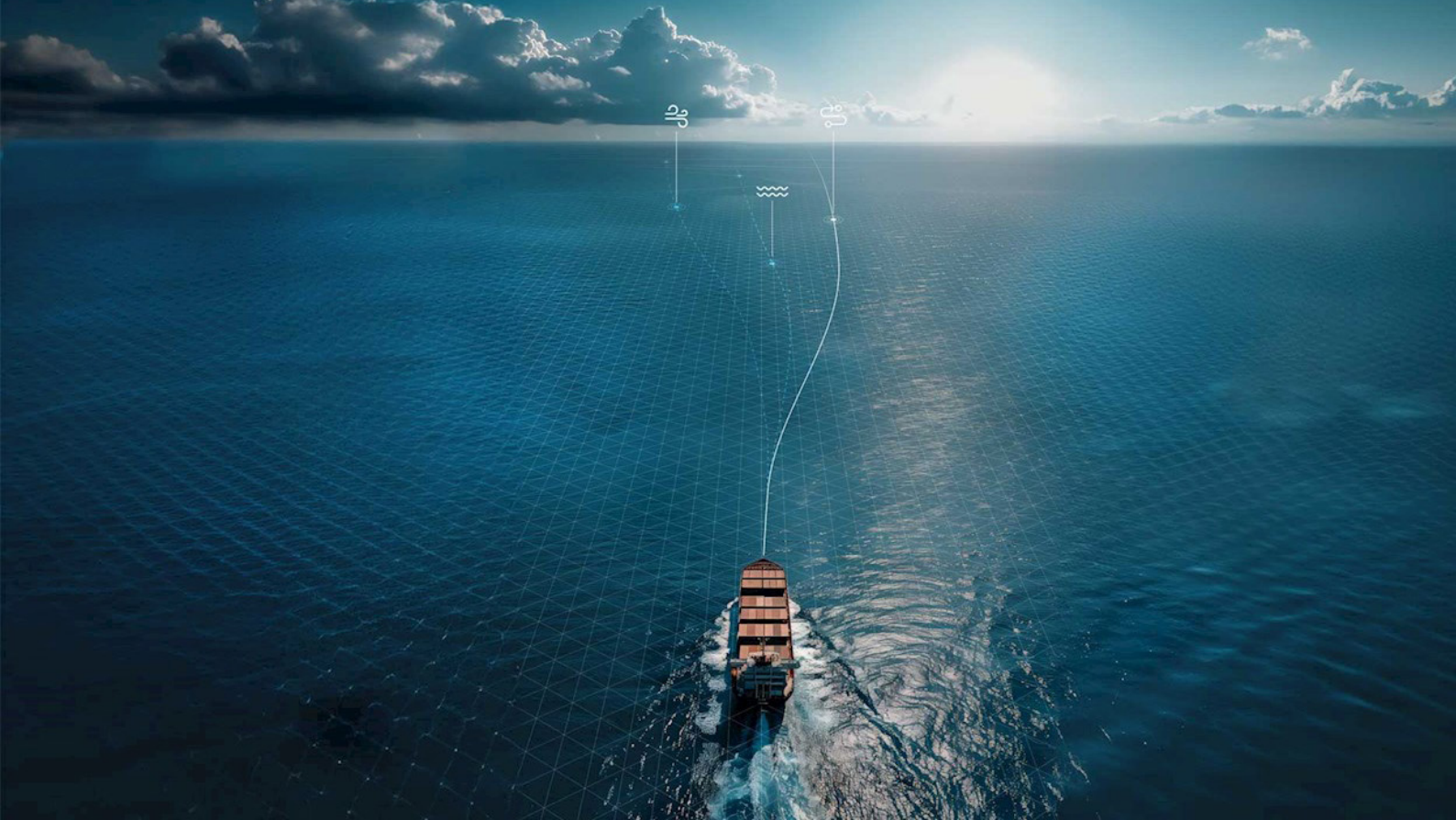
ABB finalized the acquisition on June 3rd, 2024, entering into agreement with global data, analytics and technology group DTN to acquire the shipping business of DTN Europe BV, in the Netherlands, and DTN Philippines Inc.

Continuing ABB's investment in marine digitalization to serve the efficiency and decarbonization needs of ship owners and operators, the business adds approximately 85 specialized staff and new areas of expertise to ABB's digital offering for the maritime industries.

Weather routing is invaluable if you want to establish a prognosis for how the vessel is going to perform one hour or one day ahead, not only to avoid bad weather but also to use wind speed and direction, and currents, to the advantage of ship performance.

To be clear, ABB has not purchased a meteorology business, and it will continue to buy weather data from third parties including DTN to support the needs of its shipping clients' geographical operating profiles.

Rather, it has acquired weather routing advisory services which continuously update to the conditions ahead of a ship change, to add a new dimension to its relationships with its ship owning and operating clients. The deal includes the vessel and weather monitoring application programming interfaces (APIs) previously developed by DTN, as well as the algorithms used to determine how weather will impact a voyage.



“Weather routing is invaluable if you want to establish a prognosis for how the vessel is going to perform one hour or one day ahead, not only to avoid bad weather but also to use wind speed and direction, and currents, to the advantage of ship performance,” observes Osku Kälkjä, Head of Digital Business, ABB Marine & Ports.

Instead of an in-principle but hard to pin down positive, the available gains for voyage efficiency add up to “fuel savings of 5-10 percent”, he says.

Routing Services & ABB Ability™

Post acquisition, all products have been rebranded to reflect their inclusion in ABB Ability™ portfolio for marine, part of the portfolio of solutions ABB offers to a shipping industry that is increasingly reliant on digitalization for efficiency and decarbonization gains. The acquired portfolio forms ABB Marine & Ports’ Routing Services, with solutions called ABB Ability™ SPOS – Ship Performance Optimization System, ABB Ability™ Routeguard – Onshore routing service and ABB Ability™ Fleetguard – vessel and weather monitoring.

Heading ABB Marine & Ports’ service business strategy and development until February 2024, Tomas Arhipainen led the team overseeing the acquisition of DTN shipping business. Now, as SVP, Global Business Line Manager, Marine Service and Digital, Arhipainen is taking responsibility for its integration into ABB.



“We had long experience as a user and through our product development work with DTN on SPOS Seakeeping, and they had a portfolio we could plug into our digital offering to bring a bigger scope,” Arhippainen explains. “It was a successful, fully scale-up business in its own right, staffed with experienced innovators: it ticked all the boxes.”

In big picture terms, Kälkäjä also portrays purchasing DTN Shipping business as a milestone for ABB. Until now, for over more than a decade, the division’s digital path has been defined by expertise in vessel systems, service and support, as well as evolving IT competencies, and has now taken a major step forward.

ABB initially leveraged its installed base to evolve predictive and remote maintenance services, with 24/7 support provided to around 6,600 vessels by a network of collaborative operations centers ashore.

Building on cumulative experience of fleet tracking, data acquisition and advisory software, the company subsequently turned towards sharing its optimization capabilities, unfolding a new ABB Ability™ digital services offering over the same period.

Leveraging synergies

ABB’s collaboration with DTN to develop SPOS Seakeeping, for example, added significant power to the capabilities of ABB Ability™ OCTOPUS – Marine Advisory System software that is widely used by heavylift ship operators. Integrating wave measurements, weather forecasts, navigation information, ship characteristics, loading conditions and motion sensor measurements, SPOS Seakeeping has significantly enhanced the voyage planning capabilities available using OCTOPUS.

The ability of SPOS Seakeeping to account for individual vessel responses, resonances and stresses has clear potential for wider use, says Kälkäjä, noting the impression OCTOPUS has already made on container ship owners seeking to avoid losing more containers over the side.

Meeting the weather routing needs for ship owners signed up to ABB's new weather routing business will open channels of communication for using existing APIs with other ABB products and services which aim to enhance efficiency and advance decarbonization.

Approximately half of the former DTN employees who are now joining ABB are based in the Philippines and the other half in the Netherlands. While weather routing will doubtless benefit from the support of the 26 countries where ABB Marine & Ports is directly represented, the Philippines has previously not been among them. In this case, therefore, the former DTN Shipping business provides a platform in-country to growing ABB's other marine products and service business, while in the Netherlands the company has already an established business and organization.

—
Osku Kälkäjä,
Head of Digital
Business,
ABB Marine & Ports

However, both Kälkäjä and Arhippainen recognize more than short term business opportunities in the ABB Marine & Ports' strategic move into weather routing.



Kälkäjä sees it as an advance in a quest for “The Holy Grail” of just in time vessel arrivals, where voyages are planned for optimized ship speeds and fuel use, and the minimized emissions possible when needless waiting time at the berth is avoided. “Integrating weather routing services brings that possibility one step closer,” he says.

Arhippainen describes it as a steppingstone towards integrated voyage planning that can bring greater transparency and better practice to the maritime world more immediately.

“Today, there is no speed optimization for the sea leg,” he says. “An operator can of course slow down and arrive just in time, but the reality is that vessel speeds are pre-determined and ships wait on arrival – sometimes up to 2-3 days. The point is that there is a lot of inefficiency in today’s marine market and ABB is now in a better position to offer change.”

Working with OVERSEA

The DTN Shipping business will complement ABB’s interest in OVERSEA – a cooperation combining ABB Ability™ Genix Industrial Analytics and technical support with Wallenius Marine ship management expertise to offer digital and remote operational assistance from Fleet Support Centers to all-comers.

While OVERSEA will focus on supporting operational strategies for route selection, emissions reduction and maintenance efficiency, “the DTN Shipping business will provide customers with a weather routing service”, comments Arhippainen.



—
Tomas
Arhippainen, SVP,
Global Business
Line Manager,
Marine Service
and Digital, ABB
Marine & Ports



—
ABB Ability™
OCTOPUS –
Marine Advisory
System

In an industry hungry for the gains of digitalization, Kälkäjä presents OVERSEA as a means to centralize expertise and optimize use of available resources. “And the ‘human in the loop’ approach we are developing in OVERSEA to help crew respond to biofouling, engine monitoring, emissions or whatever has also shown us just how pivotal weather routing is to vessel efficiency, safety and overall voyage performance.”

In fact, Kälkäjä portrays the addition of weather routing to ABB’s digital portfolio as a “next step” for fleet support as a service which also reframes the relationship with owners.

“Weather routing puts us in the center of day-to-day ship and fleet management decisions, where accurate and timely information is critical for safety, but also the fuel consumption that is decisive in performance against charter terms. We become a 24/7 service provider of the digital weather routing services on which owners increasingly rely.”

Arhippainen emphasizes that weather routing is complementary to other analytics products and services that ABB Marine & Ports has already developed to help owners face up to EEXI, the IMO’s Carbon Intensity Indicator (CII) and even emissions trading.



—
OVERSEA – a cooperation combining ABB Ability™ Genix Industrial Analytics and technical support with Wallenius Marine ship management expertise to offer digital and remote operational assistance from Fleet Support Centers to all-comers

“Knowing the safe route won't save you anything but adding that information to the other data creates significant opportunities for voyage optimization and speed advisory services that can have a big impact on fuel consumption and decarbonization,” he says.

Other synergies will also follow, as the newly named Routing Services business is integrated into the wider ABB marine digital portfolio.

The former DTN Shipping business is well known within ABB, and both the newcomers and the existing ABB team will have ideas about the opportunities for beneficial integration between weather routing services and ABB's wider marine digital portfolio, says Arhipainen.

Certainly, the safety case behind weather routing significantly strengthens ABB's hand in the cargo segment, according to Kälkäjä. •

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Overcome uncertainty with electrification

My role as Head of Sales for Marine Systems at ABB Marine & Ports means that I inevitably talk with all sorts of people across the industry. I know that one of the things at the front of people's minds is the uncertainty around the availability and cost of alternative future energy modes. It is possibly the biggest challenge for companies looking to decarbonize.

To do so, every industry and corner of society must pull in the same direction – maritime is no different. We cannot wait for fully electrified infrastructure or other industries to fully transition to renewables or wait for breakthroughs in novel energy sources, such as hydrogen, biofuel, and methanol production. Investment and innovation in these areas are welcome but maritime – similar to any carbon intensive industry – cannot rely on others before we take action ourselves.

Transitioning to electric drive trains and propulsion enables making flexible use of the full scale of renewable energy modes.

This is where electrification comes in. It presents a two-fold opportunity for feasibly decarbonizing and aligning with global shifts.

Firstly, transitioning to electric drive trains and propulsion enables making flexible use of the full scale of renewable energy modes. With batteries and fuel cells vessels can run on anything from nuclear to green hydrogen. Electrification is how uncertainty around emerging energy infrastructure can be overcome. Action today can safeguard maritime no matter the eventual direction of travel.

Secondly, electrification is an ideal blueprint for efficiency improvements. Electric propulsion systems are enormously efficient and utilities that run on electricity are highly adept at enhancing efficiency through automation and digital solutions.



Saara Kuusisto
Vice President,
Head of Sales,
Marine Systems,
ABB Marine & Ports

Decarbonization is happening for two major reasons. One is for the good of the planet, the other one is savings. After all, the cleanest and cheapest fuel is the one that remains unused. Electrification enables vessel owners and operators to walk and run at the same time; it is the way maritime can reach those around-the-corner milestones by 2030 in a financially viable way, while optimally positioning businesses to make the necessary leaps towards 2050.



Electrification is an ideal blueprint for efficiency improvements.

It is probably true that, as an industry, we are starting late when it comes to decarbonization. But it is never too late to take the first or next step. The alternative is waiting for vessels licenses to operate vanish. Electrification is a fast way to get a move on, even for vessels that have been sailing for decades. At ABB, we have plenty of cases where electrification has increased asset lifetime and generates savings every mile and minute. Not everything can happen all at once, but there are feasible solutions for all types of vessels. We believe every vessel can be decarbonized.

Climate change and the push towards decarbonization is no longer a new phenomenon. The solutions of electrification and the associated benefits, such as digitalization and automization are also no longer entirely novel. Maritime, like other industries, increasingly employs a workforce that have no memory of a pre-digital world. If a digital native is considered someone born after 1980 then



Electrification enables vessel owners and operators to walk and run at the same time.

we are surely at, or approaching the point, where a majority of people working in maritime are born digital natives, resulting in an accelerated expectation and adoption of digitalization, automation and electrification. After all, for all the wonderful traditions and heritage in our industry, we must also recognize the hesitance that exists when it comes to change.

A majority of people working in maritime are born digital natives, resulting in an accelerated expectation and adoption of digitalization, automation and electrification.

By plotting the most feasible pathway for any vessel, we aim to make decarbonization the generation-defining experience for the current and future generations of maritimers.

Maritime is electrifying. •



—
A majority of people working in maritime are born digital natives, resulting in an accelerated expectation and adoption of digitalization, automation and electrification.

—
Images credit: ABB

'It feels like I'm contributing to a better future for the industry'

Mathilde Bergerskogen, Technical Sales Support Specialist at ABB Marine & Ports, set out to be an electrical engineer but had not envisioned working in the maritime sphere before her final graduate-training assignment. That changed everything and she is now busy speaking for ABB Onboard DC Grid™ amid an industry push towards decarbonization – which she sees as 'simply the right thing to do, not because the IMO demands it'.

Twenty-eight year old Bergerskogen grew up in an Oslo suburb some distance from the sea. "My mum's an accountant and dad was a musician and instrument wholesaler. In fact, my brother Pål and I were the first in our family to go to university. We had no previous family links to engineering, marine or otherwise."

There were summer trips to relatives in northern Norway, with much time spent fishing, as well as ferry trips to a holiday cottage in Denmark. "The ferry was a highlight; tearing around the decks gave me a great feeling of freedom. But that was the limit of my maritime exposure."

At school, she was curious about everything, including social studies and languages, but her special interest was maths and science – solving puzzles.

After school she chose to do military service for a year in the Navy. "I really wanted to do something outside my comfort zone and ending up serving on a Coast Guard vessel mostly in the far north, doing fisheries inspections and providing technical and medical assistance at sea."

Her duties included voyage and operations planning, as well as navigation. "One of my tasks was to update the paper maps, and I did a lot of lookout duty on the bridge. It was an eye-opener, because it rekindled my love of the ocean, but I didn't then see myself working in the maritime industry."

—
Mathilde
Bergerskogen,
Technical
Sales Support
Specialist,
ABB Marine & Ports



Bergerskogen's brother had, meanwhile, gone on to study engineering at the Norwegian University of Science and Technology (NTNU) in Trondheim. "He's always been someone I've admired, and I decided to go to Trondheim as well. I chose the integrated Energy and Environmental Engineering MSc because it has a really good balance between maths, physics and chemistry and gives a strong foundation for understanding and developing the sustainable energy systems of the future."

Enjoying the advanced technical courses, she later specialised in electrical power conversion, also doing internships for power distribution and transmission grid operators. However, going into her fourth and fifth years she became more interested in smaller components like converters and electrical machines, rather than full transmission systems.

Testing the waters

After graduating from NTNU, Bergerskogen joined ABB Norway's two-year graduate trainee program, as one of six successful candidates. "You can test different business areas and roles, which is great because I wasn't quite sure what direction to go in."

Her first assignment was in ABB Energy Industries working on early-phase feasibility studies for large oil and gas projects, as well as electrification projects in the fishing and rail industries. The next six months were spent getting hands-on experience as an assistant commissioning engineer also in Energy Industries, installing and commissioning electrical equipment at a biofuel production plant.

"Following that I did an overseas stint at ABB Motion in Switzerland, working partly in technical R&D for a system drive at our factory in Turgi, and partly in sales writing customer tenders."

What fascinates me about shipping is that it's an industry with such deep roots.

Working both at the commercial front end and in R&D made her realise she didn't want to work exclusively with either, but somewhere in the middle. "My manager in Switzerland suggested I get more experience in product management, versus just projects. He put me in touch with John Olav Lindtjørn at ABB Marine & Ports in Norway, who is global product manager for Onboard DC Grid and still my line manager today."

Dropping anchor in marine

The move felt right from day one. "What fascinates me about shipping is that it's an industry with such deep roots. And people don't realize how much really cool and advanced technology goes into modern vessels. Marine projects are also relatively short term, so you get to see tangible results of your work fairly quickly."

Going to work she feels like she's meeting friends, regardless of age. "I learn something new from them every day. It's a very inclusive environment."

She also relishes nuts-and-bolts interaction with customers. "They come to us with a challenge they want solved. We try to make a good fit tailoring the building blocks that Onboard DC Grid offers. Finding the common ground and coming up with a good solution is very motivating."

Supporting the product team involves raising awareness at conferences and seminars. "I never wanted to be a teacher per se, but I've always had an urge to share whatever knowledge I've gained, even back at school. That's pretty much what I do now, bridging the gap between the product and sales team and customers. As an outgoing and social person, getting to meet new people from all sorts of cultures is a cool part of the job."

Working with solutions to improve energy efficiency feels like I'm contributing to a better future.

In the beginning, presenting to owners, CEOs, CTOs, and other high-ranking people was a bit scary. "But you soon discover they're just people and usually fun and interesting to talk to."

Green shift advocate

She applauds the IMO for setting ambitious climate targets. "It should go even faster, but at least things are happening. Working with solutions to improve energy efficiency feels like I'm contributing to a better future. I get to work on technically interesting projects that are really game-changing – testing new technology and fuels, as well as redesigning system topologies for cleaner operations."

We have no option but to follow a more sustainable path. In terms of emissions, shipping contributes only around three percent of the global carbon footprint, but we have to change in step with other industries.

Sustainability is not something the industry should do because the IMO demands it, she adds, but simply because it's the right thing to do. "We have no option but to follow a more sustainable path. In terms of emissions, shipping contributes only around three percent of the global carbon footprint, but we have to change in step with other industries. If we continue business as usual, it could end up a much higher percentage come 2050, which in addition to the emission impact would be very negative for the reputation of the industry."



Interferry 2023
(Image credit:
John Nedwidek –
Interferry)



—
WATTS UP 2024
(Image credit:
Maritime Battery
Forum)

While environmental impact is a crucial aspect, sustainability is not only about carbon emissions. She urges an emphasis also on the economic and social dimensions of sustainability – diversity, equity, and inclusion and doing business responsibly. "That's vital because as a global business we touch so many people's lives."

She considers herself lucky to have found a career that suits her. "Engineering's not for everyone and it likely won't make you rich. But we share one key characteristic – a kind of unique enthusiasm for problem solving – that makes work meaningful."

—
Find something that's good for you and not those around you. In the end, you'll be doing the work, so you need to enjoy it.

"People may see shipping as conservative, but that's certainly not been my experience. There are some narrow-minded people, but that's the case in every walk of life. The industry really deserves more attention. There are even people in ABB who don't recognize the big role we play in Marine & Ports!"

In terms of leadership, she believes a good leader should always try to listen and understand each team member's perspective. "We've all got different needs. For example, I need flexibility and freedom, but also support. And I know my manager John is always there if I'm stuck or need advice. Leaders need to be flexible and able to adapt."

Role models outside work are her brother and her mum, as well as a good friend from NTNU who's now an environmental consultant. "She's fantastically skilled and a real trailblazer, but also a caring and inclusive leader. I'd love to have her as my boss or colleague!"



Mathilde representing ABB at a booth at the Norwegian University of Science and Technology (NTNU) in Trondheim (Image credit: ABB)

'Find your own path!'

Her advice to the next generation, is simply: "Find something that's good for you and not those around you. In the end, you'll be doing the work, so you need to enjoy it. I don't jump around having an amazing time every day. You're not supposed to, either. But working with something you enjoy and find meaningful makes doing extra hours all the more fun."

I'm often the only female in the room but so what? There have been a handful of occasions where I've had to have a thick skin, but overall, it has not been a problem. Even now in my global role I've never experienced any negative attitude personally.

Secondly, she says don't be afraid to ask dumb questions. "It's a cliché but very important. Don't get hung up on being perfect. Share your half-baked ideas, because they'll definitely get better with input from those with more experience."

The fact that marine, and engineering generally, tends to be male-dominated isn't something that crosses her mind too much. "I'm often the only female in the room but so what? There have been a handful of occasions where I've had to have a thick skin, but overall, it has not been a problem. Even now in my global role I've never experienced any negative attitude personally."

As to where she will be five to 10 years' time, Bergerskogen is open-minded. "I'll of course explore whatever opportunities arise, but one thing's for sure – I can't imagine not working in marine!"

Outside the office, she is a keen sportswoman, skiing and snowboarding in winter, running and hiking in the mountains in summer. "This year I decided to step up the running a notch and registered for a half-marathon in early April. It was my first long race and a fantastic experience."

Otherwise, she enjoys listening to music and podcasts, reading, and playing board games. "I also have the very geeky hobby of playing Dungeons & Dragons with friends. And I try to make the most of what Oslo has to offer in terms of concerts, theatre, pub quizzes, nightlife and trying out new eateries. Abroad, I love exploring new cities and outdoor pursuits, including going to music festivals. I guess you could say I like to keep myself busy both at and outside of work!" •

Educating the market on DC ascendancy

At a conference in 2023, Bergerskogen was nicknamed 'ABB's Battery Lady' by a couple of mischievous delegates, although that is something of a misnomer. "Part of my address was about batteries, but mostly about Onboard DC Grid – but 'Onboard DC Grid Lady' doesn't really roll off the tongue. I take 'Battery Lady' as a compliment; but there are people at ABB who know a whole lot more about batteries than I do."

She is used to explaining the ins and outs of Onboard DC Grid often to large audiences. "Using DC as the main distribution media for electric propulsion onboard ships has only happened for the last 10 years – ABB delivered the world's first DC-based onboard power system to an oceangoing vessel in 2013. Many people still aren't familiar with electrical versus mechanical propulsion, and not with DC versus AC for electrical systems. It can take some time to wrap your head around DC concepts because there are key differences from AC, which may be more known to people."

Combining Onboard DC Grid's standardized building blocks in the most optimal way enables flexible and functional integration of a wide range of energy sources and loads.

Beauty in modularity

Combining Onboard DC Grid's standardized building blocks in the most optimal way enables flexible and functional integration of a wide range of energy sources and loads, Bergerskogen explains. "So you can tailor it to the needs of your vessel. New energy sources such as batteries and fuel cells are by nature DC-based, so much simpler to integrate. Onboard DC Grid is also agnostic to energy sources, so very well suited to building the next generation of sustainable power systems – dual-fuel or engines running on alternative fuels like ammonia and hydrogen."

She adds that you with low effort can make use of variable-speed engines. "The generator set you are integrating only needs to match the system voltage; you don't need to match the frequency because you connect the machine to a frequency converter anyway. So you're free to run the engine at the best speed for the load conditions. An AC system has to match both voltage and frequency, so you need to run the machine at a fixed speed. With DC, being able to reduce the speed of the machine at lower loads automatically improves fuel consumption and lowers emissions."

Simplifying power conversion

Onboard DC Grid is very beneficial for systems with larger converter-based loads. "By integrating the converters into a main, centralized DC distribution, you can avoid large and heavy transformers. Eliminating power conversion steps and components also reduces losses, and simpler integration drastically increases system efficiency."

Over the last decade, Onboard DC Grid has proved itself to be a robust, reliable system that is highly fault tolerant. "And because it's based on the ABB's common Ability 800xA control-system platform, it's just as suitable for our portfolio of digital services including remote diagnostics and condition monitoring."

It doesn't suit all vessels, however, but is still customizable for a wide range of applications. "Being based on low voltage, there's a natural limitation in terms of power – it's best for ships in the low-to-mid power range. At the same time, the modularity of Onboard DC Grid allows us to build systems having up to tens of megawatts of installed power."

From cradle to grave

Bergerskogen points out that as a large, global supplier ABB Marine & Ports has the advantage of proven components and decades of experience. "Plus, we're a very reliable, cradle-to-grave partner and can support projects from the very early design phase throughout vessels' operational lifetime."

She highlights Onboard DC Grid as a great example of ABB being a front-runner. "With our R&D resources we're able not only to follow, but to drive developments in the market. I'd also like to give a shout to our sub-suppliers of components such as converters, rotating machinery, and batteries. We wouldn't be able to deliver quality systems without them. It's all about collaboration."

ABB spearheads future-proof technologies for icebreaking ships

Operating safely and responsibly in the toughest ice conditions on the planet requires the toughest technology. Harsh environments, regulatory requirements, and lack of infrastructure are key challenges in building icebreaking vessels for operations in Polar waters – not only research vessels, but also expedition ships, cargo ships, tankers, and LNG carriers. System redundancy and equipment reliability are critical for the safety of both vessel and crew. Podded propulsion solutions have been developed to meet these stringent requirements offering effective, clean, and quiet operations together with superior maneuverability and reliability.

—
Samuli Hänninen,
Segment Manager,
Icebreaking Ships

Ahmad Arslan,
Solution Manager

Sampo Viheriälehto,
Master Mariner,
Sales Manager

Pirjo Määttänen,
Senior Engineer,
Icebreakers and
Ice-going ships

Torsten Heideman,
Senior Engineer

Jani Hakala,
Product Manager

ABB Marine & Ports

This article starts by reviewing the history of icebreaking vessels and how Double Acting Ship (DAS™) concept, developed by Aker Arctic, revolutionized this domain, enabling ships to operate without dedicated icebreaker support. DAS designs combined with podded propulsion systems have proven highly effective in carrying out operations in ice-infested waters. To break ice in the most challenging conditions, vessels powered by ABB's Azipod® propulsion navigate stern first. Propellers mill the submerged part of the ice ridge to open a passage, while water flow generated by the propeller flushes the hull, allowing the ship to move with ease through the thick ice. The OPEX and CAPEX benefits provided by Azipod propulsion are also discussed.

The article then investigates the evaluation criteria for selecting the optimal propulsion system for LNG carriers, as well as mitigation of Underwater Radiated Noise (URN) from electric propulsion systems, at a time of increasing awareness and concerns around the impact of ship traffic on Polar marine flora and fauna. ABB recently completed a full-scale validation of the prediction method for URN that can be efficiently applied to any new project.

The article also discusses the development of electric powerplants for modern icebreakers, including future-proof sustainable solutions such as Onboard



DC Grid™, a modular power system platform that enables simple, flexible, and functional integration of energy sources and loads, as well as increasing adoption of energy storage systems (ESS).

Icebreaking history

The past 30 years have seen a rapid development in the propulsion of ships operating in ice-covered waters. The emergence of podded propulsors with high ice class changed the game. Previously, rigid shaft lines and propellers, with or without nozzles, were the only options available for icebreakers. Around the world, the predominant choice of propulsion was electric drive with fixed-pitch, open propellers. Prime movers ranged from nuclear-powered engines in Russia, steam- and gas-turbines in Canada and the US, and diesel engines elsewhere. All these typically state-owned icebreakers had large crews, typically from 50 to 150 persons, and were expensive to operate.

The oil discoveries in the Beaufort Sea changed this picture. Privately owned and operated ships started to appear in the late 1970s. These were built to support the drilling fleet during the summer season and to act as research platforms. The machinery layouts typically featured geared, medium-speed diesel engines and

controllable pitch propellers with and without nozzles. The main drawbacks of this kind of propulsion configuration were poor capability to handle ice torque and clogging of the nozzles by ice blocks.

However, all icebreakers, except for the bow-propeller-equipped Baltic icebreakers, had challenges with maneuverability when performing both icebreaking and ice-management duties. To solve this, a couple of projects were initiated in Finland at the end of the 1980s. Two small icebreaking waterway service vessels were equipped with steerable thrusters, the Lonna with a mechanical thruster and the Seili with an Azipod propulsion unit. In this context a mechanical thruster refers to a thruster where the motor drives the propeller via several bevel gears (normally two), while an Azipod is a propulsion unit with the electric motor located inside the pod, driving the propeller directly.

The result of the ice trials of these two vessels led to the invention of the revolutionary DAS ship. DAS means the vessel is designed to run stern first in the most difficult ice conditions – normally compacted pack ice of very high ice concentration – while the bow can be optimized for other conditions. For example, a bulbous bow enables good open-water performance, while an extreme icebreaking bow is ideal for ramming in multi-year ice.

The DAS principle

In the evolution of icebreaking the effectiveness of having at least one propeller in the bow has always been recognized. In 1888, a railroad ferry by the name of SS St Ignace began sailing across the Straits of Mackinac between the Upper and Lower Michigan peninsulas. The wooden vessel had one propeller in the aft and one in the bow. It operated for more than a decade and served as an example for designers of icebreakers in Europe. Finnish designers visited the vessel around the turn of the century, and it later inspired the country's sub-Arctic Baltic icebreakers.

Icebreaking tests with Baltic icebreakers in the 1970s revealed that ice resistance decreased when more power was distributed to the bow propellers. In theory, the ultimate icebreaker would have 100 percent power in the bow. In practice, this is not feasible since the vessel would be difficult to steer in the desired direction and inefficient transiting in open water.

The advent of the azimuth thruster with pulling propeller was a game-changer for icebreaking technology. It now became possible to fully utilize the combination of full power when running astern with good performance going ahead i.e. DAS operation. As already stated, DAS optimizes the stern for icebreaking in difficult ice conditions and the bow for other conditions.



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Figure 1: The DAS
principle

Following the retrofit of a podded propulsion prototype with a power of 1.3MW to the Seili in 1990, the first commercial applications were retrofits of the ice-class 1A Super tankers MT Uikku and MT Lunni at the beginning of the 1990s. These vessels were extensively tested in both Northern Baltic and Arctic conditions, and they fully revealed the overwhelming icebreaking performance of DAS vessels running astern in difficult ice conditions.

Research and expedition icebreakers

The history of Polar exploration is full of not only success and glory, but also expeditions that ended up in disastrous loss of life and equipment. The earliest expeditions clearly revealed the need for careful preparation and self-contained operation in the most remote areas of the world. Explorers in those days relied on sailing ships and quite a few were lost in Polar waters.

The operation of sailing ships in ice conditions is difficult due to maneuverability issues, particularly the inability to reverse. Rowing boats were often used to pull the ships backwards.

The advent of the coal-fired steam engine solved some of these challenges and later expedition vessels used a combination of steam engines and sails. The long voyages to the Polar regions used wind for propulsion, saving fuel for the boilers during ice transits.

Following the Second World War, diesel engines came to dominate maritime transport, including icebreakers. Most of the nations with permanent research bases in Antarctica have dedicated logistical support vessels to serve those bases. Some of these also serve as Polar research vessels as a secondary mission, however much of their interior space is reserved for containerized cargo and fuel for the bases, as well as accommodation for base personnel on rotation, leaving less room for scientific equipment and laboratories. The propulsion system of these vessels was normally geared to diesel or icebreaker-type diesel-electric configurations.

More recently, the growing interest in the Polar regions prompted the development of dedicated Polar research vessels where logistical support played a much smaller role. In these vessels the focus is on research work with a large open deck area, numerous probe winches, and well-equipped laboratories. Many cabins are also provided for scientists.

Diesel-electric propulsion remains predominant, but there is an emerging trend for hybrid technology using fuel cells and battery packs together with “green” fuel.

Meanwhile, Dynamic Positioning (DP) requirements paved the way for azimuthing propulsors.

In recent years, the cruise industry has expanded into the Polar regions in the shape of expedition cruise vessels. Some of these have high ice class and good icebreaking capability. An excellent example of a state-of-the-art luxury Polar expedition vessel is Le Commandant Charcot (Figure 2), owned and operated

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Figure 2: Le
Commandant
Charcot



by Ponant Cruises. It was the first vessel built to Polar ice-class 2 (PC2) and was delivered in the summer of 2021. The ship operates in all harsh and sensitive Arctic and Antarctic areas, where passenger safety and environmental aspects are the top priorities. It has cruised several times to the North Pole and along the North-West Passage. Its impressive power of 34MW enables smooth and safe voyages in the hardest ice conditions.

With LNG-fueled main engines, Le Commandant Charcot's propulsion power is provided by two 17MW Azipod VI2300L units. A relatively high-capacity 4,500kWh battery pack contributes to peak shaving and allows zero emission operation. The system is complemented with ABB Ice Mode propulsion control functionality, allowing seamless power sharing between propulsion engines and load banks (Barisic M. et al, 2017, 2018).

Le Commandant Charcot's excellent icebreaking capability, particularly going astern, is due to its DAS design. In this case, DAS refers to the bow being specifically designed for economic open-water performance and moderate icebreaking whereas the stern is designed for more demanding icebreaking.

Icebreaking cargo vessels, tankers, and LNG carriers

Operating in ice was not an option for tankers for a long time. In ice conditions, tankers were always assisted by icebreakers, only requiring a slightly stronger hull. The idea of operating a tanker that could break ice independently took hold when Esso/Humble Oil started to study the possibility of transporting oil from the Alaskan North Slope. The SS Manhattan was the first open-water vessel to be converted to an icebreaking tanker by reshaping the hull. The 30,000-horsepower (hp) machinery with fixed-pitch propellers driven by steam turbine was sufficient for it to break ice.

In 1970, the Finnish Government decided that all major ports should be navigable year-round, from Hamina in the eastern Gulf of Finland to Kemi in the Bay of Bothnia in the far north. This decision affected the ice-strengthened fleet in many ways. More icebreakers and ice-capable cargo ships were needed. Tankers played a crucial role as all the ports around Finland tend to freeze every winter. The Finnish national oil company, Neste Shipping, was a key player in the development of vessels for ice operation. In the 1960s and early 1970s, there were already several ice-strengthened tankers of ice-class 1A.

Neste gradually developed the fleet for better ice performance during the early 1970s. This work started with the product tanker Kiisla (5,752 dwt, power 5,000 hp, length 109.32 meters (about 358.66 feet), breadth 17.60 meters, and

draft 6.60 meters), equipped with a controllable-pitch propeller. Following this development, other existing vessels needed to be replaced resulting in the Lunni class of vessels (Mäkinen et al, 1977).

The MT Lunni was the first tanker intended for regular independent winter service in the Baltic Sea. Its main parameters were: 15,975 dwt, length 164.45 meters (about 539.53 feet), breadth 21.5 meters, draught 9.5 meters, and ice-class 1A Super. This was followed by a sister vessel, the MT Uikku. Both were equipped with geared diesel engines and controllable-pitch propellers.

Neste subsequently wanted to modernize both Lunni-class tankers and so they became the first vessels to incorporate large Azipod units (electric transmission azimuth drives with 11.4MW of power). The project was executed in collaboration with Masa-Yards. The partners established a new shipping company named Nemarc to operate the pair.

The MT Uikku was converted first and full-scale tests were carried out in level ice in the northern Baltic Sea in 1994. The tests delivered quite interesting results. The ship was able to proceed astern better than ahead and the resistance was some 40 percent lower, even though it had a good icebreaking bow. One of the characteristics tested was its maneuverability. In the tests, the vessel made a turning circle in 40cm level ice in 2-2.5 ship lengths, one-third of the original design. The MT Lunni was tested in heavy ridges in 1996 (Heideman et al, 1996) at a site in the northernmost reaches of the Baltic Sea off the town of Kemi where the heaviest ridges could be found. The main objective was to study the vessel's capability to run astern, to confirm the indications seen during the tests with the MT Uikku. The tanker had no problems running astern through a 10-13-meter-thick ridged area (as seen in Figure 3, right). However, it could not

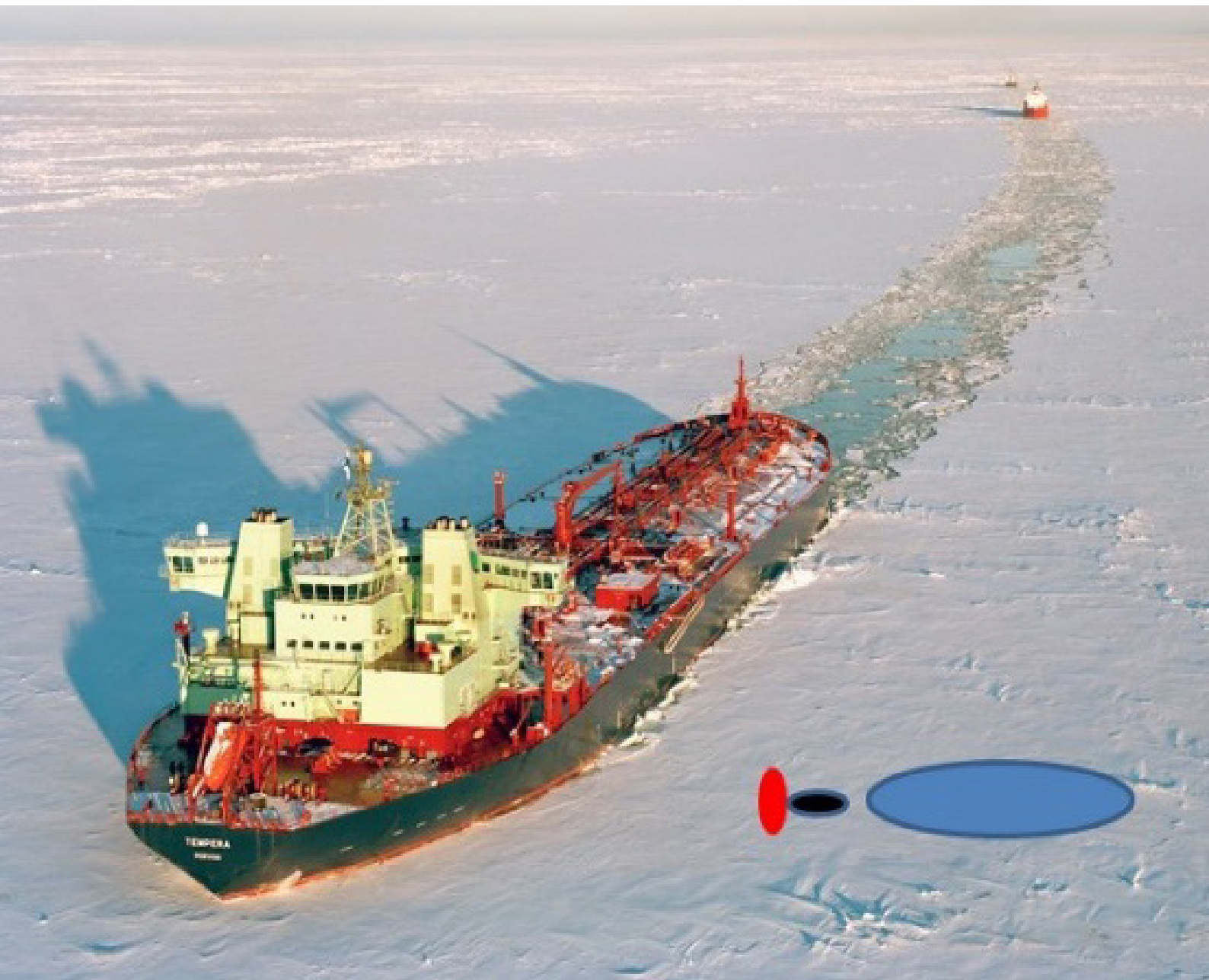
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Figure 3: MT Lunni after conversion to 11,4MW Azipod propulsion (left) and a view of the ship in a rubble field in astern mode



return along the broken track through the ridge field running bow first despite having a very good icebreaking bow. Following the results with both ships, it was time to scale up.

The pair of tankers were originally built with a 6.6kV power system to feed their bow thruster and other high-power consumers. In the conversions, new medium-voltage switchboard sections for propulsion drives and three diesel gensets were installed. The double-windings synchronous motor of the Azipod unit is fed by a redundant 12-pulse cyclo-converter system, connected through propulsion transformers to the 6.6kV switchboard. Total installed generator capacity is 18.6MVA.

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Figure 4: MT
Tempera assisting
other vessels
running astern



In early 2000, a new oil export terminal was built in the eastern Gulf of Finland triggering a need for tankers of at least 100,000 dwt year-round. These vessels would also have to operate in ice conditions. Neste decided to build two 106,000-dwt DAS tankers (Wilkman et al, 2006, 2014, 2016) on the premise that they should be independent and able to operate without icebreaker assistance.

In heavy ice conditions these two tankers, the MT *Tempera* and MT *Mastera*, run stern first and bow first in light ice conditions and open water (Wilkman, 2004). With such good capability, they can also act as icebreakers escorting non-capable vessels when needed. Their parameters are: length 230 meters (about 754.59 feet), breadth 44.0 meters, and draught 15.3 meters. Both were built to ice class 1A Super and are equipped with one 16MW Azipod unit.

The MT *Mastera* was tested in March 2003 during a voyage to the oil terminal in both ballast and loaded conditions. Ice conditions were level ice with small ridges, old channels, and ridged ice up to 12-15 meters. The successful tests provided the final kick for further development of azimuth thrusters for large Arctic tankers capable of independent icebreaking both bow-ahead and in astern mode. The MT *Mastera* utilizes a similar propulsion drive arrangement as the MT *Lunni* and MT *Uikku*, but with a higher level of redundancy. The 6.6kV power plant consists of two 8.6MVA and two 5.7MVA main generators, and a 2.4MVA auxiliary generator. The main bus and 12-pulse cyclo-converter propulsion drive are split in two sections installed in separate rooms. The 16MW Azipod propulsion unit has two 1500V winding systems.

The next major step in tanker propulsion development was to design the first twin azimuth propulsion systems for two types of 70,000-dwt tankers operating in the Arctic, one having a total of 20MW propulsion power in two Azipod units, and the other one equipped with two 8.5MW Azipod units.

These vessels' 6.6kV power plant has four main generators shared between two separate switchboard sections. VSI-type propulsion drives are used to control the 3kV propulsion motors of the Azipod units. To increase system redundancy the propulsion transformers can be supplied from either of the two 6.6kV switchboards. In addition to propulsion drives, the 6.6kV switchboards supply the bow thrusters, ship services, and cargo transformers.

Over the last two decades, LNG carriers as well as Arctic tankers have been in the forefront of adopting new propulsion technology. The driver for change has been the challenging environmental conditions in the operational area. The *Christophe de Margerie* was the very first in a series of 170,000-cbm Arctic LNG carriers ever

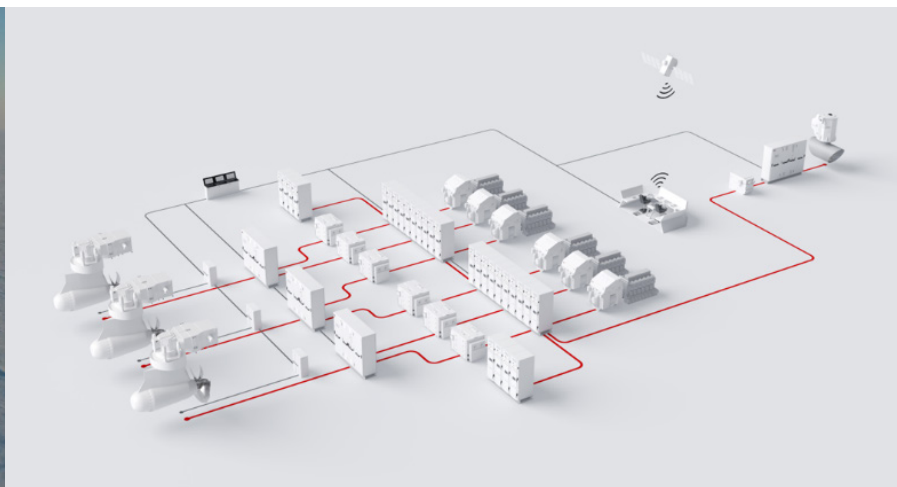
built. The vessel's three 15MW Azipod propulsion units make it the most powerful LNG carrier in the world. ABB's special Ice Mode propulsion control function was also developed for Arctic LNG carriers to deal with fast load reduction in the AC electric propulsion and network. The function is designed to minimize load variation of the LNG-powered main engines by utilizing "load banks" and available power reserve of electric propulsion motors.

AZIPOD PROPULSION FOR ICEBREAKERS

Azipod is a gearless steerable propulsion system where the electric drive motor is in a submerged pod outside the ship hull. The system improves vessel safety, design flexibility, energy efficiency, and maneuverability, while delivering high levels of ice-breaking performance, greater uptime, and reduced construction and maintenance costs. Since 1990, two of the three new icebreakers have used electric podded propulsion systems. Specific benefits of Azipod propulsion for Polar research vessels include:

- Flexibility in vessel design and general arrangement resulting in more space available for cabins, research facilities, and other equipment. Another alternative is to build a shorter and more compact vessel with the same capacity, resulting in a more efficient and cost-effective design.
- Excellent icebreaking capability and safety
- Superior maneuverability, especially at low speeds in harbor and research operation mode
- Reduced level of propeller-induced pressure pulses resulting in minimized noise and vibrations onboard and underwater
- Built-in system redundancy and excellent DP operation capability
- Lower total fuel consumption due to the power plant principle and improved hydrodynamic efficiency
- Vessel building schedule and yard costs can be optimized with modular construction of the propulsion system.
- Project risk is further reduced by the fact that there are fewer vendors, interfaces, and installation trades to schedule.

Figure 5: Electric propulsion line-up topology including three 15MW Azipod units



For Polar research icebreakers, Azipod propulsion eliminates the need for rudders and steering gears, shaft lines, gear box, stern tube and seals, lubrication system, inboard propulsion motors, retractable aft thruster, and controllable-pitch propellers. It also minimizes propulsion system complexity, maintenance, fuel consumption and the number of equipment suppliers and interfaces while maximizing reliability and performance.

Operational performance of Azipod propulsion

The maneuverability of a vessel equipped with Azipod propulsion is superior compared to a conventional vessel, making tactical ice navigation more efficient. Azipod propulsion thrust can also be used to clear ice between a pier and the ship. This allows considerably faster berthing in ice-infested ports. Several other ice-management tasks can be efficiently performed using the propulsion wake, for example clearing an ice-free 'lake' for the safe operation of a remotely operated vehicle (ROV). Ice ridge and ice rubble penetration capacity is far better going astern than with traditional bow-first operation.

Compared to the classic icebreaker with shaft-line propellers and rudders, the improvement in turning capability in ice using podded propulsion is remarkable. Figure 6 depicts the turning circle of various vessels plotted against a given ice

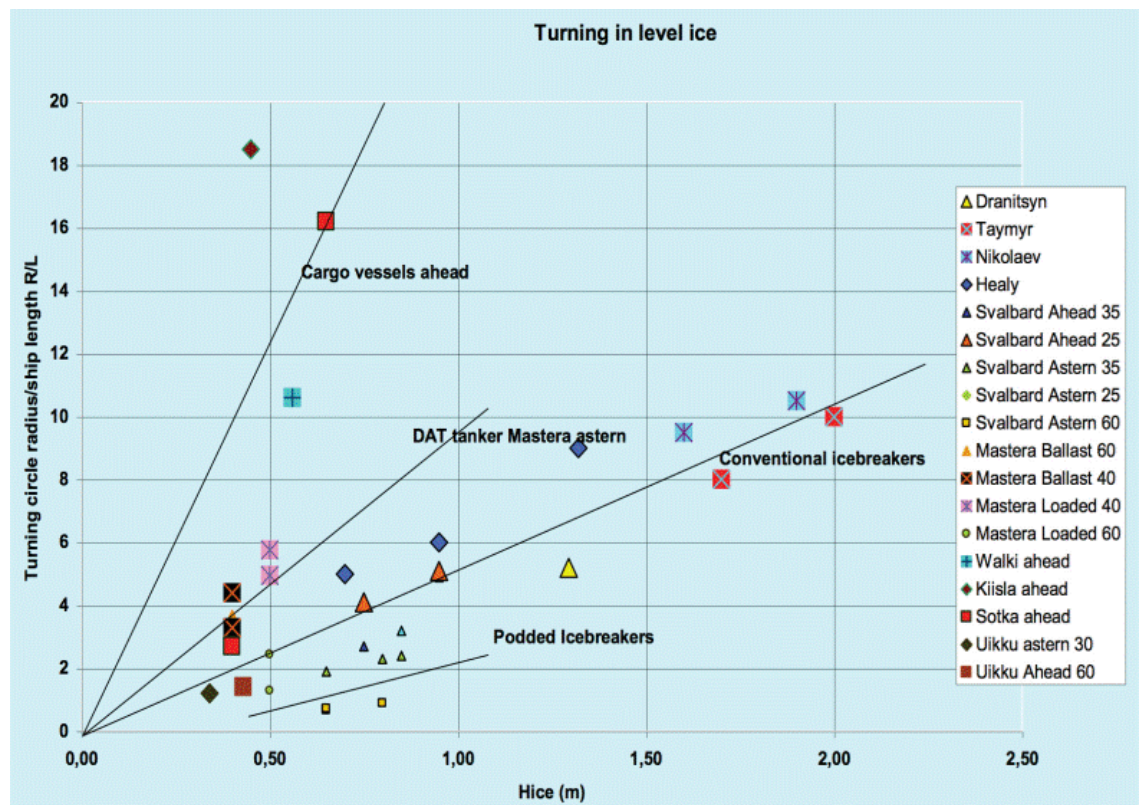
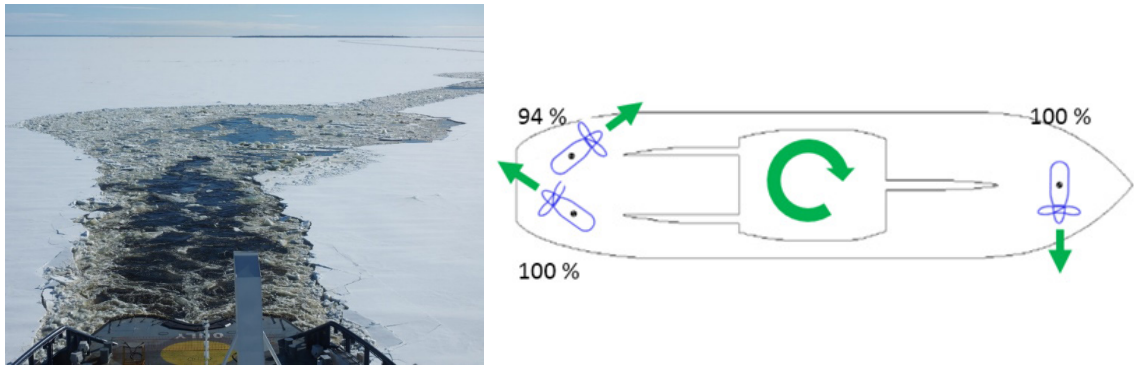


Figure 6: Different icebreaking vessel turning capacities in ice

Figure 7: View from the aft of the icebreaker Polaris having turned on the spot (left) using the given thruster orientation (right)



thickness. It clearly shows how podded icebreakers can turn in much tighter circles than conventional vessels. To further enhance the turning capability, a propulsion arrangement that combines Azipod units in the bow and two units in the aft will provide unrivalled maneuverability. Figure 7 shows the result of the icebreaker Polaris turning on the spot using the illustrated Azipod orientations.

Research operations in astern mode

Research icebreakers with Azipod propulsion can be operated in low-speed science/silent mode running the vessel astern. The ship hull and propeller stream work as noise barriers for scientific towing equipment, while maintaining course stability and maneuverability. This capability can further extend the operating window for scientific work even in the presence of ice.

OPEX efficiency

Icebreakers with podded propulsion are more fuel-efficient than conventional drive-shaft vessels due to the efficient hull design and the system's reduced power requirement, which can in some cases lead to a substantial improvement in efficiency, reducing fuel costs and increasing endurance. Modern power systems together with podded propulsion can be designed to operate at variable frequency, which allows the machinery system to run at varying RPMs in response to changing demand. This has two benefits: it can deliver substantial fuel savings compared to conventional power distribution systems and it allows the engines to run at optimal levels in relation to fuel economy and long-term durability while still delivering outstanding performance. This is especially important in the constantly changing conditions that research icebreakers encounter while operating in ice.

CAPEX benefits

As exciting as many new marine technologies are, they must also be viable in an industrial manufacturing environment. It is essential to consider production attributes early in the design and acquisition cycle, especially in cases where

the equipment faces unique demands, as is the case for research icebreakers. Azipod propulsion systems have proven themselves in terms of ease of installation; the single lift requires less time in drydock and reduces schedule risk for the shipyard.

Project risks are also reduced by the fact that there are fewer vendors and installation trades to schedule. Furthermore, the podded system eliminates the need for gearbox, thrust bearing, shaft line, stem tube and seals, lubrication system, rudder and steering gear, stern thrusters, and an interior electric motor. Improved performance and propulsion efficiency may allow a reduced power rating for the whole power plant and propulsion system, resulting in smaller propulsion motors, drives, generators, and main engines.

AZIPOD PROPULSION AND UNDERWATER RADIATED NOISE (URN)

The main contributors to URN from Azipod propulsion are the hydrodynamic noise from the propeller and the electro-magnetic noise from the electric motor of the Azipod unit. The electric motor is located outside the ship hull and cannot be isolated from radiating acoustic energy to the underwater environment. The electric motor is the main contributor to URN from Azipod units in non-cavitating conditions, an equally important source as the propeller in cavitating conditions.

The propeller design for Arctic research icebreakers is driven by the bollard-pull condition, ie, the ship at zero speed. The ship must be able to operate safely in harsh ice conditions. The propeller is designed to absorb full power available from the electric motor, and to give as much thrust as possible at zero speed. The propeller loading is adjusted according to the performance requirement in bollard pull and the blade area ratio is adjusted to avoid thrust breakdown due to cavitation. Heavy ice-class propellers typically have zero or very moderate skew to be more resistant against heavy ice loads. The thickness of the blades is determined based on the ice loads acting on the propeller blades. The propeller blades are then easily recognized for their symmetric outline and relatively large blade area ratio as shown in Figure 8.

In addition to the bollard-pull condition, research icebreakers have both transit and research modes. The propeller efficiency should be reasonable in transit mode, although it is compromised since the design point is in the bollard-pull condition and the blade profiles are thick compared to propellers designed for open water.

In research mode, acoustic emissions from propulsion are restricted in research vessels. Many classification societies have their limits for underwater noise emissions. The limits are based on the vessel types and their mission. The



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Figure 8: Heavy
ice-class Azipod
VI1600 units

first underwater noise level was set in ICES 209 (Mitson, 1995), which gave recommendations for underwater noise levels for fishery vessels. Regarding Arctic research vessels, the noise levels are determined for low ship speeds, typically around 10 knots in research missions.

Hydrodynamic noise

As already stated, the propeller design is very much focused on the bollard-pull condition. The means to affect underwater noise levels in transit are then limited by propeller designer. The required power level for near 10-knot vessel speed is only 10-30 percent of that required at the bollard-pull condition. The propeller blade loading is then relatively low due to the high blade area and the margin against cavitation inception is usually reasonable. The ship wake field at the propeller plane is very smooth in icebreakers equipped with Azipod units, which also helps to avoid cavitation at low ship speeds. The hydrodynamic noise emitting from non-cavitating propellers is usually clearly below the relevant noise limits at low speeds.

The prediction methods for hydrodynamic underwater noise levels from propellers still rely on empirical or semi-empirical methods, or measurements in model tests. There have been attempts to simulate hydrodynamic noise using a combination of CFD and acoustic analogies (Viitanen et al, 2018, Lidtke et al, 2022), but proper full-scale validation of the approaches is still missing. The noise measurements in model tests are subject to background noise, influences of the measurement system, and scale effects. The model test measurements are only available at a late stage in the propeller design process.

ABB uses tools and methods developed within the CRS (Cooperative Research Ships, <http://www.crships.org>) community to predict hydrodynamic noise from propellers. The Boundary Element Method (BEM) code Procal is used to calculate the flow field around propeller blades. The Procal code calculates the propeller performance, the pressure field, and sheet cavitation extent around the propeller. The output of the BEM simulations is used by the Empirical cavitating Tip Vortex (ETV) method (Bosschers, 2018). The semi-empirical ETV model calculates the noise emitted from cavitating tip vortices. The CRS community developed a MATLAB implementation of the semi-empirical method predicting broadband noise from cavitating bubbles emitting from propeller sheet cavitation (Matusiak, 1992). The MATLAB simulations also use output from the Procal code.

Electromagnetic noise

Sound emission from an electrical motor can be considered as a sum of three types of sources acting simultaneously: 1) Cooling noise; 2) Mechanical noise; and 3) Magnetic noise due to magnetic interaction between stator and rotor (airgap). In this case magnetic noise is of importance. The rotating magnetic field in the motor is never fully sinusoidal (due to slots, saturation, pole shape, voltage waveform, etc), which means that also harmonic field components are generated to some extent. These harmonic field components are the main cause for magnetic noise. The flux harmonics generate rotating force waves having distinct frequency f and wave number r . Some examples of magnetic force waves are shown in Figure 9.

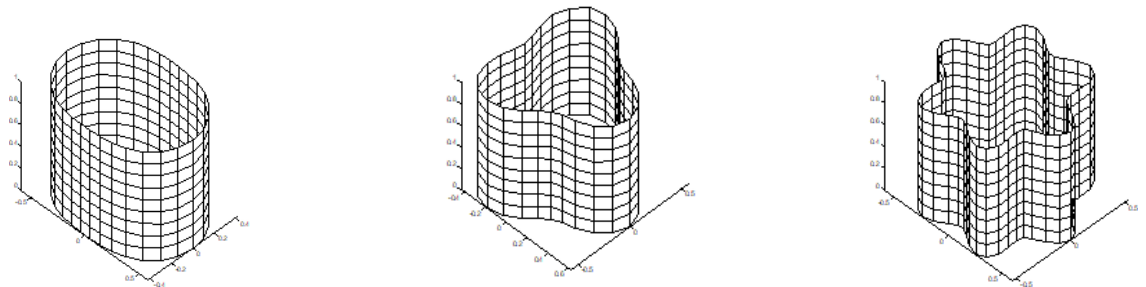


Figure 9: Rotating force waves, (from left to right) $r = 2, 3,$ and 6

An electrical motor operating with sinusoidal supply voltage (Direct On Line, DOL) is typically very silent. This is due to two reasons: 1) The motor is running with constant speed making the vibroacoustic design more straightforward with respect to structural or acoustical resonances; and 2) The voltage waveform produces an airgap flux with low Total Harmonic Distortion (THD). In the case of frequency converter supply (Variable Speed Drive, VSD), the previous two aspects fail to hold true. Especially as the voltage waveform is not sinusoidal anymore, the airgap flux THD increases heavily. Increased distortion in airgap flux manifests itself in the form of increased magnetic noise level. For a standard industrial induction motor, the noise level increase can be as high as 30dB.

Electromagnetic noise studies rely on underwater noise simulation using coupled models: To get reliable underwater noise predictions, the Fluid-Structure-Interaction (FSI) approach is essential. In short it means that the Azipod structural vibrations and underwater sound radiation are solved simultaneously to include the water inertial (attached mass) and dissipational (radiation damping of the structure). FSI-based methods are computationally heavy, but the reward comes in the form of improved URN accuracy. The coupled analysis method is then validated during sea trials.

Finally, the hydrodynamic noise prediction is added to the electro-magnetic noise prediction to obtain the total noise level of Azipod propulsion. When measuring URN levels in full scale, the other noise sources from the ship are also present in the noise spectra. Careful analysis of the measurement data is needed to identify all sources present in the spectra.

An example of noise spectra from the simulated hydrodynamic and electro-magnetic noise sources, and the sum of the sources for a vessel designed without noise restrictions, are given in Figure 10. The far field measurement results and RINA transit noise limit are also given in the figure for reference. The peaks present in the far field measurements noise spectrum are well captured by the ETV model and the electro-magnetic noise simulations.

Solutions to mitigate electro-magnetic URN

In conclusion, propeller hydrodynamic noise is highly dependent on the load and rotational speed, and it can be reduced if the propeller is carefully designed according to speed and load situations. The main concern still lies with electro-magnetic noise of the motor inside the pod. To smooth the output voltage wave form of converters, one simple and cost-efficient solution could be to use passive filters between the motor and drive, see Figure 11. Filter size in this case will depend on the switching frequency of the converter and may not be suitable for cases where drives typically operate at switching frequency of few hundred Hz.

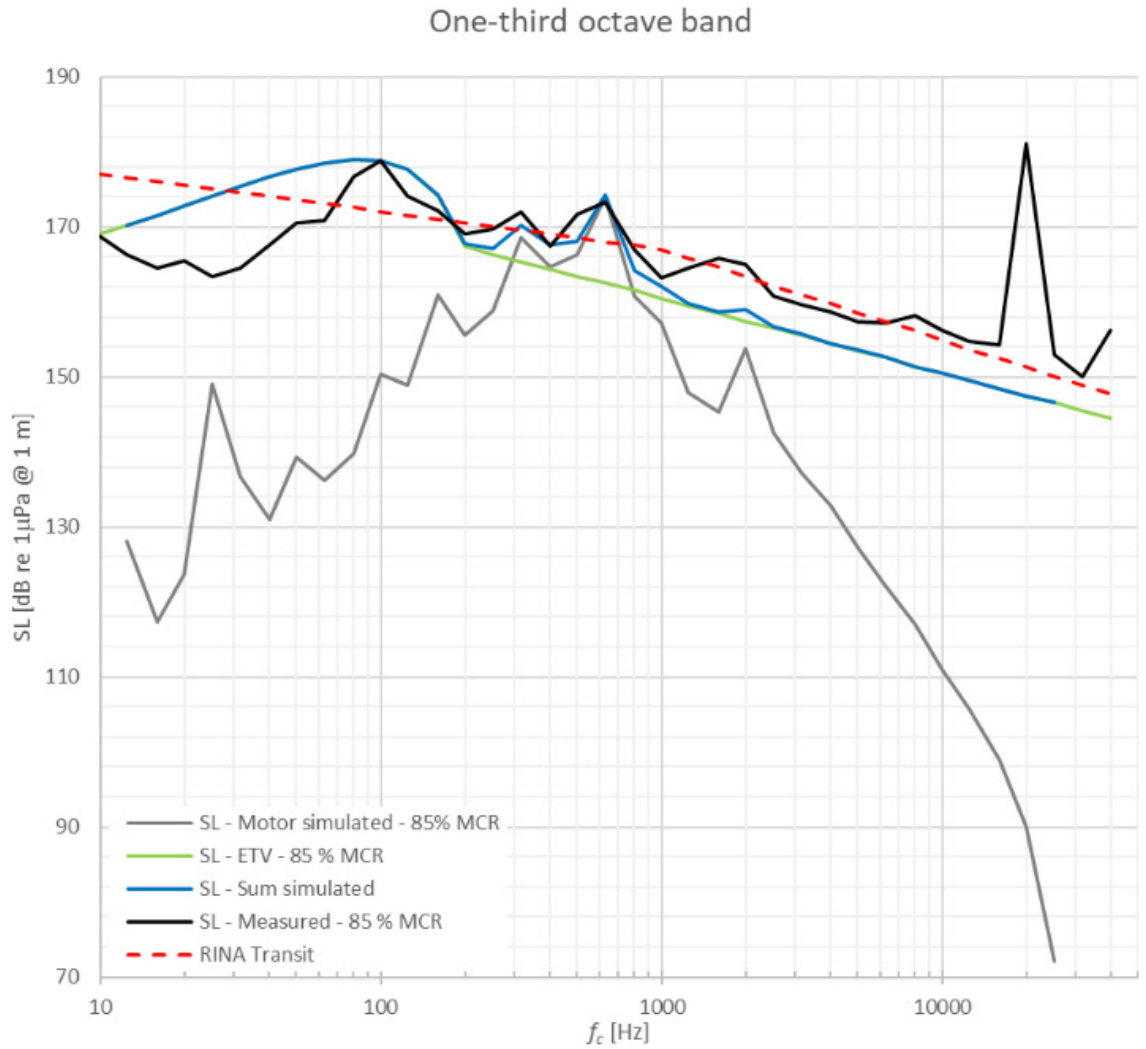


Figure 10: Simulated hydrodynamic noise (ETV), simulated electro-magnetic noise, and sum of simulated noise sources for a ship without noise restrictions

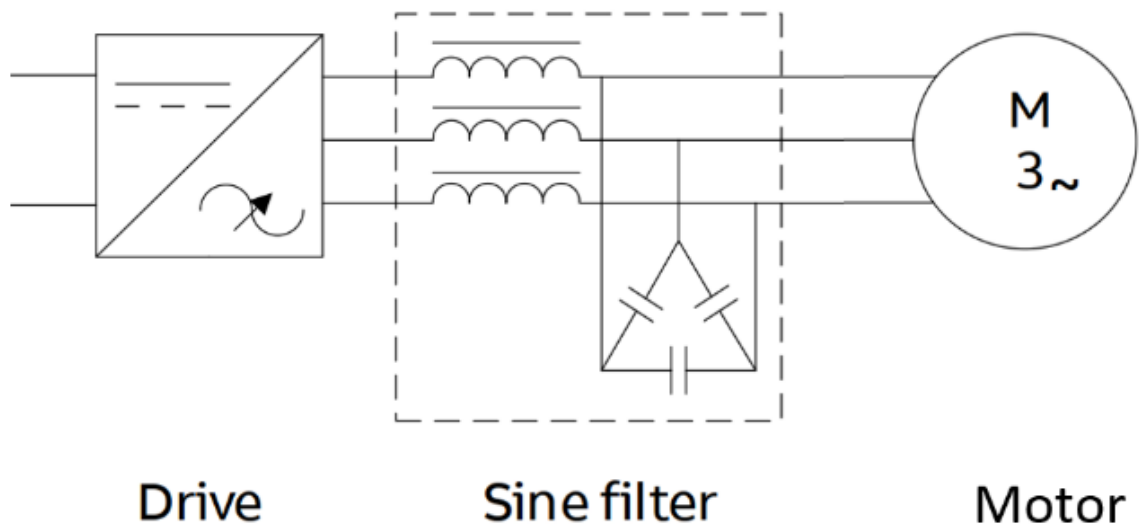


Figure 11: Sine (passive) filter between propulsion drive and Azipod motor to reduce harmonic content in voltage waveform

Active harmonic filters could be a more compact solution to be used with low switching frequency converters, however this may require additional power source and comes with a price tag.

Another possibility is to use a propulsion transformer with two voltage levels on the secondary side, such that 100 percent voltage is available for normal operation with first tap, see Figure 12. While 100-x percent voltage is available via second tap, this will result in reduced DC link voltage in the drive. This will inherently bring down the airgap flux THD level in the Azipod motor. The x percent voltage reduction can be selected based on characteristics of the propulsion system. Operation with reduced voltage will also limit the available power, therefore this methodology is not suitable for icebreaking operations nor to mitigate URN of ships in general. It is suitable only for silent operation where the vessel operates at reduced speed.

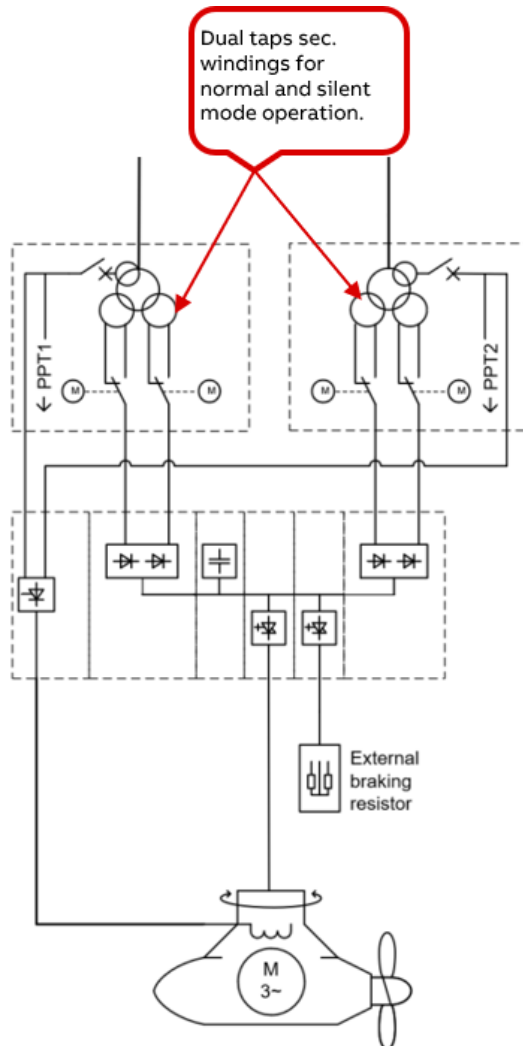


Figure 12:
24-pulse
propulsion
solution with
dual taps on
secondary side
of propulsion
transformers

SELECTING A PROPULSION SYSTEM FOR ARCTIC LNG TRANSPORTATION

Icebreaking projects vary greatly by environmental requirements and operational demands. When investigating alternative propulsion systems for an LNG ship project, the fleet's total operation should be considered. Naturally, the performance of an individual ship in specific ice conditions is the basis for any evaluations, but it is recommended to include the following topics as part of a fleet evaluation:

- Icebreaker assistance requirements
- Icebreaker availability
- Operational aspects of low-load operation of the machinery
- Hull form performance both in open water and ice conditions

When investigating what type of power plant and propulsion system to choose, the following should also be considered:

Maneuvering in ice

The maneuverability of vessels with azimuthing propulsion is superior to normal rudder and shaftline vessels. This makes tactical ice navigation more efficient.

Harbour maneuvering in ice-covered waters

Azimuth thrust can be used to clear ice between a pier and the ship. This will result in considerably faster berthing. The benefit can be used for increased transportation capacity per vessel or fuel savings due to slower vessel speed during voyages.

Ice management

There are several possibilities for ice management tasks that can be efficiently performed using the wake of azimuth propulsion, for example:

- Clearing of hummocked ice and breaking of ice ridges
- Ability to operate autonomously by making free a beset vessel without external icebreaker assistance by manipulating the thruster-vector thrust
- Breaking and clearing moving pack ice
- Clearing ice channel behind vessel
- Clearing ice from around hull of the vessel
- Clearing ice from between the vessel and a secondary object
- Widening ice channel behind the vessel

Auxiliary icebreakers

Vessels with azimuth thrusters have proven to navigate independently in difficult ice conditions. This leads to the need for fewer or no auxiliary icebreakers. This results in savings in both investment and operational costs of the fleet. The

use of auxiliary icebreakers should be evaluated against the project operational requirements. Feasibility varies between projects. As an example, if port operations are abundant, and the port facility is by nature collecting difficult ice concentrations, a port icebreaker should be considered. In some cases, however, overall CAPEX/OPEX are optimized by purpose-built vessels able to operate independently in all conditions without icebreakers. It should be noted that for vessels with beams over 40 meters, two icebreakers per vessel are typically required for successful assistance. The daily rate for one medium-size icebreaker can be in the magnitude of USD 30,000 per day, meaning investment in a more ice-capable vessel design can be well justified.

Fuel consumption and exhaust emissions

Due to a lower installed power requirement, the fuel consumption of an azimuth thruster vessel is considerably lower than shaft-line propulsion. Depending on the vessel design and propulsion configuration, the fuel consumption with podded drive can be reduced up to 20 percent. With the electric power-plant principle, the diesel engine loading can be kept closer to optimum. This will lead to reduced specific fuel consumption of the diesel engines, which yields lower fuel consumption and lower emissions overall.

Cargo capacity per vessel

Podded propulsion and its auxiliary equipment arrangement have a smaller footprint than a shaft-line vessel. Therefore, more cargo capacity can be designed into the same size of ship, which increases transportation capacity and/or gives the possibility to reduce speed during voyages.

Ship hull form performance

Icebreakers have traditionally been designed to strike a balance between icebreaking performance and open-water seakeeping ability, i.e., the time used for open-water operations versus that used in icebreaking. As an example, some icebreakers designed for solely Baltic icebreaking are unable to safely transit sea voyages even in moderate wind conditions of over 15m/s. On the other side of the spectrum are multipurpose icebreakers designed to mostly operate in open water but with limited icebreaking capability. Azimuth propulsion thrust gives vessel designers the possibility to incorporate both operational requirements i.e., excellent icebreaking and seakeeping in open water. This is the DAS principle described in Section 2.1 above.

Efficiency and seaworthiness in open water

With azimuth thrusters and the DAS concept the bow shape can be optimized for open-water operation leading to reduced resistance and improved seakeeping

characteristics. An extreme icebreaking bow or long bow with a small stem angle can be highly questionable in open-water conditions due to slamming loads in heavy weather. The benefit of reduced resistance can be used for a higher open-water speed or reduced fuel consumption.

When designing the specific icebreaking capacity of a ship the following additional criteria should be considered:

- Operational profile (how much of the time will the vessel operate in ice and in open-water transits)
- Prevailing ice conditions
- Maximum ice conditions to be reasonably expected
- Cargo-carrying capacity and vessel dimensions
- Geographical and climate requirements, such as Polar Service Temperature
- Maritime Treaty Obligations like Polar Code, ISM, and SOLAS
- Classification society selection and requirements

Power requirement

Due to more efficient ice and open-water hull characteristics of DAS with azimuth propulsion, the comparative power requirement in some cases can be 50 percent of a shaftline vessel. This will lead to considerable cost and space savings in machinery as total installed power and auxiliaries are significantly reduced.

Ice ridge and rubble performance

Ice ridge and rubble penetration capacity is far better with the DAS principle than with traditional bow-first operation since the ice resistance can be up to 50 percent less when going astern. Penetrating hummocks and ridges in difficult

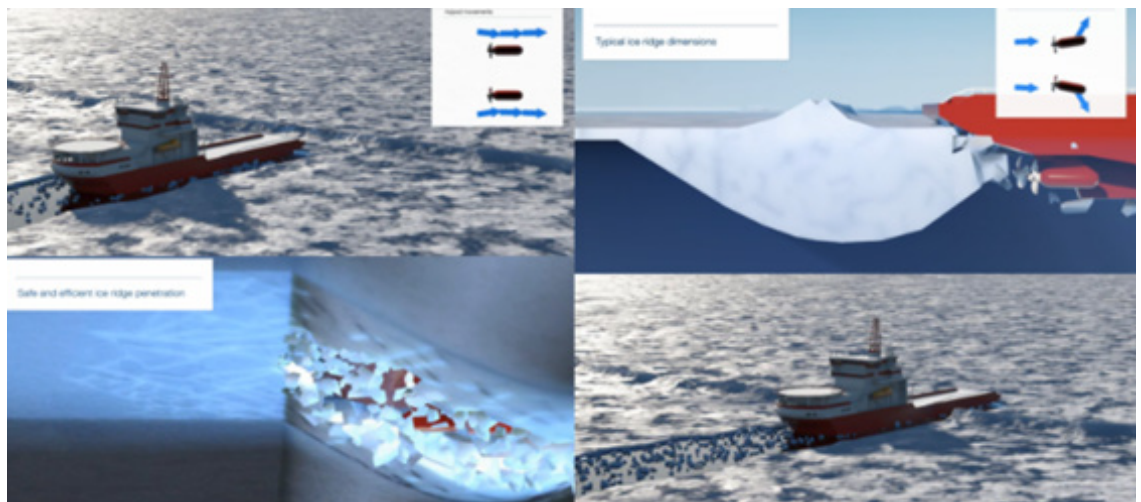


Figure 13: Stern-first operation through an ice ridge

ice conditions pose great demands for ship design. When a vessel is breaking ice, it uses both the hull shape and thrust to force the ice. When the ridge formation resistance exceeds the power output, the vessels stop. If the ridge must be forced, a traditional icebreaker reverses to gain a path to accelerate in and then rams the ice features bow first. This operation is violent and offers only one option for the bow shape. A DAS vessel enters the ridge aft first and manipulates the pods repeatedly. In this way it enters the ridge without the need for ramming, as in Figure 13.

Novel fuels and carbon emission targets

Many shipowners have decided to build new vessels with dual-fuel capability, and this is of course a natural choice for icebreaking LNG carriers. The combination of marine diesel and LNG brings together long endurance and low emissions. However, LNG dual-fuel engines produce methane and there can be methane slip. This occurs mostly in high dynamic load variations of power, of which icebreaking is a good example. A load bank or battery energy storage can greatly reduce methane slip and enhance icebreaking capability.

DEVELOPMENT OF ELECTRIC SYSTEMS IN ICEBREAKING SHIPS

Electricity was first introduced in ships back in the 1880s to illuminate light bulbs with DC current. By the end of the 19th century, advantages in research and innovation of AC motors, transformers, and diesel engines paved the way for modern diesel electric power plants. After the development of power electronics technologies in the 1980s, efficient variable-speed control of electric motors became possible and propulsion systems were redefined. An electric power plant in ships offers flexibility for power management, redundancy in terms of connected power sources, higher efficiency (reduced fuel consumption), and enhanced reliability, especially in harsh conditions. Electric power plants are always scalable according to vessel size and facilitate compliance with emission standards. Modern green technologies like fuel cells and batteries can easily be integrated.

Nowadays, two main categories of powerplant and propulsion system are prominent in the marine industry. Onboard AC grid systems typically include diesel gensets as the main power sources, switchboards for safe and protected power distribution using breakers, isolators and relays, and converters for power consumption and speed control of the main propulsion thrusters. There are also propulsion transformers (depending on converter configuration/type), some smaller machines (Direct Online (DOL), soft starter or Variable Frequency Drive (VFD)-controlled), as well as distribution transformers for auxiliaries onboard. The system frequency is fixed depending on the speed of the main engines,

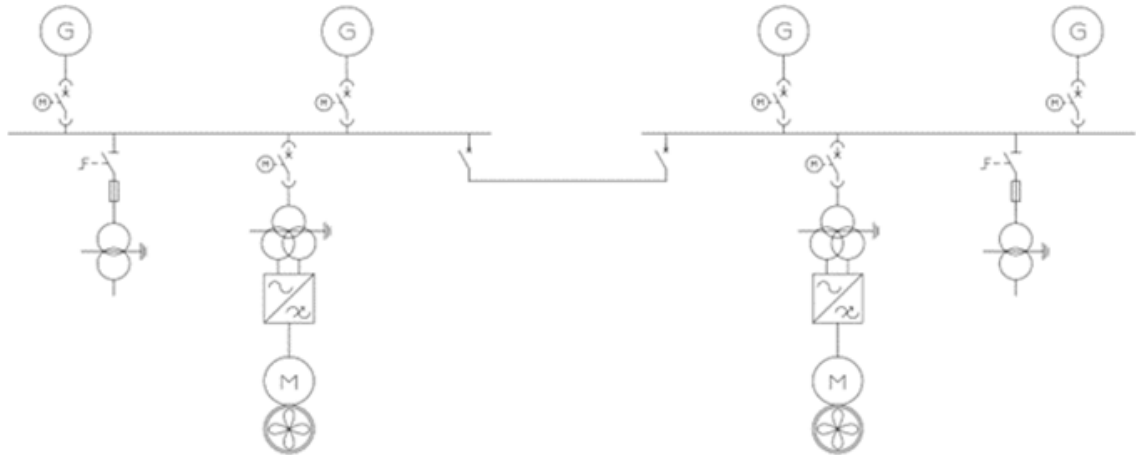


Figure 14: An example of simplified AC power plant and propulsion system

either at 50Hz or 60Hz. A typical example of an AC grid is shown in Figure 14. In earlier electrical system projects, AC-AC drives were commonly used; the so called cyclo-converter technique. The development in power semiconductors and switches made more precise frequency control possible. The first ABB Azipod units were fitted with cyclo-converter drives. Starting with the 70,000-dwt twin-podded Arctic tankers, all icebreaking vessels have since been equipped with modern Voltage Source Inverter (VSI) drives.

The VSI first converts the input AC to DC and then back again to the desired AC frequency using controllable power switches. This system has higher efficiency, higher power factor and consequently requires smaller and cheaper generators. Depending on the size of propulsion load, there are low-voltage VFDs, which operate at 690Vac for load up to 6MW, and medium-voltage VFDs with output voltage typically around 3,000Vac for load of greater than 5MW. The converter in its simplest form consists of six full wave diode bridges (rectifier), which convert AC into constant DC voltage. This is called a six-pulse drive as the current is drawn in six different pulses from the AC input side. In a similar manner, a 12-pulse converter consists of 12 full wave diode bridges, as shown in Figure 15. Frequency drives are the nonlinear loads and contribute to the harmonic

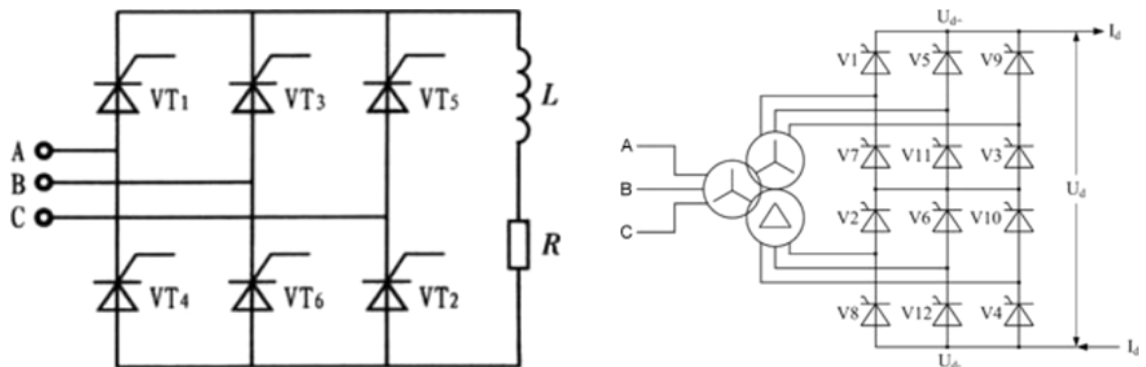


Figure 15: Six-pulse AC-DC rectifier (left) and 12-pulse AC-DC rectifier (right)

content in the AC side of distribution by drawing irregular current causing the fundamental voltage to be superimposed with harmonics (most pronounced 3rd, 5th, 7th, 11th, 13th). This results in distorted sinewave. Excessive harmonics may cause flicker, overheating in electrical machines, unwanted trips, and other problems. Total harmonic distortion level can be reduced by increasing the pulse number of the converters or using filters on the network side.

Recently, ABB's Onboard DC Grid system has been successfully installed on icebreaking vessels. This is a novel electric power distribution concept that, while utilizing well-proven AC generators and motors, opens new opportunities for efficiency improvements, as well as fuel and space savings. Enhanced efficiency is gained by no longer being locked to a specific frequency – usually 50Hz or 60Hz on ships. This also allows the use of variable-speed gensets to optimize engine specific fuel oil consumption (SFOC) according to each load situation. When the load is reduced, the engine speed also decreases, resulting in higher fuel efficiency (Kim K et al, 2018).

There are several ways to configure the Onboard DC Grid, from a multi-drive approach to a fully distributed system. A common feature is that the concept omits the main AC switchboard and converter transformers. Instead, all generated electric power is fed via rectifiers into a common DC-grid that distributes electrical energy to the consumers. Each main AC consumer is then fed by a separate inverter unit. In the system, the connected drive modules/ cabinets are water-cooled with a closed-loop cooling circuit. In a centralized Onboard DC Grid, all the rectifiers and inverter units are placed in one line-up sharing common liquid cooling unit(s) and cabinets for control equipment. The drive line-up can be arranged in various shapes as per room layout/ requirements. For AC auxiliary consumers onboard, off-grid converters together with distribution transformers are used to create the AC network. System-level efficiency from generator to propeller is typically higher compared with an AC solution for similar set-ups.

Furthermore, integration of DC-based energy storage devices and fuel cells to Onboard DC Grid is more efficient and simpler compared to an AC system. For example, a battery or super-capacitor can be connected to a DC-link either directly or via a converter, while the fuel cell always requires a converter from a controllability perspective. These energy-storage media can be used for a wide variety of functions, such as load leveling, peak power, and zero-emissions operation.

In general, an Onboard DC Grid system is the optimal choice when a compact solution is required where most of the consumers are fed by converters.

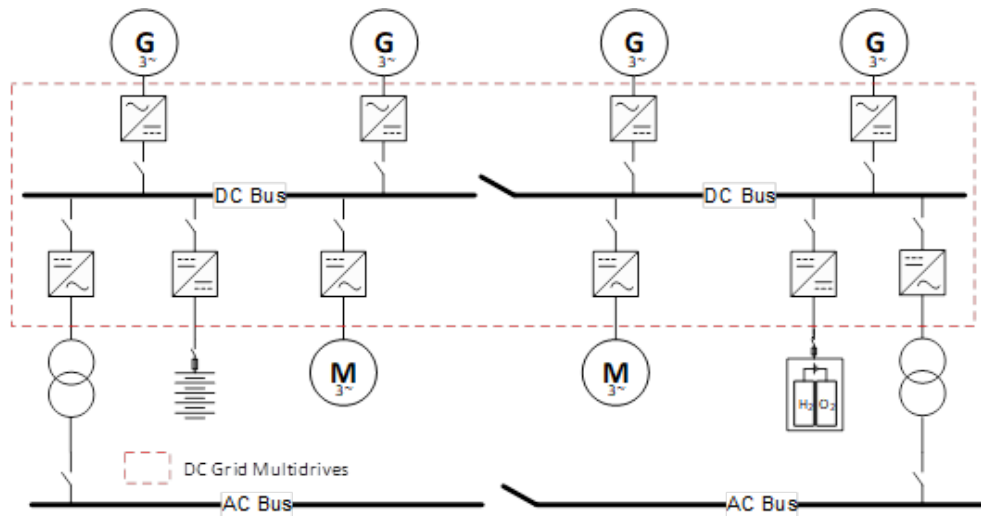


Figure 16: Single-line diagram of Onboard DC Grid

The solution also offers smaller electrical rooms and reduced ventilation requirements and cabling versus a low-voltage AC system. A single-line schematic of the Onboard DC Grid is shown in Figure 16.

Based on existing technology, Onboard DC Grid allows power distribution typically at voltage levels close to 1,000Vdc. Therefore, the solution is not suitable for large power systems involving medium to high voltage levels while aiming for variable speed operation of main engines. In such cases, ABB's Dynamic AC system is available, enabling power plants to operate at variable frequency. This solution allows existing AC equipment, but with special design considerations for variable frequency operation (Kanerva et al, 2020). For consumers onboard that require fixed-frequency power supply, a separate distribution network can be created using island converters. The layout of a

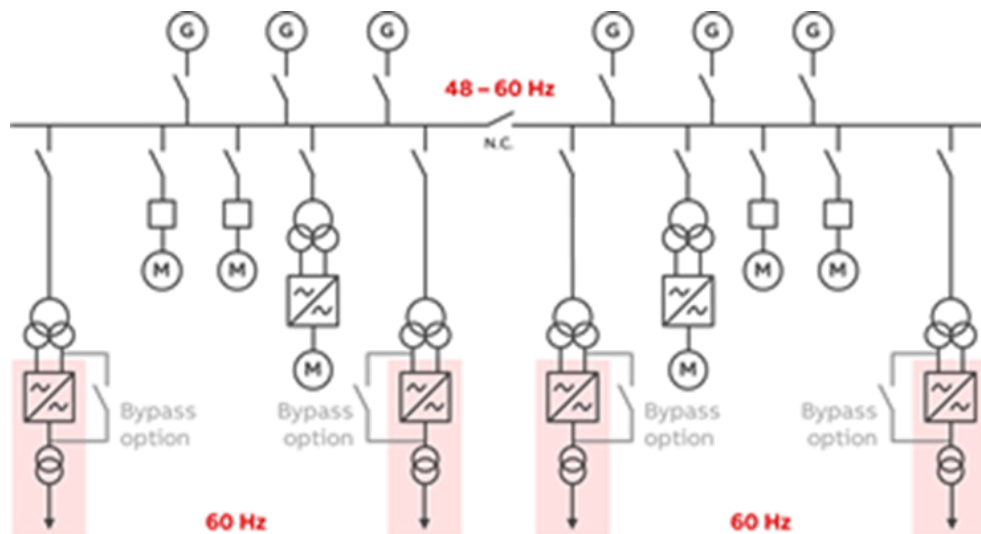


Figure 17: Single-line diagram of Dynamic AC system

Dynamic AC system is otherwise like a typical AC power plant, see Figure 17. For icebreaking LNG carriers, dual-fuel, Electric+ (DFE+) is the favored propulsion concept using dynamic AC power distribution with improved and optimized power and energy management control systems as the basis to reduce carbon footprint and fuel costs, as well as to increase operational flexibility. With variable-speed control, and load leveling using energy-storage devices, the solution can be used to optimize the dual-fuel main engine strategy. Dual-fuel engines can use cleaner fuel and provide flexibility to switch to conventional fuels when required. The concept is well aligned with the progressive regulations on emissions (CII and EEDI) and capable of maintaining efficiency throughout the speed range. A further improvement in efficiency can be achieved by using permanent magnet motors, and Azipod units as main propulsors.

ENERGY STORAGE SYSTEMS (ESS) IN ICEBREAKERS

In the early days, icebreakers were steam powered. The first diesel-electric icebreakers were introduced in 1933, although diesel-electric propulsion remained rare outside the icebreaking sphere for decades. However, with the passing of years, the diesel-electric powertrain has gained momentum. It offers many advantages over traditional mechanical diesel shaftline propulsion, including enhanced power management at speed and more reliable dynamic power handling. With the advent of onboard ESS, yet another major milestone has been reached in operational safety and improved power management.

Onboard ESS are usually designed with an approximate operational profile of the newbuild vessel as a planning basis. The battery dimensioning criteria varies from one vessel to another. The requirements set for the ESS can vary from relatively modest spinning reserve to a wholly battery-operated zero-emission mode.

Icebreaker ESS case study: Polaris

The Polaris (Figure 18) is the world's first LNG-powered icebreaker. Owned and operated by Finnish state-owned company Arctia Ltd, it was built primarily for line icebreaking services in the Baltic Sea, in addition to oil-spill response operations. The vessel is equipped with four Low Pressure Dual Fuel (LPDF) engine-driven gensets, with an auxiliary engine for producing electricity when the vessel is in port. The electrical power plant's combined output is 22.5MW. The propulsion system consists of three ABB Azipod units, two 6.5MW stern units and one 6MW bow unit.

Vessel-based power systems often come with highly dynamic load profiles, and this is especially true for icebreakers. Traditionally, dynamic load is met by oversized generators running on fossil fuel, which leads to inefficient operation during periods of low demand.



Figure 18: The icebreaker Polaris

The Polaris has been operating for several winter seasons in the Bay of Bothnia. ABB conducted a study investigating how an ESS could improve the environmental footprint of the vessel while improving fuel efficiency and dynamic response. Key findings include the following simulation results for LNG and diesel operation, assuming an onboard hybrid battery system:

- For LNG: 38 percent CH₄ reduction, 16 percent less fuel consumption, and 46 percent reduction in engine hours
- For diesel: 10 percent reduction in fuel consumption and 36 percent reduction of engine hours

Scope of the study

Installation of an ESS could contribute to reducing total GHG emissions, primarily CH₄, in addition to reducing fuel consumption and improving the dynamic performance of the system. In this project, a MATLAB file was programmed to investigate the effect of installing an ESS onboard the Polaris, based on real-life operational data from the vessel. The overall objective was to simulate a battery system that can absorb large load variations and hence improve fuel efficiency and ramping capability.

Operational conditions

The Polaris is designed for four consecutive weeks at sea, although the normal crew-change interval is 10 days. During operations in the Bay of Bothnia, the ship was equipped with an ABB Ice Load measuring system to determine load levels. From January 2017 to May 2019, around 7,400 hours (about 10 months) were recorded, and about 4,000 hours (about five and a half months) of operation observed. For the case study, load measurements for two days have been extracted: one day for diesel operation and one day for gas operation.

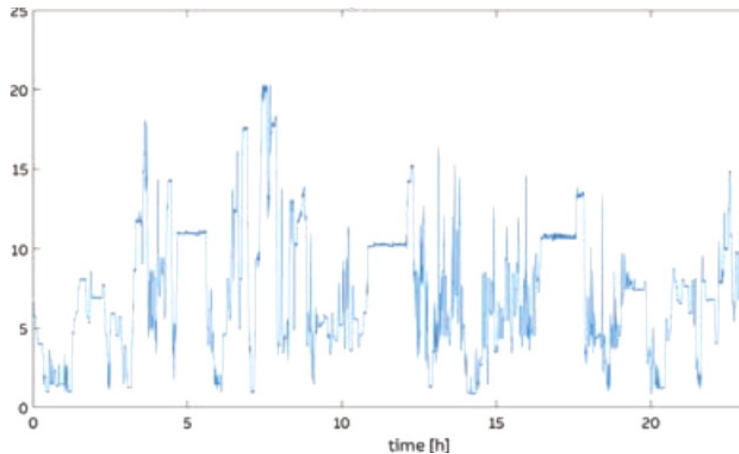


Figure 19:
Polaris load
profile, 9 Feb 2018

Comparing the ship log and the load profile the following conclusions can be made:

- The generators are mainly loaded by the pod propulsion motors (as expected) with approximately 200kW vessel hotel load (pumps, fans, lightning, HVAC, etc.)
- Large load fluctuations during icebreaking
- Large increase in power consumption during assistance

On 9 February 2018, the Polaris was mainly fueled by LNG. Only 23 hours of operation were available for the day, as presented in Figure 19. For LNG operation the engines do not allow for fast load changes and have an even slower response compared to diesel. Consequently, the performance of the vessel is slower when running on LNG versus diesel.

Modelling and simulating the system and preconditions

The hybrid power system in the model consists of four main generators (the auxiliary generator is excluded), one battery and one main system load, as shown in Figure 20. The battery is charged from the generators since the vessel usually does not operate close to a harbor. It is worth noting that the model is simplified and cannot embody the full complexity of the power system onboard the Polaris.

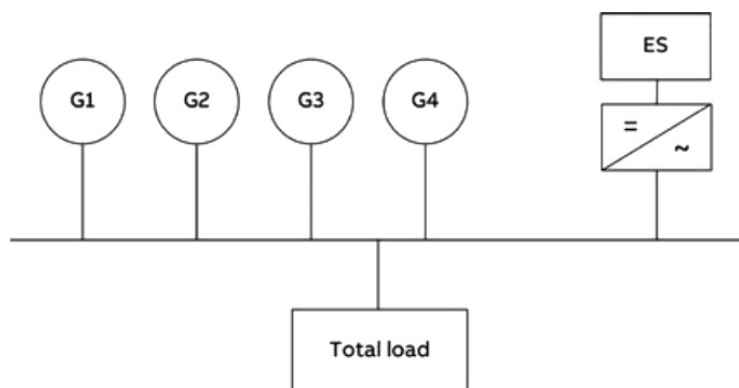


Figure 20: Polaris
machinery system

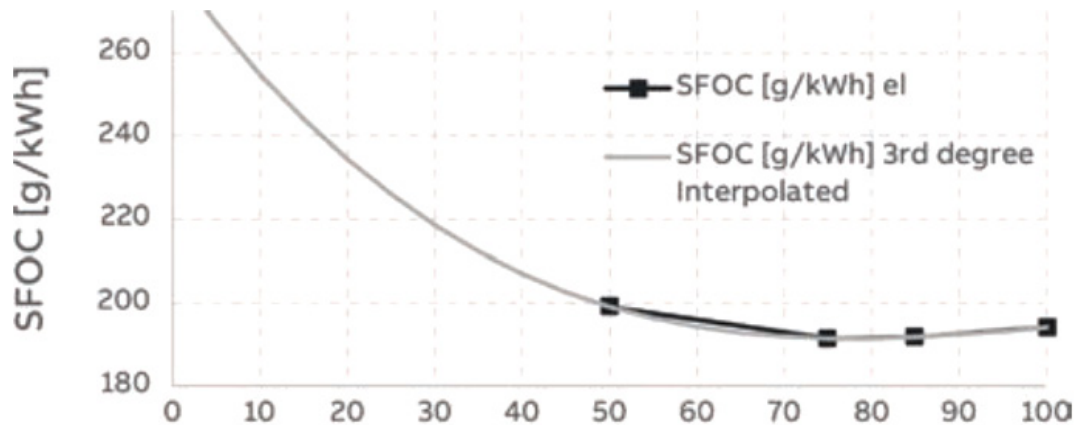


Figure 21: SFOC in diesel mode

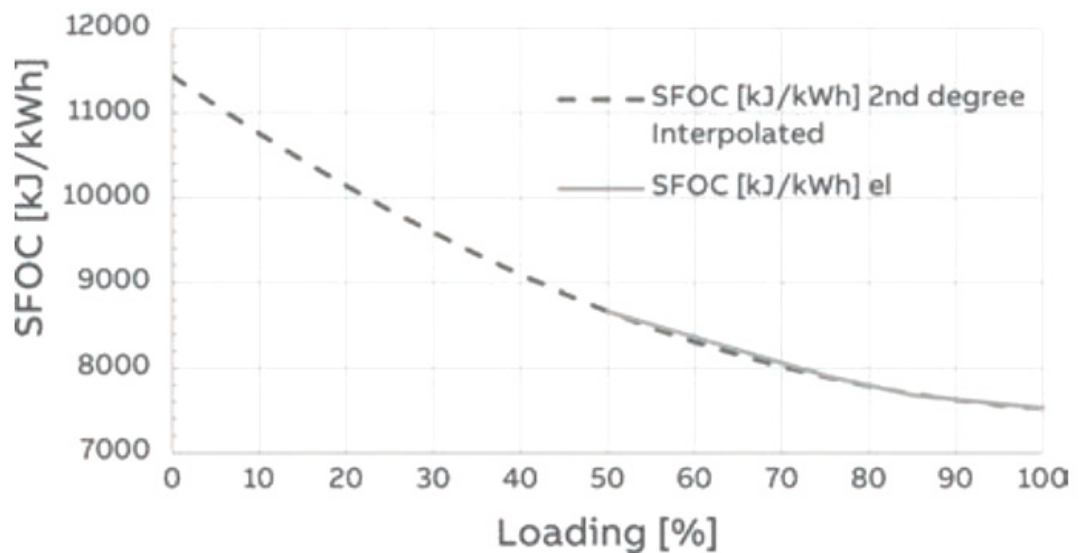


Figure 22: SFOC in LNG mode

The gensets are based on characteristics of dual-fuel engines. They can be operated in gas mode or in diesel mode, and the fuel consumption is assumed to follow the SFOC curves shown in Figures 21 and 22 for diesel and LNG, respectively. The Figures are adjusted for genset efficiency and interpolated for loading lower than 50 percent. Both Figures show that fuel consumption increases substantially during low load.

In load dynamics, a common belief is that high ramp rates on generator loading negatively impacts fuel efficiency and emissions. Accelerating the engines occurs with lower efficiency and leads to incomplete combustion. Owing to the paucity of independent operational analytics data to quantify this, data for this study was based on ABB internal estimates and experience. This simulation was premised on the assumption there is a linear correlation between load fluctuations, fuel efficiency and CH₄ emissions, resulting in an added penalty for dP/dt on both fuel consumption and CH₄ emissions. In real operational

conditions the CH₄ emission may not be linear in respect of power. Maximum limitations were set for load gradient 0.16 percent/s with corresponding penalties of 10 percent fuel increase and 20 percent CH₄ increase.

Selection of ESS

The analysis was based on a JP3 battery cell, and the design of the controller on a fixed energy-storage dimension. The size was selected by iteration to simulate the dynamic behavior of the gensets. With the assumption of 95 State of Charge (SOC), battery capacity was concluded to be 4.5MWh for these simulations.

Results and discussion

The simulation resulted in the following savings for the two respective days:

LNG operation:

- CH₄ reduction: 38 percent
- Fuel reduction: 16 percent
- Engine hour reduction: 46 percent

Diesel operation:

- Engine hour reduction: 36 percent
- Fuel reduction: 10 percent

The simulation of the power system shows how an ESS can contribute to supply power peaks during periods of high demand, as well as absorbing load fluctuations. These aspects appear to pay off especially in terms of reduced CH₄ emissions. The large decrease in the number of engine hours can also be seen as enabling direct savings in terms of maintenance costs. Installation of energy storage can also improve the dynamic performance of the system, which may have great significance for an icebreaker. Exact quantification of the performance improvement is excluded from the analysis, as slow engine speed already limits the load profile used in the simulation. Energy storage can nevertheless provide instantaneous power and hence also provide ramps where the engines fall short.

Simulation shows reduction potential for both fuel consumption and CH₄ emissions when gensets are operating more efficiently, and when the dynamics of the load are decreased. As already stated, high ramp rates on generator loading are known to affect fuel efficiency negatively, but there is limited data to quantify this. It may therefore be reasonable to believe that savings potential may be higher or lower in the transformation to a more stable load profile. This could be the subject of further study.

Spinning reserve

As the minimum SOC is set to 20 percent of installed capacity, there will always be a certain amount of energy available in case of a generation outage. The range of SOC can consequently be adjusted accordingly. This contributes to increasing redundancy and can allow generators to work at optimum power output, without the need to keep additional genset capacity for spinning reserves.

The impact of battery choice

A larger battery could provide more savings for two reasons: a more efficient energy management system and lower losses due to lower C-rate. A battery cell with enhanced cycle life, charge and discharge capability could enable a smaller battery. Depending on the choice of battery and the control strategy, an ESS could be optimized further in terms of sizing, as a trade-off between cost and performance.

Conclusions

This article summarizes the recent work and studies on icebreaking propulsion technology at ABB, which have been published in various international Arctic conferences and events [1], [2], [3], [4], and [5].

First, we reviewed the history of icebreaking vessels and how the DAS concept revolutionized this domain, enabling ships to operate without dedicated icebreaker support. Next we investigated the evaluation criteria for selecting the optimal propulsion system for LNG carriers, as well mitigation of Underwater Radiated Noise (URN) from electric propulsion systems. In the last part of the article we discussed the development of electric powerplants for modern icebreakers, including future-proof sustainable solutions such as ABB Onboard DC Grid, a modular power system platform that enables simple, flexible, and functional integration of energy sources and loads, as well as adoption of energy storage systems (ESS).

The development of the propulsion of icebreakers has taken place step by step during the last 60 years. As technology has advanced, it has made it possible to operate in increasingly harsh environments. At the same time, the development of podded propulsion has enabled the change in how icebreakers are operated in ice-covered waters.

Acknowledgements

Acknowledgements to our colleagues in ABB Marine and Ports for their support and contribution to the work. We also thank our valued customers for the good co-operation in various projects. •

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Command and control

In contrast to a traditional ship's propeller, ABB's revolutionary marine propulsor, the ABB Dynafin™, has multiple moving parts. To obtain optimal performance, these parts must be precisely orchestrated – even under the toughest oceanic conditions. For this task, a sophisticated control system is required.

—
Ali Pekcan,
ABB BL Propulsion,
Helsinki,
Finland

ABB Dynafin is a revolutionary marine propulsion system designed to extend the abilities of cycloidal-type propulsor concepts by introducing individual blade control with permanent magnet motors. The concept combines propulsion and steering, with blade trajectories inspired by the movement of a whale's tail. Due to its effective pitch angle change of each blade, ABB Dynafin delivers much better hydrodynamic efficiency and maneuverability than traditional screw propellers.

It is essential that ABB Dynafin's propulsion and steering elements are very carefully controlled so they follow exactly the required trajectories, even in very dynamic environments. For this, a precise control strategy is required.

Control via a “digital propeller design”

ABB Dynafin has two major parts: a main propulsion motor and a rotating lower part with blade motors (Figure 1). The main motor, which is fixed to the vessel hull, rotates the lower part and thus delivers the main thrust. Each blade on the lower part is driven by an individual blade motor, allowing the setting of the exact pitch angle required for adjusting the thrust magnitude and direction. The blade drives are powered through a slip ring unit, enabling the free rotation of the main propulsion motor. The slip ring also provides the physical link needed to communicate with the blade drive control units.

The principal control commands in a typical vessel are the rudder angle and propeller speed. In ABB Dynafin control, the captain can give the desired thrust magnitude and direction from the bridge's remote control via common control interfaces (ABB Dynafin replicates the Azipod® experience in terms

of compatibility with existing systems and extending and improving user experiences). This ability to effect a “digital propeller design” broadens the availability of standard modes of ship operation. For example, in addition to the standard modes – such as bollard pull, dynamic positioning, sea transit and maneuvering modes – new modes and trajectories can be created and supplied since each blade can be controlled individually. Each mode is implemented by optimizing the control parameters for that mode, resulting in different blade pitch angle trajectories and main wheel behavior. Behind this simple-sounding steering approach lies a sophisticated control system.

Figure 1: Thrust conversion: required thrust magnitude and direction is converted to motion control parameters



The ABB Dynafin control system

On a high level, the ABB Dynafin control system translates the speed and heading that the captain requests into an appropriate main wheel speed and a pitch angle for each blade. This part of the control – the thrust conversion module – takes place in the main control unit. The thrust conversion module then supplies the speed reference to the main propulsion drive and provides each blade drive control unit with the motion control parameters needed to achieve the required blade trajectory.

The low-level motion control on each blade control unit is designed to implement the trajectories defined by the motion control parameters designated by the thrust conversion. Motion control parameters define trajectories that each blade will follow during one rotation of the main wheel. These parameters are the eccentricity point (ECC), ie, the point to which all blades are perpendicular; the main wheel position and rotation speed; and the yaw angle. Yaw defines the rotation of the thrust vector effected by rotating the eccentricity point (Figure 1 and 2). The eccentricity parameter is used to calculate the pitch angle of the blades. To create a whale tail motion, the blades follow a trochoidal path where the eccentricity point is outside of the circumference of the rolling circle. In the case of $ECC = 0$, the blades will be rotating along the circumference with a pitch angle following the circle.

The main wheel speed reference from the thrust conversion is sent to the main propulsion drive. The actual speed and position of the main wheel are then measured by the main wheel encoder and sent to the main control unit. Tests have proven that the ABB Dynafin control algorithm achieves blade-tracking with the required precision.

The main wheel encoder measurements are also sent to the blade control units in each blade module so they can precisely maintain their position during the main wheel's rotation. As mentioned, blade motion control is implemented in the blade control units separately for each blade drive. This separation allows fast communication with each drive and reduces the computational load on the main control unit. The low-level control executes in sub-millisecond cycle times. The blade position and angular speed are measured by encoders on the blades and sent directly to the blade control units. It is important to note that the number of blades has no effect on the overall control system and the control can be implemented in a modular way for a higher or lower number of blades.

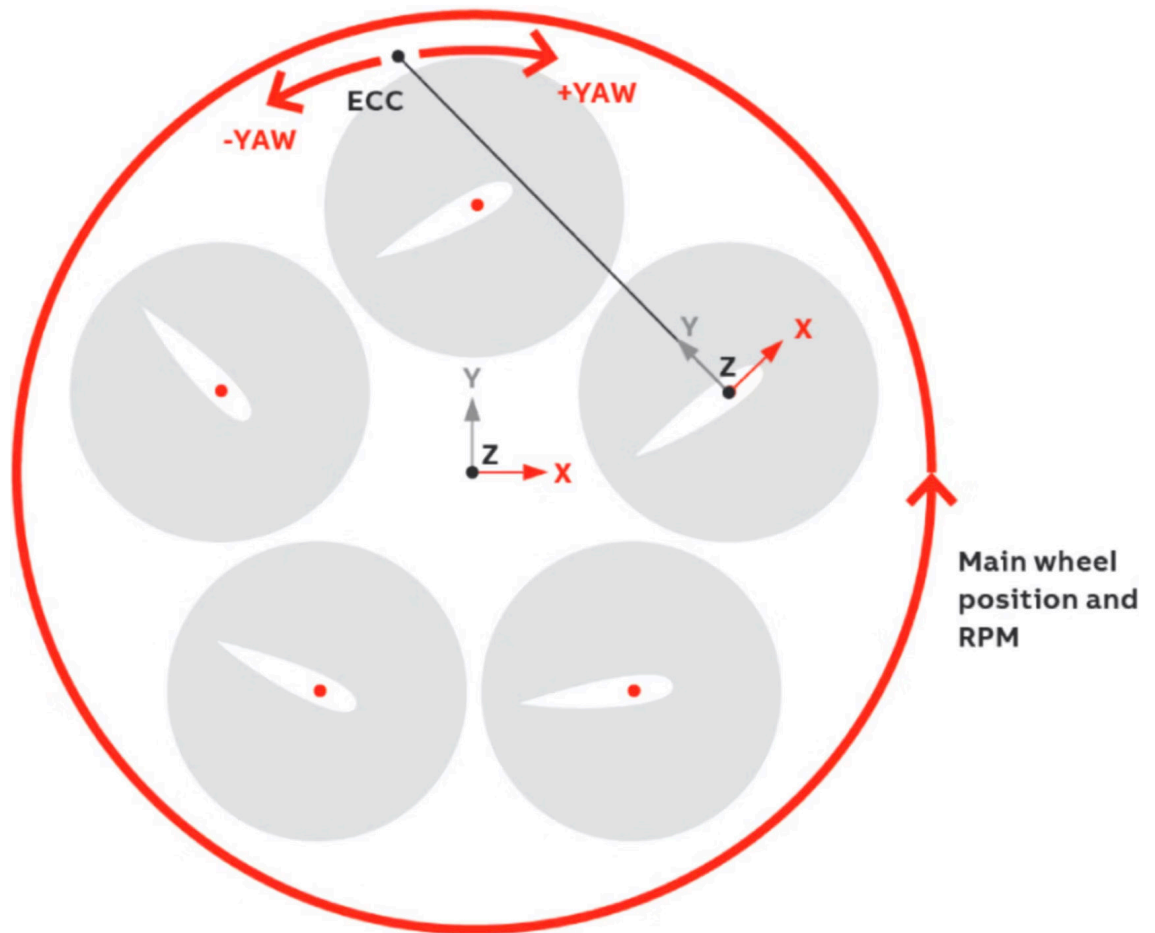


Figure 2:
Motion control
parameters:
ECC, yaw angle,
and main wheel
position and RPM

Driving force challenges

The low-level control is based on the blade pitch function in the form of a mathematical model and on knowledge of disturbances (hydrodynamic loads, frictional loads, acceleration changes, etc.). To achieve high performance, the ABB Dynafin propulsion system must follow the predefined blade pitch function with high accuracy. However, several challenges arise when attempting to control blade motion:

- The blade's pivot point is typically not aligned with its principal axis of inertia. This misalignment induces a centrifugal torque during wheel rotation, complicating blade control.
- Many blade pitch functions aimed at achieving high efficiency require both high acceleration and rapid acceleration changes for blade motion, which pose difficulties for the blade motors and drives to handle effectively.
- Certain blade pitch functions involve changes in blade rotational direction, necessitating blade motors to compensate for frictional torque.
- Hydrodynamic loads applied to the blades introduce tracking errors in blade pitch functions. Failure to accurately follow specified blade pitch functions can degrade propeller performance, increase torque on wheel motors and reduce overall efficiency.

The ABB Dynafin control algorithms are designed to cope with these challenges.

The torque reference from the blade control is generated for each blade drive using a feed-forward loop (Figure 3). Motion control parameters (RPM, ECC, yaw and main wheel position) are input to the blade motion control block, where a position reference is calculated as well as the necessary feed-forward model outputs for disturbance compensation. The cascaded blade-drive control block calculates the final torque required for high-precision tracking of the blade motion. Employing this model-based torque feed-forward compensation provides an accurate torque value to compensate for centrifugal torque, acceleration torque, friction torque and hydrodynamic torque, all of which are difficult for the feedback control. Finally, control software handles the limits and transition of trajectories in the final stage for smooth transitions and affordable torque profiles.

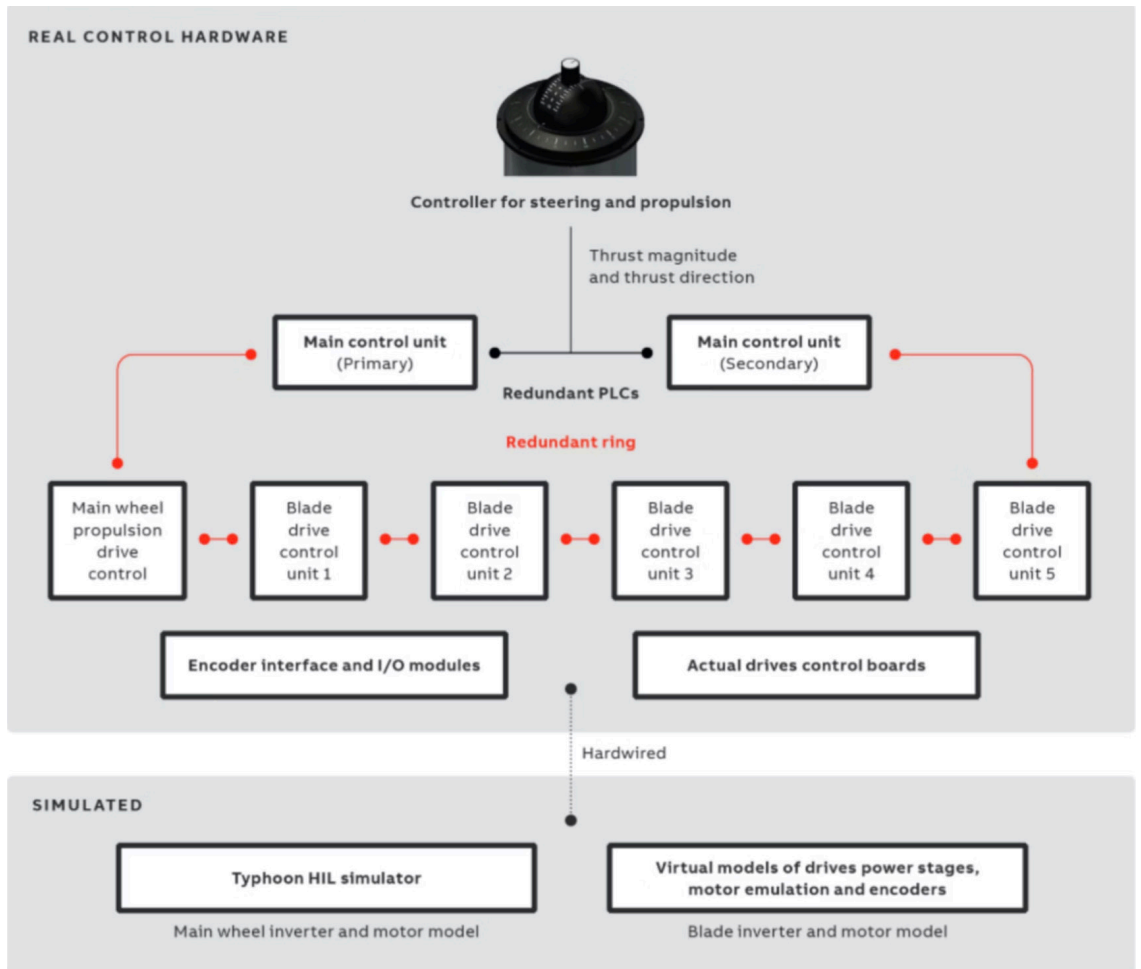


Figure 3: HIL setup. HIL testing connects actual product hardware to simulated load and operating conditions

Testing with hardware

The ABB Dynafin team has developed a hardware-in-the-loop (HIL) test platform to verify control performance, requirements analysis, failure modes and effects analysis (FMEA), and hardware suitability for the final product.

In HIL testing, the system under test is connected to a simulation or model of its environment. The system's response to various inputs is then measured and compared to expected results. HIL simulation allows control system evaluation in a controlled environment before deployment in the actual marine environment.

In the case of ABB Dynafin, HIL testing involves connecting all the physical components from the control network topology – such as the main control unit, blade control units, interface cards and I/O modules – to a simulation that mimics the load conditions and various operating scenarios. The motor suppliers provide motor model parameters. Hydrodynamic loads are generated

using computational fluid dynamics (CFD) simulations corresponding to the trajectories under test. The power stage of the drives is also modeled.

Initially, a two-blade system was created to verify various aspects of the drives, control units, redundancy schemes, blade tracking, etc. Since the control network topology is now frozen, the HIL test system will be expanded to a five-blade setup for the second stage of the testing.

Redundancy and failsafe

At sea, vessel reliability and the safety of the crew are of paramount importance. For this reason, the control network topology has been designed to follow standard requirements, ensuring redundancy and high performance. An extensive design FMEA has been carried out for each design component and, according to “single failure criteria”, active components have been duplicated for redundancy. The FMEA outcome shows ABB Dynafin fulfills the rules established by the International Maritime Organization (IMO) and the International Convention for the Safety of Life at Sea (the SOLAS Convention). For example, in the case of a failure, vessel steering is ensured by switching the failed unit to rudder mode, where the main wheel is stopped and all active blades are used as rudders for steering.

ABB Dynafin provides all-round best-in-class performance, efficiency, safety and reliability – all enabled by a sophisticated control system that overcomes the many challenges faced by a marine propulsor composed of multiple moving parts that is exposed to the harsh conditions found at sea. The modular nature of the control system simplifies the extension of ABB Dynafin to cover many more marine applications. •

Cavitation

Several of the articles relating to ABB Dynafin™ mention cavitation and stress its importance in marine design. But what exactly is cavitation and why can it be detrimental to marine systems?

—
Anthony Byatt,
External
contributor

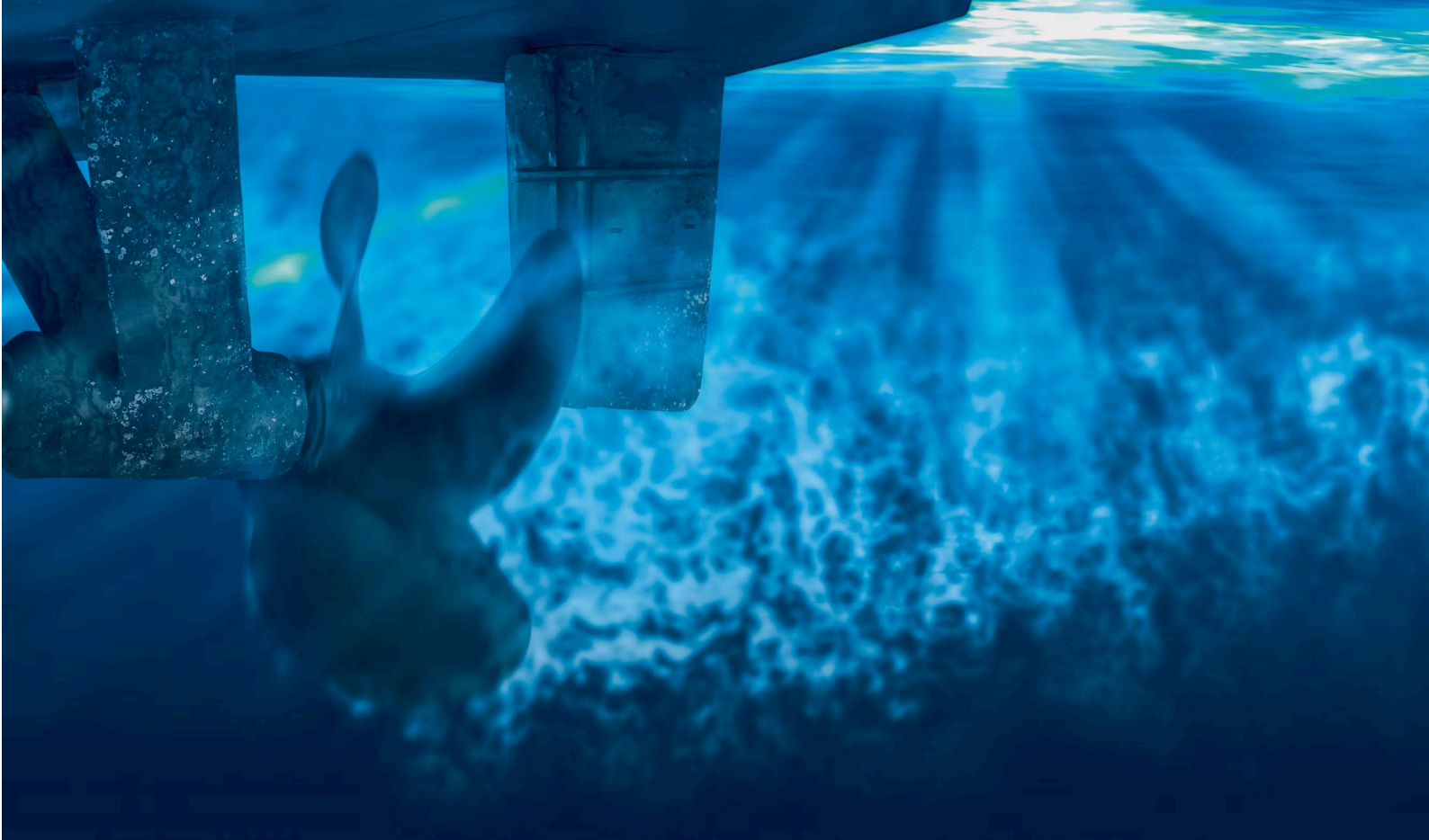
In the realm of fluid dynamics, cavitation is a phenomenon characterized by the formation and implosion of vapor bubbles in a liquid when the local pressure falls below the vapor pressure. This process occurs when a liquid, such as water, experiences a rapid change in pressure, typically in regions of high-velocity or low-pressure gradients. The formation and collapse of these bubbles create intense shock waves that can have significant detrimental effects on ships, particularly on their propellers.

In marine propellers, the bubbles are formed by the creation of low-pressure regions at the back of the blades as they move through the water at high velocity.

Breaking and shaking

Most marine propellers are actually designed to allow cavitation, as it is then possible to reach higher efficiency. Cavitation must, in such cases, appear as a stable sheet, rolling smoothly over the tip of the blade. When cavitation is unstable, erosion can occur: When vapor bubbles collapse near the surface of the propeller blades, they release energy in the form of small, high-velocity jets. These jets can impinge on the material surface with a significant force, causing pitting and erosion. Over time, these effects can degrade the integrity of the propeller blades, leading to reduced performance and increased maintenance costs for vessel operators.

Furthermore, cavitation-induced vibrations can also degrade the structural integrity of the propeller and the rest of the propulsion system. The pressure pulses created by the collapsing vapor bubbles propagate through the surrounding fluid, inducing vibrations in the propeller blades and other components of the propulsion system, leading to fatigue and potential failure



—
Twin propeller
and rudder
of a big ship
underwater

over time. In addition to the pressure pulses, the noise generated by cavitation can also be a concern in terms of its impact on marine life in sensitive areas and on the comfort and safety of the vessel's crew and passengers.

Cavitation mitigation

Engineers employ various materials and design techniques to mitigate the adverse effects of cavitation on propellers. Propeller designs may feature modified blade profiles or cavitation-resistant materials to reduce the likelihood of cavitation and minimize its effects when it does occur. The computational fluid dynamics (CFD) simulations described in ABB Review 03/2024 are a good example of how engineers analyze and optimize propeller designs to minimize cavitation-induced performance losses.

Cavitation is a complex fluid dynamic effect with significant implications for ship propulsion systems. While cavitation can enhance propulsive efficiency under certain conditions, its effects are mostly adverse, in the form of erosion, vibrations and noise, leading to performance and integrity degradation over time. The ABB Dynafin team has invested much time and effort in understanding fully the mechanisms of cavitation and its effects. The knowledge gained informed the advanced design techniques and technologies they used to ensure the optimal performance and longevity of the ABB Dynafin propulsor. •

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This article
was originally
published in ABB
Review 03/2024

Bubbling under

Cavitation and hydrodynamic performance are critical aspects of ABB Dynafin™, ABB's high-efficiency ship propulsion system, that have been investigated at the VTT Technical Research Centre of Finland via computational fluid dynamics (CFD) [1]. These methods deliver insights that lead to improved designs.

—
Ville Viitanen,
Antonio Sánchez-
Caja,
Jussi Martio,
Ilkka Perälä,
VTT Technical
Research Centre
of Finland Ltd.,
Espoo,
Finland

The innovative ABB Dynafin is a marine propulsion system that generates thrust by means of blades that project outward from the bottom of the ship. The blades rotate around their own axis and around the axis of the rotatable wheel upon which they are all mounted. The ABB Dynafin can achieve very high hydrodynamic efficiencies and change thrust direction almost instantaneously, giving far better maneuverability than an azimuthing thruster, where a conventional propeller is rotated about a vertical axis to direct thrust.

Mika Nuutinen,
ABB Marine & Ports,
Helsinki,
Finland

The ABB Dynafin concept is essentially a cycloidal propeller with individually controlled blades following a trochoidal path (Figure 1). (A trochoid is the curve generated by a point on the radius of a circle as the circle rolls on a fixed straight line.) Trochoidal propellers have been studied before, but until now, technology constraints have prevented them from being commercialized and introduced to the market.

Cavitation

Cavitation describes the formation of small vapor-filled cavities, such as bubbles, in a liquid. Cavitation can occur when local static pressure falls below the liquid's vapor pressure. This undesirable phenomenon often causes noise plus propeller erosion and damage.

Accordingly, to gain a detailed understanding of ABB Dynafin's hydrodynamic and cavitation performance in a ship-scale context, the VTT Technical Research Centre of Finland and ABB collaborated on a numerical study to investigate a full-scale trochoidal propeller in wetted and cavitating conditions. The analyses are based on transient viscous-flow CFD simulations using both open-source

Figure 1a: Blade trajectories in propellers, where V_a denotes the advance speed, and V_r the angular speed. Cycloidal low-pitch propeller

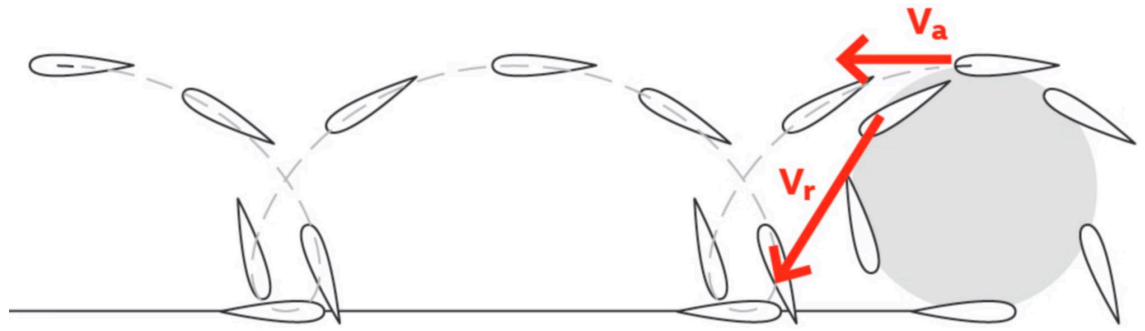
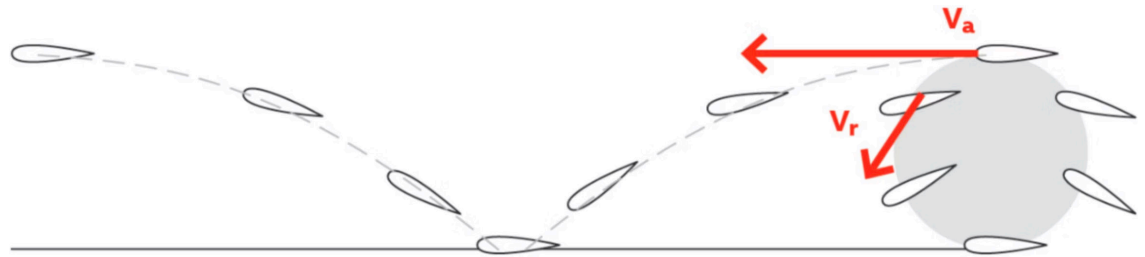


Figure 1b: Blade trajectories in propellers, where V_a denotes the advance speed, and V_r the angular speed. Trochoidal high-pitch propeller



OpenFOAM and the commercial STAR-CCM+ software tools. Cavitation modeling is done using volume-of-fluid (VOF)-based homogeneous multiphase mixture flow models with standard Reynolds-averaged Navier–Stokes (RANS) and hybrid RANS large eddy simulation (RANS-LES) turbulence modeling approaches.

Flow based on Navier-Stokes equations

The homogeneous flow model used is based on the Navier-Stokes equations for two incompressible, isothermal and immiscible fluids with phase change accounted for by mass-transfer models. Liquid flows around an ABB Dynafin blade are turbulent and this situation has to be taken into account. For this task, the popular $k - \omega$ shear stress transport (SST) base turbulence model is used [2]. The study also uses a scale-adaptive simulation (SAS), which is a hybrid RANS-LES turbulence modeling method that functions with the SST model [4]. The SAS method has the advantage that it adjusts the turbulent length scale based on local flow.

Mass transfer models

Cavitation is modeled using a mass transport equation for the liquid phase volume fraction. Different mass transfer models can be employed to account for local effects in the flow. Several cavitation mass-transfer models have been developed and typically, the mass-transfer rate is proportional to a pressure difference from saturation pressure. A number of mass-transfer models are available in OpenFOAM and STAR-CCM+ for homogeneous mixture modeling. For the present work, the model described in [5] is used with both solvers.

The flow equations are discretized with a collocated finite volume method. Time-accurate simulations are carried out to resolve the flow field. In the case of OpenFOAM simulations, a first-order implicit scheme is applied for time derivatives, with a time step determined by a maximum Courant number of 1 in the vicinity of the blades. (The Courant number indicates an appropriate size of the time step for a given velocity flow speed range.) In practice, this resulted in physical time steps corresponding to 0.1 to 0.5 ° of the main wheel's rotation. For STAR-CCM+ simulations, a second-order, three-level implicit scheme is applied for time derivatives. The used time step size corresponded to 1 ° of revolution of the main wheel. For both solvers, all flow variables are discretized using second-order spatial schemes with upwind-biased methods applied for convective terms.

Validate then test

To ensure the validity of the numerical methods, they are tested against two cases for which experimental data and numerical analysis are available:

- A four-bladed trochoidal propeller. Here, previous open-water and self-propulsion experiments have been carried out at the VTT towing tank and numerical analysis was performed [6].
- A five-bladed cycloidal propeller, for which experimental results are available.

Once it is shown that the methods work in these two cases, the five-bladed ABB Dynafin concept can then be investigated under wetted and cavitating conditions using the same methods. The validation cases were analyzed in model-scale conditions, whereas the five-bladed ABB -Dynafin concept was studied in fullscale conditions. The diameter of the ABB Dynafin device is 3 m, the span of the blades is 3.5 m and a symmetrical blade profile is used.

Results of the validation cases

For the simulations, boundary conditions were set, for example:

- The devices were modeled as if inside a rectangular cavitation tunnel.
- Flow speed was specified at the inlet and pressure at the outlet.
- A no-slip condition was used for the tunnel ceiling and a no-slip moving wall boundary condition was used for the blades.
- The sides and bottom of the rectangular domain were modeled as slip walls.

Figure 2:
Hydrodynamic
efficiencies:
four predicted
with CFD and
one showing
experimental data

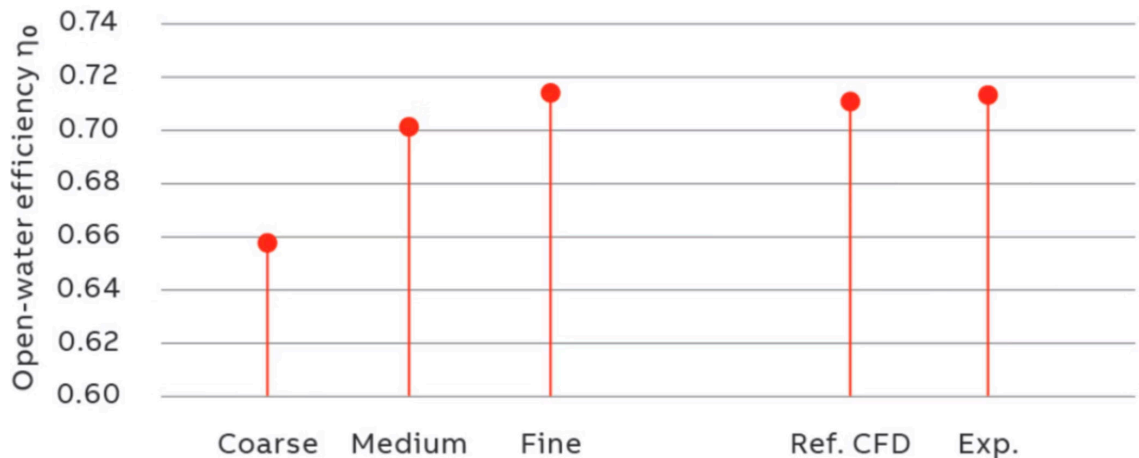


Figure 2 shows simulated hydrodynamic efficiency values for the four-bladed trochoidal device based on three different grid resolutions, together with FLUENT simulations [6] and the model-scale experimental result. The latter two correspond well. The case is pure trochoidal motion with $\lambda = 1.6$. The simulations converge monotonically toward the experimental result and the fine grid result is within 0.2 percent of the reference experimental value. The deviation of the medium grid result is roughly 1.5 percent and the coarse grid result is a bit less than 8 percent.

Figure 3 illustrates the instantaneous flow field from fine grid simulations of the four-bladed device. Accelerated flow near the blades and in the middle of the device, as well as individual blade wakes, are clearly visible. Resolution of wake flow features is sustained in the slipstream. Blade wakes interact with succeeding blades at the aft part of the device, as well as farther downstream.

Cavitation performance of the ABB Dynafin

For the cavitation performance of the ABB Dynafin, calculations were performed based on a cavitation number, σ_{veff} , ranging from 1 to 5 – that is, from wetted or non-cavitating (high cavitation number) to fully cavitating conditions (low cavitation number). Most conditions were analyzed with OpenFOAM and a comparison at a selected operating point was carried out with OpenFOAM and STAR-CCM+ solvers. A λ of 1.6 was used for all cases. In addition to a pure trochoidal trajectory, an optimized pitch function was also analyzed. Optimization, in this case, was based on further improving the efficiency and cavitation performance of the device. Results at different cavitation numbers, in terms of the global performance coefficients, are given in Figure 4. The table shows the coefficients for the trochoidal trajectory used and the optimized trajectory. The results shown in the table are also shown in Figure 5 to compare performance coefficients for trochoidal and optimized blade trajectories.

Figure 3a:
Illustration of CFD
predicted flow
field for the four-
bladed device.
2-D section

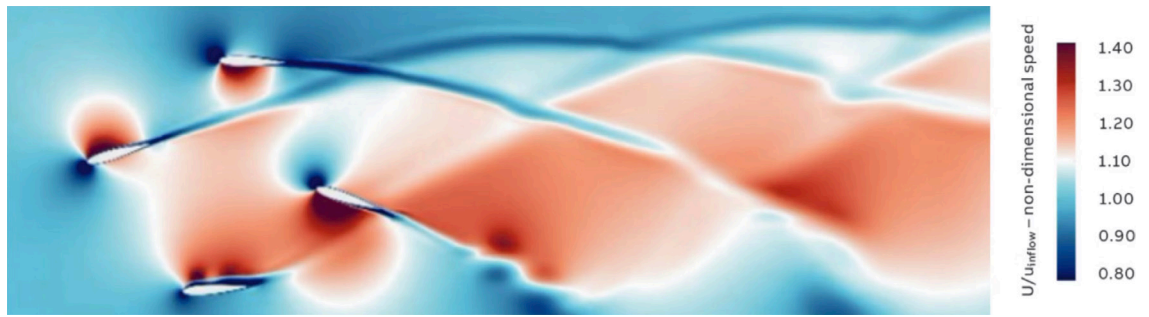
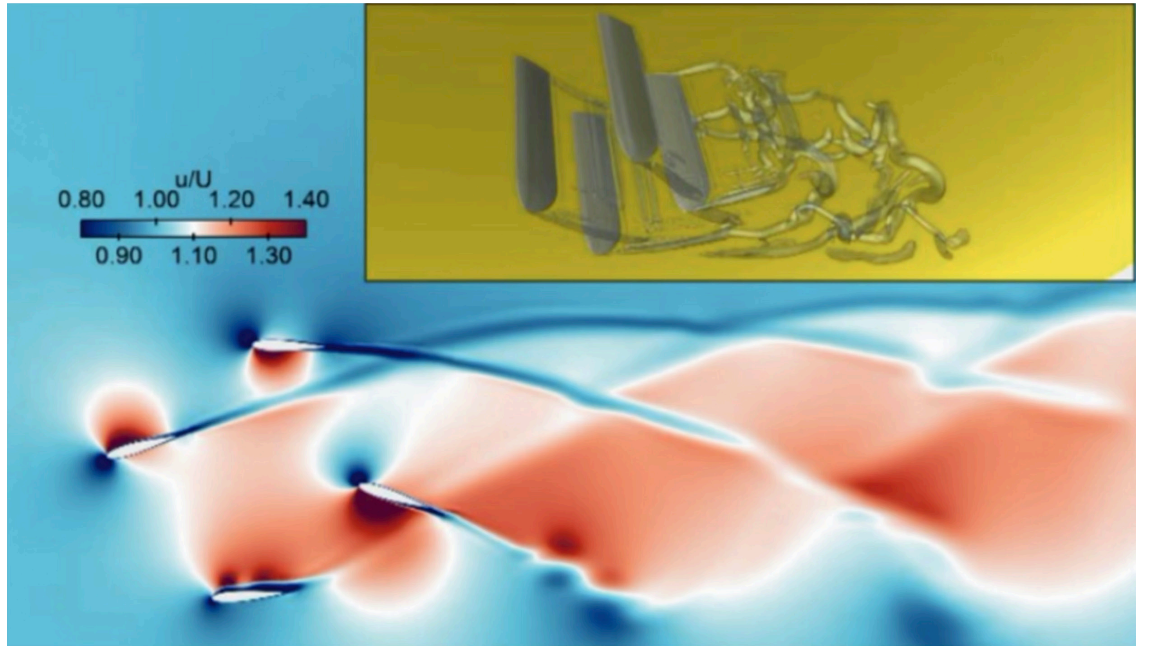


Figure 3b:
Illustration of CFD
predicted flow
field for the four-
bladed device.
Vortices in 3-D



A high open-water efficiency of 0.77 is reached with the trochoidal motion and an even better 0.8 is obtained with the optimized trajectory. The performance and thrust remain high with little variation until below $\sigma_{Veff} \approx 1.7$ with the optimized blade trajectory. For pure trochoidal trajectory, a breakdown of thrust occurs slightly earlier, and after that condition, there is a decrease in the efficiency curve. Comparing the results from OpenFOAM and STAR-CCM+ CFD solvers, there are slight differences in the predicted thrust and torque coefficients, the coefficients being smaller in the STAR-CCM+ solution. Deviation in torque coefficients is slightly larger than in the thrust coefficients. These differences may be partly attributed to dissimilar temporal and grid resolutions applied, especially in the boundary layers of the blades. Still, predicted hydrodynamic efficiencies are very close to those of the CFD solvers.

The thrust coefficient for a single blade from OpenFOAM and STAR-CCM+ simulations during one revolution of the main wheel is shown in Figure 6. The evolution of vapor volume for a single blade is shown in Figure 7: As the blades

rotate in the fore part of the device (θ 315 ° to 45 °) and go downward, cavitation starts to form first near the root, then grows spanwise to cover a thin region near the blade leading edge. A cavitation-free region is followed by a two-peaked pattern of increasing vapor volume at around $\theta \approx 160^\circ$ and $\theta \approx 200^\circ$. Greatest vapor formation takes place at the aft part of the device, that is, after the blade has passed $\theta \approx 180^\circ$. Between roughly 240° and 315° , a cavitation-free region appears. The applied homogeneous-mixture CFD methods predict mainly sheet-type cavities on the blades.

σ_{veff}	Thrust coefficient in x-direction, K_{Tx}	Torque about the z-axis	Open-water efficiency
Trochoidal trajectory			
5.0	4.28	4.45	0.77
3.0	4.27	4.41	0.77
2.0	4.29	4.47	0.77
1.7	4.20	4.74	0.71
1.5	4.13	4.77	0.63
1.0	3.11	5.87	0.42
Optimized trajectory			
5.0	4.26	4.28	0.81
3.0	4.27	4.26	0.80
1.7	4.24	4.25	0.80
1.7*	4.16	4.12	0.81
1.5	4.06	4.23	0.77
1.0	2.87	4.38	0.52

Figure 4: Performance coefficients of the ABB Dynafin device as functions of the cavitation number with different blade trajectories

*STAR-CCM+ result

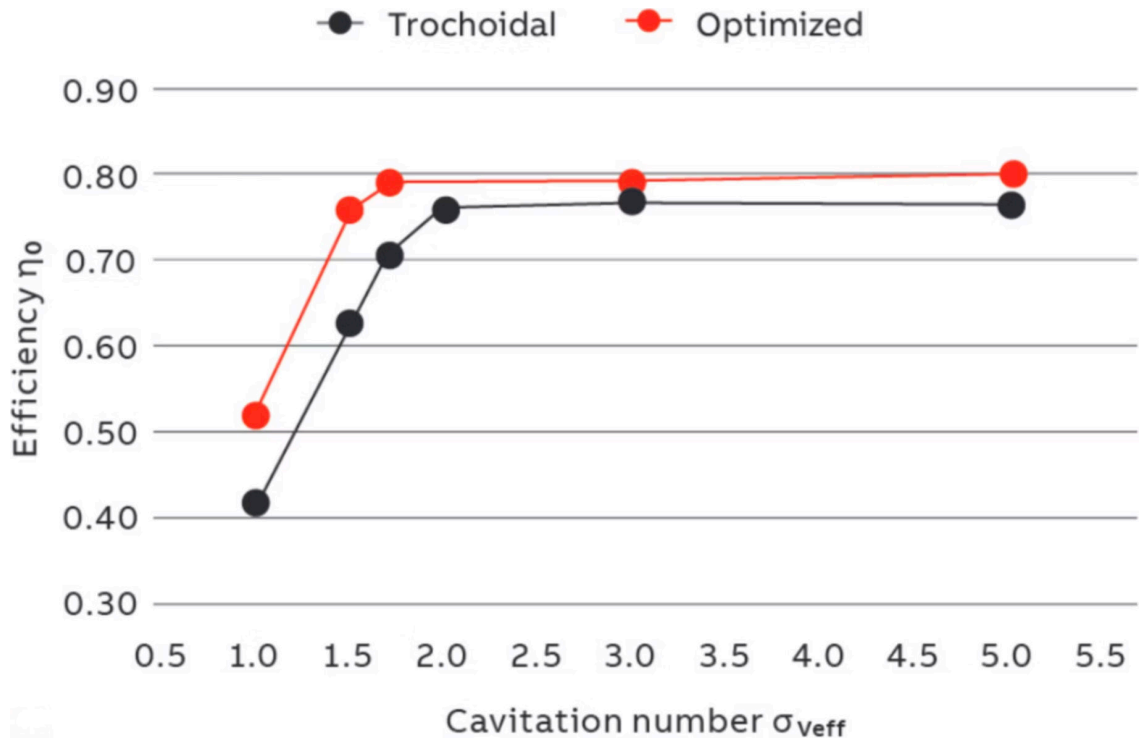


Figure 5: Efficiency of the ABB Dynafin with cavitation numbers. Comparison of trochoidal and optimized blade trajectories

Overall, the thrust and gas volume values have similar forms for each CFD solver for most of the wheel's rotation. Differences arise mainly when the blade passes through the wake generated by the other blades as the main wheel rotates – for example, near $\theta = 180^\circ$. Figure 8 shows the scaled, non-dimensional flow speed (U/U_{inflow}) at a middle z-plane of the device, illustrating that wakes of individual blades are more distinctly resolved in OpenFOAM simulations and as a blade passes through the wake of another blade, the wake's effects are more pronounced in the blade's force time history. Note that there is a slight deviation in shapes of vapor time evolution close to $\theta \approx 45^\circ$ – ie, when the rotating blades meet an undisturbed flow. Possible causes of this discrepancy require further investigation. In addition to differences in grid resolutions, the time step used in the STAR-CCM+ simulations was a bit larger, which may increase numerical diffusion in the flow solution. The shorter time step applied in the OpenFOAM solution can also result in a more resolved vapor field.

Simulation matches reality

This VTT and ABB collaborative study shows that the performance of the ABB Dynafin with a purely trochoidal motion of the blades is good, with efficiencies near 0.8. Under the conditions considered, performance remains excellent up to relatively low cavitation numbers. Cavitation and hydrodynamic performance can be further enhanced with an optimized blade pitch function, which leads to improvement over the pure trochoidal motion.

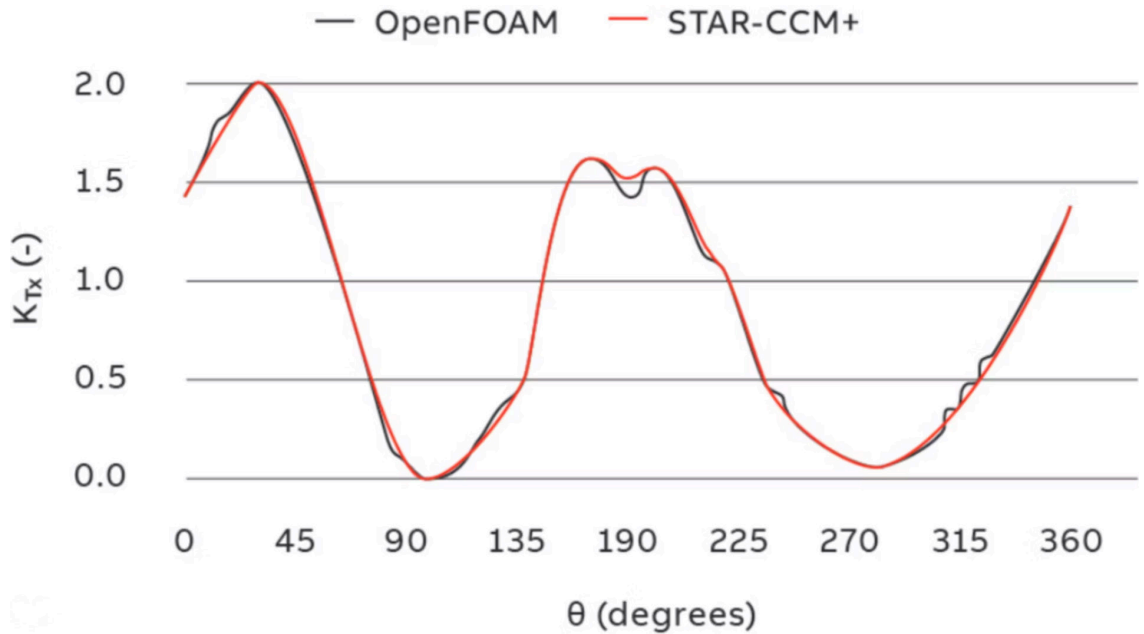


Figure 6: Thrust coefficient for one blade during rotation of the device. Comparison of OpenFOAM and STAR-CCM+ results at $\sigma_{Veff} = 1.7$

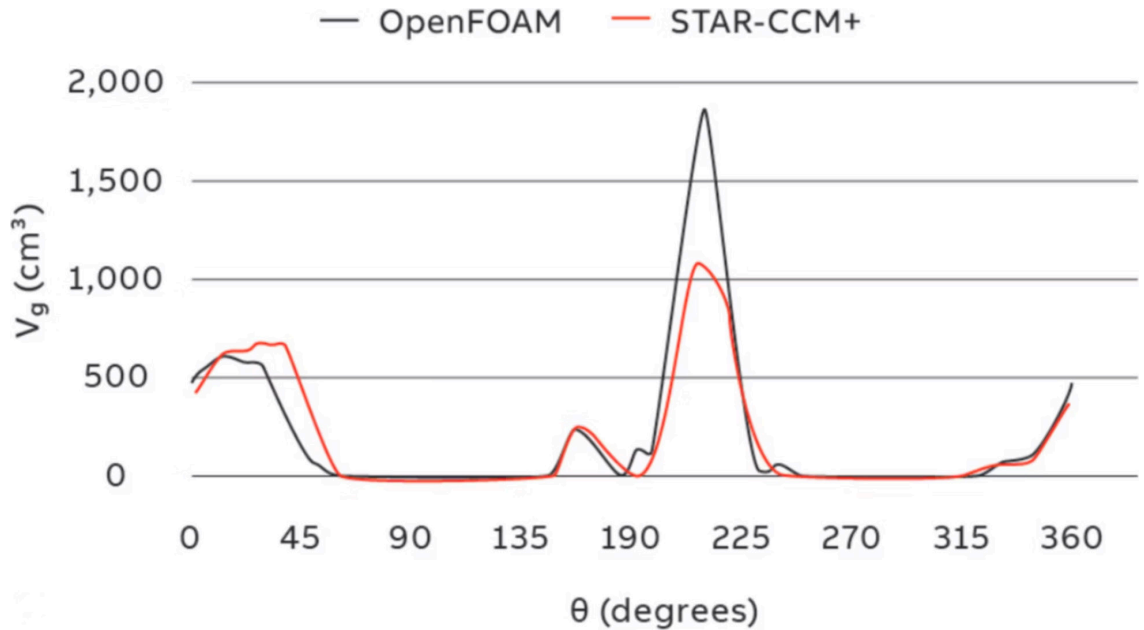


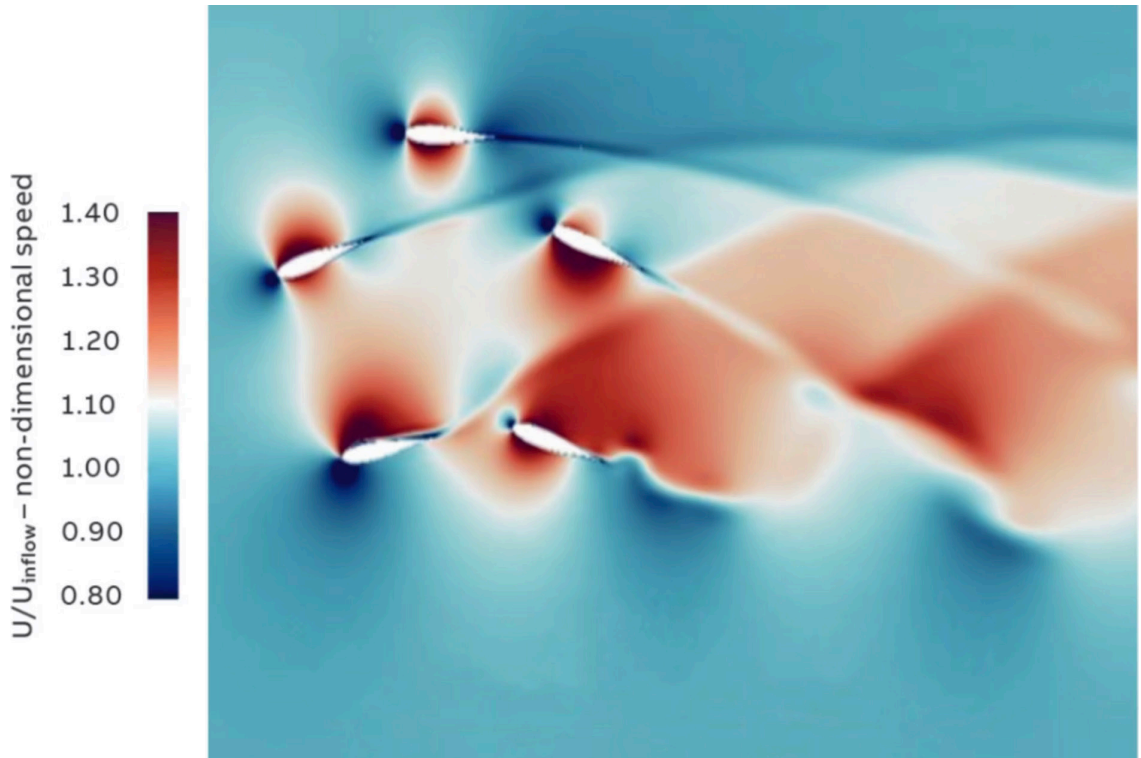
Figure 7: Vapor volume for one blade during rotation of the device. Comparison of OpenFOAM and STAR-CCM+ results at $\sigma_{Veff} = 1.7$

OpenFOAM simulation results compared well with available experimental and reference simulation data. Overall, the CFD methods applied to the ABB Dynafin device produce similar results. Differences in the flow field and time evolution of the vapor volume were observed and discussed. More operating points should be investigated to obtain more precise data about the onset of cavitation and the trend of the performance coefficients. A detailed description of the study described in this article can be found in [1].

Acknowledgements: The authors wish to acknowledge VTT's HPC cluster ("The Doctor") and the CSC – IT Center for Science, Finland, for computational resources. They would also like to express their gratitude for Business Finland's support in the project "UltraPropulsor".

Figure 8: Illustration of CFD predicted flow field at $\sigma_{\text{Veff}} = 1.7$. The flow speed has been scaled with the inflow speed. From OpenFOAM simulations

Future work includes a numerical uncertainty assessment with respect to grid resolution. Further, the implementation of scale-resolving turbulence modeling techniques could allow for a more thorough investigation of cavitation dynamics and multiphase flow. Moreover, to supplement current mixture multiphase flow models, the application of two-fluid methods could ensure cavitation features and types are represented more completely. •



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Propulsion evolution

ABB's new, cycloidal-type propulsor concept – ABB Dynafin™ – significantly increases a vessel's efficiency and promises to substantially reduce emissions across the marine industry.

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Jani Hakala,
Janne Pohjalainen,
Veli-Pekka Peljo,
ABB Marine & Ports,
Helsinki,
Finland

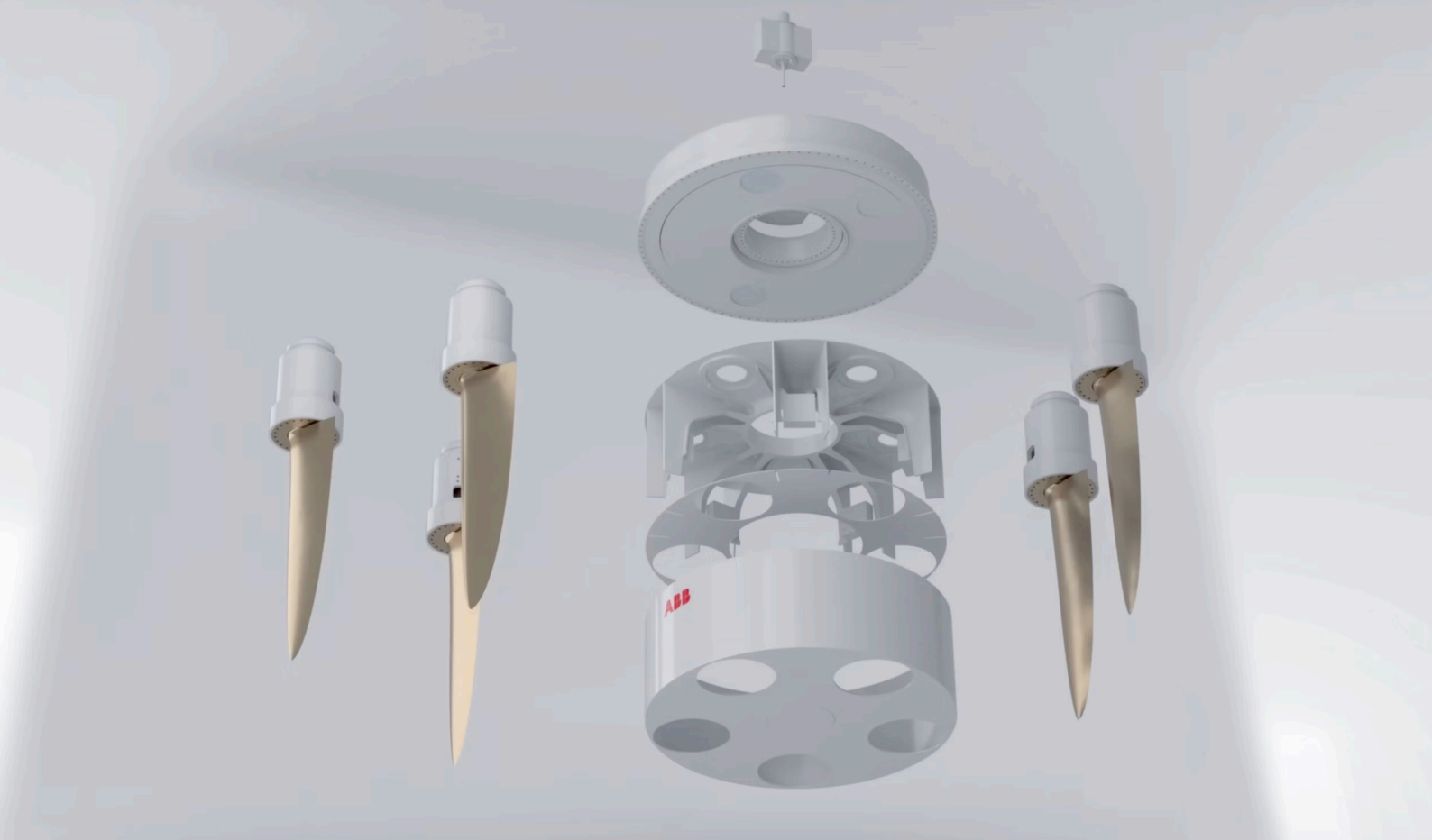
Most international trade relies on waterborne transportation. Despite providing the most cost-effective means of moving the goods involved in this trade, the shipping industry suffers from the drawback that ships typically burn heavy fuels that produce greenhouse gases (GHGs), such as carbon dioxide (CO₂), making the marine sector responsible for around two percent of human-made CO₂ emissions globally [1]. Indeed, if shipping were a country, it would be the sixth-largest emitter of GHGs worldwide [2].

To address these emissions, the International Maritime Organization (IMO) has declared the ambition to achieve net-zero emissions from international shipping by 2050. Alternative energy sources and advanced propulsion technology are seen as crucial elements of the plan to accomplish this goal.

In May 2023, ABB presented a breakthrough solution that looks set to revolutionize marine propulsion – ABB Dynafin, a cycloidal-type propulsor that meets the urgent demand for higher efficiency and emissions reduction.

ABB Dynafin

The innovative ABB Dynafin generates thrust by means of blades that project outward from the bottom of the ship (Figure 1). The blades rotate around their own axis and around the axis of the rotatable wheel upon which they are mounted. In this way, and under the control of a sophisticated control system (see the article “Command and control”), ABB Dynafin can achieve very high hydrodynamic efficiencies and change thrust direction almost instantaneously, giving far better maneuverability than arrangements in which a conventional propeller is rotated about a vertical axis to direct thrust.



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Figure 1: Each blade can rotate, as can the main wheel onto which they are mounted

The ABB Dynafin concept is essentially a cycloidal propeller with individually controlled blades following a trochoidal path, analogous to that of a whale's tail. (A trochoid is the curve generated by a point on the radius of a circle as the circle rolls on a fixed straight line.) Trochoidal propellers have been studied before, but until now, technology constraints have prevented them from being commercialized and introduced to the market.

Rotational movement of the main wheel is produced by an electric direct-drive motor. The main wheel rotates at a relatively low 40 to 80 rpm and has four to six identical blades (Figure 1). The direction of rotation is kept the same under all operational situations and thrust amount and direction are determined by a combination of main wheel rpm and blade adjustment. Initially, ABB is concentrating on developing ABB Dynafin units in the power range of 1 to 4 MW per propulsor (Figure 2).

Models and modeling

The development of ABB Dynafin was greatly aided by using computational fluid dynamics (CFD) simulations to evaluate hydrodynamic performance as well as by scale-model open-water testing (Figure 3). Much of the detailed work was carried out in collaboration between ABB and a team from the VTT Technical Research Centre of Finland in Espoo, Finland (see the article "Bubbling under").



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Figure 2: Two (shown here) or even four sets can be fitted to a vessel, giving up to 16 MW of installed power

The next step in hydrodynamic performance testing was to expose ABB Dynafin to conditions closer to those in the real world by retrofitting propulsors to a platform support vessel's hull. Performance could then be compared against existing Azipod® units in the same power range. Following the successful simulations and scale-model and vessel-hull tests, ABB engaged in productive discussions with several ship design offices, shipyards and ship owners and operators to validate the feasibility of the concept.

Key efficiency factors

Several factors drive the high efficiency of ABB Dynafin, such as its larger propulsive area, which lowers the propeller loading, giving the lowest thrust loading coefficient. The lower this coefficient, the higher the ideal open-water efficiency of a propulsor.

Further, ABB Dynafin's geometry makes it ideal for shallow-water vessels as it protrudes less far than an equivalent screw propeller. In contrast to a traditional vessel, which has a rudder and struts for the shaft that create drag, a cycloidal propulsor only has the blades protruding from the hull, giving a better hydrodynamic performance.

Figure 3a: CFD simulations provided the fastest and most cost-efficient way to investigate hydrodynamic phenomena and to improve the concept. Twin-set simulation. The position, z , depicts wave height around the vessel, with blue values indicating calm water. The static pressure legend applies to the blades

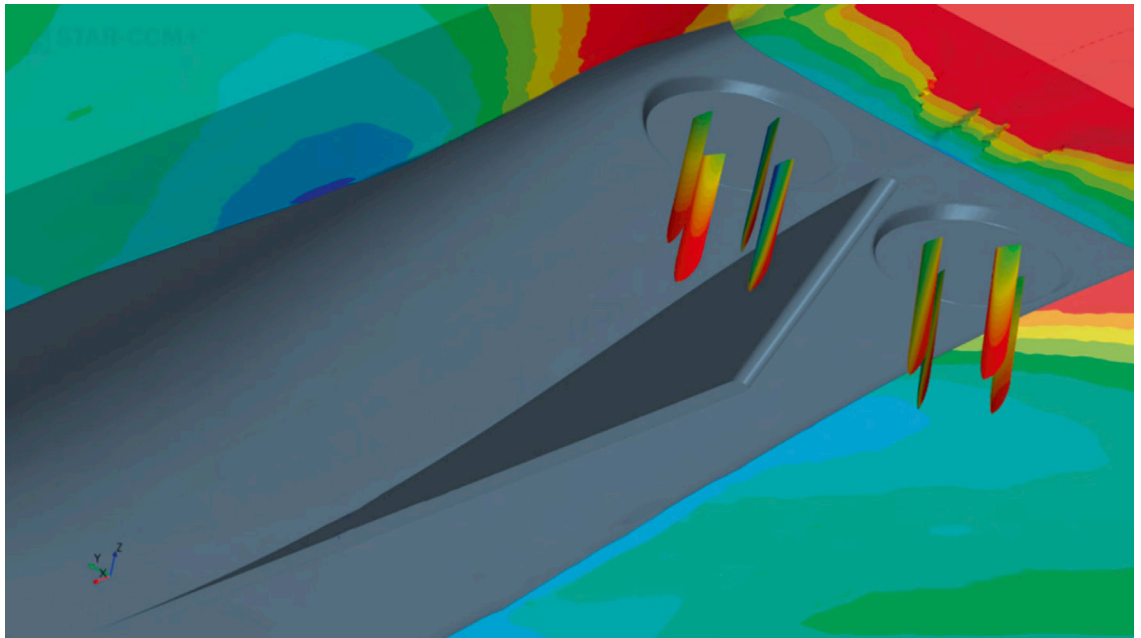
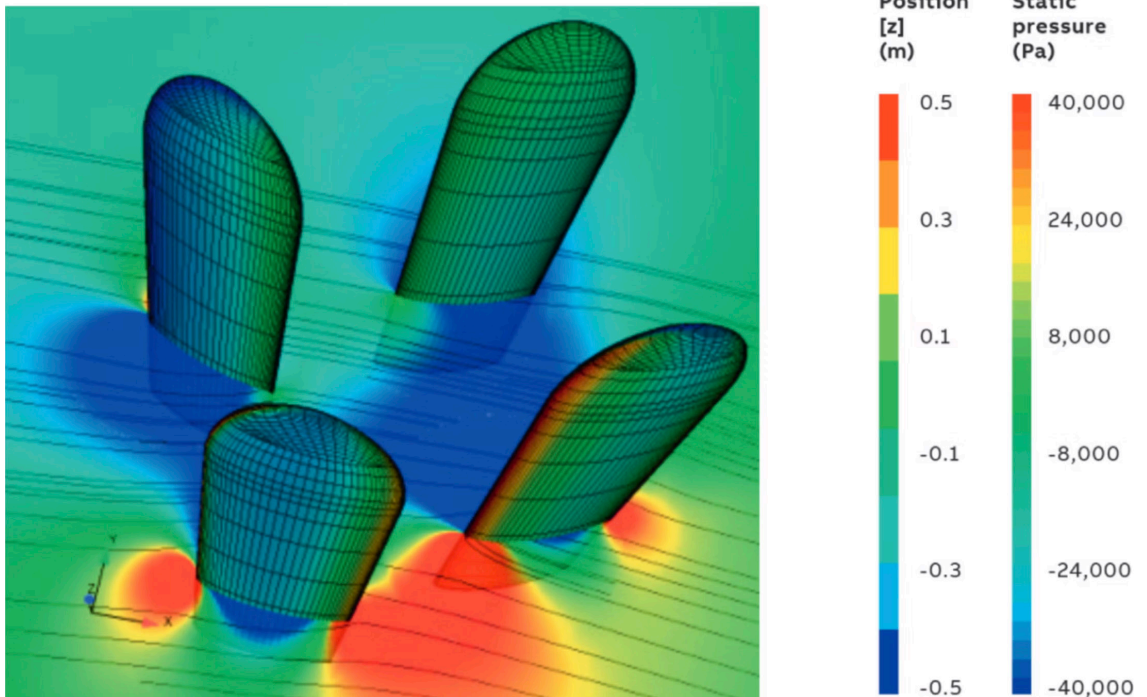


Figure 3b: CFD simulations provided the fastest and most cost-efficient way to investigate hydrodynamic phenomena and to improve the concept. Fluid flow around individual blades



A further factor that drives efficiency is the ability to control each blade individually. Each blade is controlled by an electric motor, a frequency converter (to control torque and rpm) and control logic. This arrangement enables the imitation of a high-efficiency whale-tail movement and adjustment of the

blade movement (eccentricity, advance ratio and angle of attack) depending on different vessel operational situations, maximizing efficiency and thrust in both transit and dynamic positioning modes (Figure 4).

ABB Dynafin has a major advantage over fixed pitch propellers, which are optimized to a single operational point, in that it can adjust the movement of the blades continuously to meet optimal performance over a wide speed range and different wake fields. The unit's control and software technology allows continuous vessel performance optimization throughout its lifetime, creating the concept of a "digital propeller." ABB Dynafin can also be operated in "rudder mode," meaning that all the blades are controlled as conventional rudders. This feature brings benefits not only for double-enders and sail-assisted vessels but also increases redundancy in failure situations, providing partial steering capability.

In addition to having a direct electrical power train for both the main wheel and the blade modules, a mechanical bevel gear may be used, allowing connection to the main engine and extending the benefits to vessel segments where electrical power trains are typically not used.

Other efficiency gains can be made because ABB Dynafin's superior performance allows for smaller power plants (and fuel tanks) to be used. This improvement reduces capital outlay and maintenance costs, enables a more flexible ship layout and frees up room for cargo and passengers. This power-reduction aspect is particularly beneficial to hybrid or fully battery-powered vessels, as the size of costly battery banks can be minimized.



Figure 4:
Lake trials
demonstrating
maneuverability
capabilities of a
vessel equipped
with ABB Dynafin
propulsors

Dynafin vessels make the least noise

Limits on underwater radiated noise are expected in the near future due to its potential effect on aquatic ecosystems. ABB Dynafin minimizes electromagnetic noise by having the electric motors inside the vessel's hull and minimizes hydrodynamic noise by limiting cavitation and turbulence. In addition, individual blade control enables optimized trajectories to curtail hydrodynamic noise in different operational situations.

High reliability and easy maintenance

ABB Dynafin's modular structure and high degree of standardization simplify spare part management. There are, in any case, fewer components due to the combined propulsor and steering and a direct electrical power train.

The absence of wear-sensitive gears and the main wheel's moderate 40 to 80 rpm minimizes component wear, but when component inspection or replacement is needed, the main wheel is easily accessible from inside the vessel.

A sea of application possibilities

ABB Dynafin delivers a fuel consumption reduction of up to 22 percent compared to a conventional shaftline and a propulsion efficiency of up to 85 percent. Less space is needed for the ship's power plant and fuel tanks. In addition to high efficiency, ABB Dynafin also simplifies maintenance and enables superior vessel maneuverability. ABB's expertise in hydrodynamics, mechanical systems, ship electrification and automation and control puts the company in a unique position to further improve the ingenious ABB Dynafin. This propulsion system adds a new level of adaptability and intelligence to vessel performance and changes how the shipping industry thinks about propulsion systems. •

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Strength through collaboration

A critical phase of the ABB Dynafin™ project was carried out in collaboration with VTT, the largest research and technology company conducting applied research in Finland. This work is one part of a valuable and ongoing cooperation between ABB and VTT.

—
Ilkka Perälä,
VTT Technical
Research Centre
of Finland Ltd.,
Espoo,
Finland

VTT is a visionary research, development and innovation partner and one of the leading research organizations in Europe. VTT's over 2,000 professionals work to develop systemic and technological solutions that can bring about fundamental transformation.

The VTT maritime team is focused on propulsion hydrodynamics, ship energy efficiency and structural problems on ships. For hydrodynamics, VTT has strong computational fluid dynamics (CFD) capabilities coupled with codes developed in-house for quick assessment of hydrodynamic problems. Numerical assessments are backed with strong expertise in model-scale and full-scale measurements.

VTT's collaboration with ABB has deep roots, going all the way back to the development of the first Azipod® propulsion units in the 1980s. This early work included hydrodynamic assessment of Azipod propulsion units with computational tools and with model tests. Another major topic for cooperation was the assessment and measurements of ice loads on Azipod propulsors. Measurements from the harshest ice conditions helped ABB to develop Azipod propulsors for the highest ice classes. Material and component testing for some of the Azipod parts has also been carried out at VTT testing facilities.

Cooperation on the ABB Dynafin product started in 2014 when ABB approached the VTT maritime team to assess new propulsor concepts. These concepts included paddle wheels, flapping foils and cycloidal propellers. Lacking prior systematic studies of these concepts, it was essential to simulate them with a wide range of parameters to understand the hydrodynamic potential of each



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Figure 1: Scale-model testing by VTT at the Otaniemi (Finland) towing tank

one. In this task, the tools developed in-house by VTT were important as they enabled a quick assessment of the hydrodynamic performance of each concept. Later, more accurate but time-consuming CFD analyses were carried out for the chosen ideas. The chosen cycloidal approach with trochoidal blade motion would be the starting point of the Dynafin product development. When the concept was selected, the numerical simulations were verified with model tests by VTT at the Otaniemi (Finland) towing tank (Figure 1-3). The VTT maritime team helped ABB design the model device for the tests and between 2017 and 2019, several model test campaigns were carried out, including open-water and self-propulsion tests (Figure 4).

Recently, the research around novel marine propulsors at VTT has continued in a research project called UltraPropulsor, where several companies, including ABB, are developing related products and concepts. VTT is coordinating the project and carrying out a public research project that aims to deepen understanding of cavitation modelling, hydrodynamic modelling, ice loads and propeller materials. •

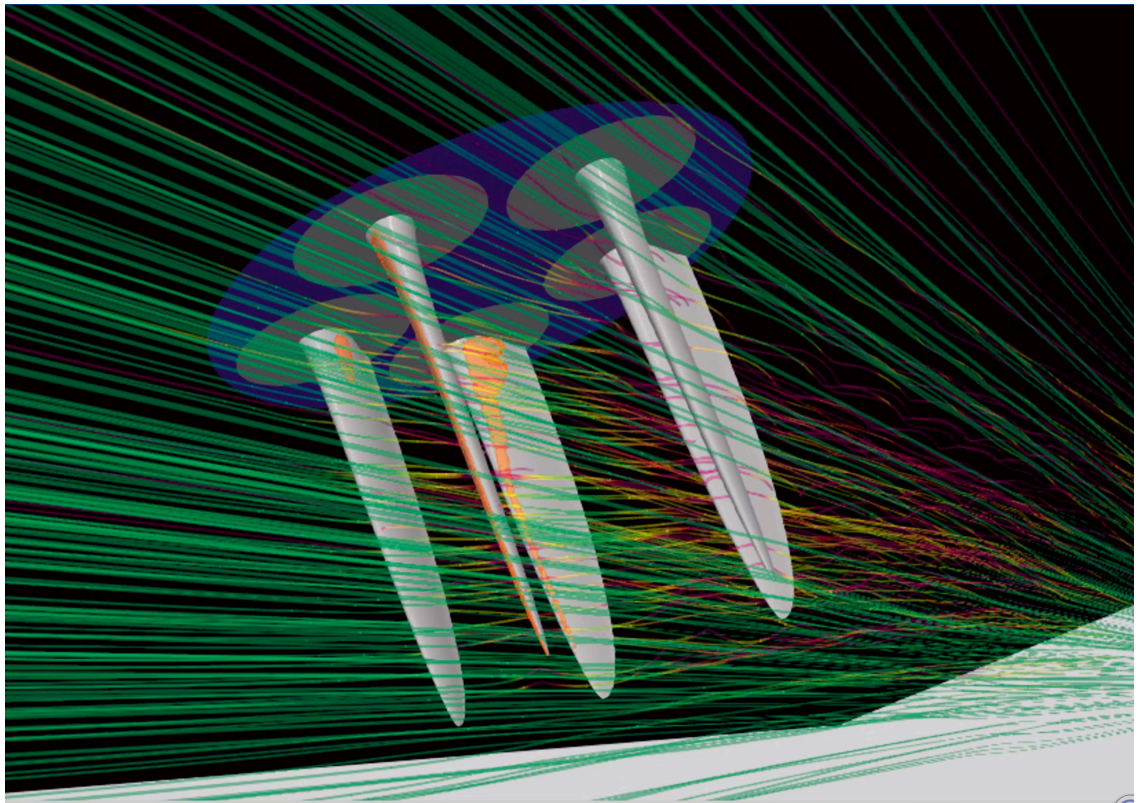


Figure 2a: VTT performed towing tank tests for comprehensive scale-model testing. "Clean" flowlines

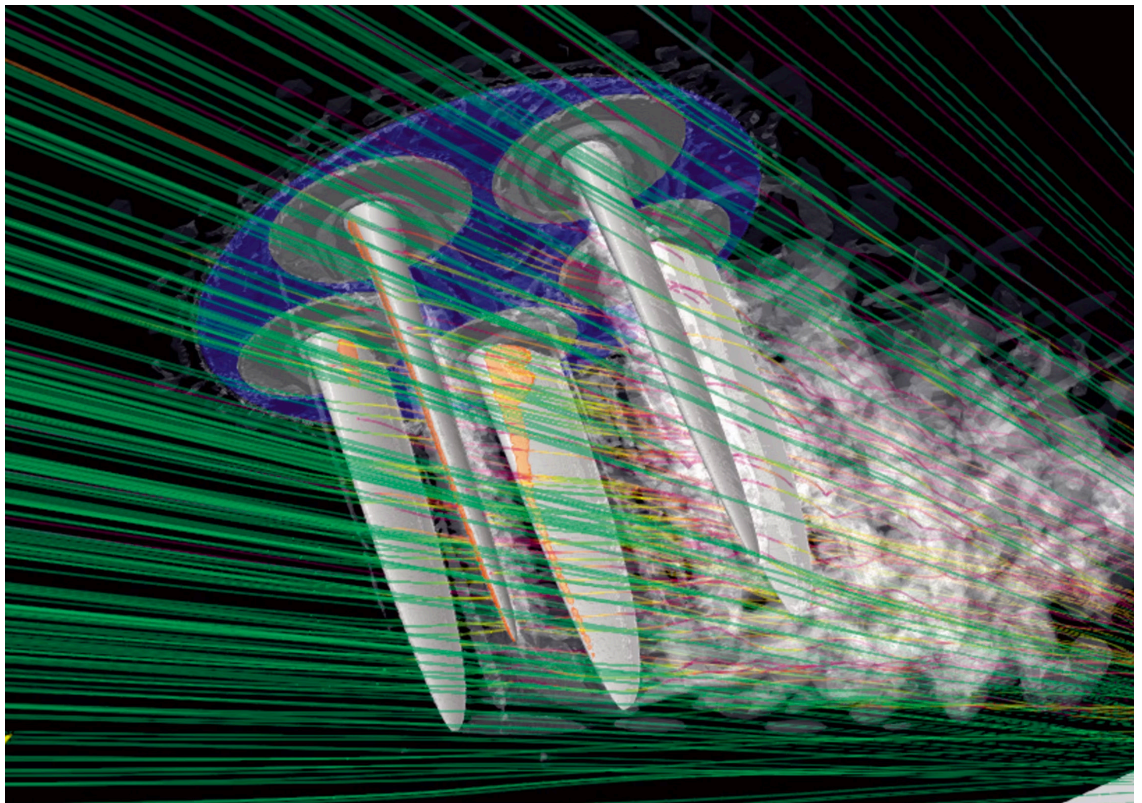


Figure 2b: VTT performed towing tank tests for comprehensive scale-model testing. With wake/cavitation



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Figure 3: The VTT towing tank is large enough for comprehensive scale-model testing



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Figure 4: VTT possesses all the skills in-house for the complete engineering of test environments. Here, a VTT engineer is installing instrumentation to a ship propeller shaft in preparation for sea trials

People power

A conversation with Veli-Pekka Peljo, who led the multidisciplinary team that created ABB Dynafin™.

Veli-Pekka Peljo, Senior Project Manager, Solutions Development (Figure 2), joined ABB Marine & Ports in 2003 as a design engineer and immediately rolled up his sleeves on the continued development of ABB's Azipod® propulsion technology. Ten years later, he was called on to helm the multidisciplinary team that gave birth to ABB Dynafin, launched in May 2023. Here, he explains how the concept came into being, the collaborative effort needed to bring it to the prototype stage and why a clear goal and open mindset are key to handling uncertainty.

It has been a long journey since 2013, when Peljo took charge of ABB's Total New Propulsion project to develop a propulsion unit with an efficiency of over 80 percent. "Already then, electrification of vessels was seen as a trend, but the green transition was still to come. At that time, marine fuel prices were at an all-time high, so fuel efficiency and reducing emissions were at the front of people's minds and became the main drivers for the project."

Fuel efficiency and reducing emissions were at the front of people's minds and became main drivers for the project.

Right back to basics

When they started out, Peljo and his team understood that it was not possible to dramatically improve the efficiency of conventional screw-propeller-based solutions beyond the incremental improvements already achieved. "To address the challenge, we knew we'd have to go right back to basics – drill down into the theoretical underpinnings of how to create thrust and come up with something radical from scratch."



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Figure 1:
Some of the
multidisciplinary
team responsible
for ABB Dynafin
pose beside the
lake where testing
took place.

ABB first enlisted the help of engineering students at Aalto University in Espoo to do a big-picture analysis of the ideal propulsor in what they call a Product Development Project (PDP) [1]. They studied the literature to identify what concepts had been floated in the past and what patents were available. “That generated a lot of ideas – everything from screw propellers, paddle wheels and air propulsion to electromagnetic thrusters and biomimetic propulsion – the Aalto guys analyzed how fish, different sea mammals and even insects create thrust,” Peljo says.

The combined Aalto/ABB team ended up with 69 concepts, all of which were tested against ideal propulsion theory. Two major criteria for the best solutions were optimal utilization of the transverse area at the back of a vessel and enabling the greatest efficiency at the lowest cost. “That involved a lot of workshops where we finally identified five concepts to take forward: Azipod XL, a rim-driven nozzle propeller, an advanced paddle wheel concept, a flapping hydrofoil and a trochoidal propeller,” explains Peljo.

“After further iterations, we saw that using a flapping foil or blade that mimics the movement of a whale’s tail (known as a trochoidal trajectory) was undoubtedly the most efficient solution. That was the germ of the idea that became the ABB Dynafin.”

Figure 2: Veli-Pekka Peljo is passionate about ABB's work in advanced marine propulsion concepts.



Solving the puzzle

The challenge was how to connect the flapping foil to the rotational movement of an electric or diesel motor shaft to propel a vessel. “You could have a single foil moving up and down, but we figured the best way would be to use multiple vertical blades connected to one central rotating wheel. We then contacted VTT – a state-owned technical research center in Finland and one of the top institutes in Europe – to collaborate with us in creating hydroanalytical models to see exactly how this set-up would generate thrust [2].

“The solution was to give each blade its own driving motor, allowing for independent control so you can pre-program the angle of attack of each blade against the inflow as the main wheel rotates, taking into account the vessel’s wake field.”

“VTT were very fast to prove the concept, with their calculations indicating an efficiency of over 0.8 with an optimized trochoidal trajectory of the blades. We also used their formulas to optimize geometry factors, including the span and chord dimensions of the blades, and operational parameters such as RPM.”

CFD proves the concept

The next step was to create an initial design for computational fluid dynamics (CFD) analysis, which – as the combined project team expected – validated VTT’s formulas and showed that the solution works. “Doing CFD, especially 3-D CFD, is time-consuming as a single model can take up to a day to process. You need to have come quite a long way before you do it. We were then able to extract the load data for detailed dimensioning of the supportive structure – for example, the center wheel, blade motors and bearings,” says Peljo.

It was only after doing the CFD that the team started to really think about how they could make the concept work in real life. Having little experience in control software solutions, Peljo and his colleagues Mirva Nevalainen, Product Manager, and Jukka Varis, Technology Manager, pitched the concept to Bin Liu, Senior Principal Scientist and his team at the ABB Corporate Research Center (CRC) in Västerås, Sweden and asked if they could make a model-scale prototype. “Pre-programming the movement and angle of attack of the blades was one of the biggest challenges, but being world leaders in robotics – they are the experts behind ABB’s family of YuMi® collaborative robots – this was well within their capability.”

Starting in 2016, the ABB teams collaborated on a novel cycloidal propulsion technology project, resulting in a prototype and the first novel small-scale demonstrator vessel, which was built and operated on Lake Mälaren, just outside of Västerås.

We saw that using a flapping blade that mimics a whale’s tail was undoubtedly the most efficient solution.

Defining moment

The resulting prototype was hydrodynamically tested in the VTT model basin in Espoo, Finland and then self-propulsion and maneuvering capabilities were confirmed in open-water lake trials in Sweden. It worked as predicted. “We did everything you’d do in a full-scale sea trial program. That was a fantastic milestone and confirmed all our hard work. We knew then we could really make the concept, which we originally called ‘Foilwheel,’ fly as a world-first digital propeller with extraordinary efficiency,” comments Peljo.

To those who might wonder why nobody had done this sooner, Peljo’s answer is: it’s not that simple. “ABB Dynafin may look similar to some mechanical solutions, but inside it’s totally different – the main thing being the blade motors and entire drive train. Instead of mechanical levers controlled by hydraulic servo actuators, we have electric motors with low RPM and high torque that we can match with the propeller blades at full scale.”

He says the final ABB Dynafin units will be of standard design, although of different propeller diameter sizes depending on the power factor. This shortens delivery lead time. “Then you just select the right blade length to fit the vessel draft. It could be that we offer only two different blade lengths, but our target is to keep the blades above the baseline.”

The fatigue strength of the blades is a critical design issue, so they need very careful design to ensure the required service life with high reliability. “We’re currently thinking martensitic casted stainless steel but given certain manufacturing constraints, we may need to use composites for the longer blades on higher-power units. We’re also working on details like sealing solutions to achieve an optimal total cost of ownership.”

ABB Dynafin can change thrust direction through 180 degrees in seconds – ideal for dynamic positioning.

Target markets

In terms of which vessels the concept is most suited to, Peljo explains that right now they are “just scratching the surface.” He elaborates, “we are aligning it with customer requirements for different segments, but there are a lot of possibilities. Transit vessels will see the biggest benefit and the faster the speed, the bigger the benefit. But we’re mostly looking at 12 to 20 knots at this stage. With ABB Dynafin, you get many different design points in just one propeller: one for maximum sea-trial speed, one optimized for economy speed, one for safe return to port at six knots, one for dynamic positioning operation and so on. It’s very versatile and can suit all sorts of ship types.”

In terms of power factors, ABB is working towards four sizes, from 1 MW to 4 MW. Four 4 MW units on a vessel would give propulsion power of 16 MW. “There’s interest in the market to go even higher, so we’re also looking at 5 MW units and upwards,” adds Peljo.

Thanks to its integrated controllable pitch propeller (CPP) feature, ABB Dynafin has the dynamic positioning capability necessary for offshore vessels. “It can change thrust direction through 180 degrees in seconds, providing a very fast response time if you need to change vessel heading. With multiple units, we’re also looking at how ABB Ability™ Marine Pilot Control can best utilize ABB Dynafin unit’s capabilities for all operational modes and autopilot configurations, with a view to remote operations and eventually autonomous operations.”

There are also low-vibration vessel cases. “The RPM is quite low at full power, but the amplitude is higher. The pressure pulses from a vertical propeller don’t interfere too much with the hull, but we can tweak the blade trajectories even more to eliminate vibration and noise almost completely for silent operations.”



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Figure 3: ABB Dynafin can operate in rudder-only mode for sail-powered vessels or when hybrid vessels switch to sail-assisted mode. (Image credit: NEOLINE/MAURIC)

Moreover, ABB Dynafin boasts other valuable features, such as regenerating power when braking the vessel, just like a self-charging hybrid car. “You can charge onboard batteries simply by the action of the water turning the blades like a windmill. Then we also have the so-called rudder mode, meaning that, when the propulsion drive is inactive, that is, with the main wheel stopped, all the blades can work together to steer, for example, a sail-assisted vessel (Figure 3).”

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Crucial for success were the great partners in Aalto University, VTT and the ABB Corporate Research Center.

Dealing with uncertainty

Peljo highlights that there is always uncertainty when developing a new concept from scratch. “To handle that, the human factor has to be constant; it’s essential to maintain a creative, open mindset and a strong focus on the goal even if the requirements are vague. Innovation is not all about luck and in-the-moment inspiration; we had a lot of arduous concept rounds. Looking back, we could, of course, have moved faster, but we’ve had a lot of parallel projects to work on, too,” he adds.

Having a proven R&D methodology is also crucial. “We use the applied ship design spiral, where you move from mission requirements to high-level concept analysis on the outer circle and gradually work inwards, honing the design in greater detail. You can’t get bogged down in details too soon. Having a clear business case also stops you from getting distracted in theoretical niceties that waste time.”

Kudos for partners

Peljo stresses that there was “no way we could’ve done this alone.” ABB Dynafin has been the result of pulling together expertise in mathematics, hydrodynamics, mechanics, electrical and control, and we’ve had great partners in Aalto University, VTT and the ABB CRC. So, having the right mix of people, combined with ABB’s strong culture of innovation and determination to always do better, has been crucial for success.”

As to his personal motivation, Peljo trained as a mechanical engineer and loves R&D work because no one day is the same as another. “I’d be bored stiff doing the same thing day in, day out. The project was a once-in-a-lifetime opportunity and it’s fantastic to have come so far in bringing ABB Dynafin to reality.”

“Given the high cost of new green fuels and the increase in fully electric vessels, the business case is even more attractive,” Peljo adds. “Contributing to the green shift gives extra meaning and I believe it’s great timing for what is an exceptional novel technology. We are working hard on the details and I can’t wait to see the first ABB Dynafin live on a real ship.” •

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Future power solutions for naval platforms

A new approach to efficiency is essential

Reflecting the push for greener solutions in commercial shipping amid ever stricter emissions regulations, navies should also be moving towards more holistic power and propulsion system tender requirements. These should encompass through-life costs, vessel availability and efficiency, and servicing, says Egil Johansen, Head of Navy Europe, ABB Marine & Ports.

ABB Generations invited Johansen to assess how the widely recognized demand for energy efficiency within commercial shipping is affecting the naval domain and government decision-makers. "The gains in operational energy efficiency that modern power and propulsion systems bring should be a key priority in procurement processes. We see a growing desire for change, and the technology and competence to facilitate it are available right now. Strategic purchasing needs to recognize this," he says.

Lowering the carbon footprint

Higher efficiency clearly reduces environmental impact. "We must do all we can to protect the planet, not least in maritime," Johansen says. "Some may feel this is not a role for navies, but I believe it goes hand in hand with the core mission of most militaries to protect our way of life. In view of the direct adverse impacts of climate change, including environment-related migration, this should not come at the continued expense of the planet. Navy and coast guard vessels must of course maintain and enhance their mission capabilities, but in terms of efficiency they should be able to transit, loiter, and train in line with the standards expected of commercial operators."

Johansen highlights that energy-efficient power and propulsion systems – enabled through the use of variable-speed generators and optimized diesel-engine configuration, in combination with alternative energy sources such as batteries and fuel cells – typically have lower or even zero emissions compared to traditional power setups, ushering in a new era of decarbonized operations.



Lower fuel consumption and higher overall system performance are the main benefits. "By applying advanced technologies and design principles we can use the power plant more effectively and thus minimize energy losses. At the same time, smart designs combined with advanced power and energy management have equal and potentially even more operational capabilities, including new large, pulsed demands."

Holistic thinking saves money

Although the initial investment for energy-efficient power and propulsion systems may be slightly higher than conventional AC solutions, the long-term savings from reduced fuel consumption achieves an acceptable balance. "Reduced running hours also mean a reduction in maintenance costs over time, which is an important cost point that is often overlooked," Johansen says.

Some countries are leading the way and setting a good example, he adds, but there are still too many examples of a "race to the bottom" mindset where the cheapest offer wins despite the solution being suboptimal. "Much more attention should be paid to through-life operational efficiencies, OPEX, serviceability, vessel availability and flexibility, and impact on the environment. It is important for both governments and private shipping companies, who value their license to operate and the value of every penny spent across the life of a vessel, to advocate for this approach."

This new strategy is also beneficial for taxpayers. "As a taxpayer myself, I want those responsible to get the most out of my tax contribution to our Navy, but at the same time I want the Navy to have the best capabilities money can buy. This doesn't need to be a choice; with the right solution you can have the best of both," Johansen says.

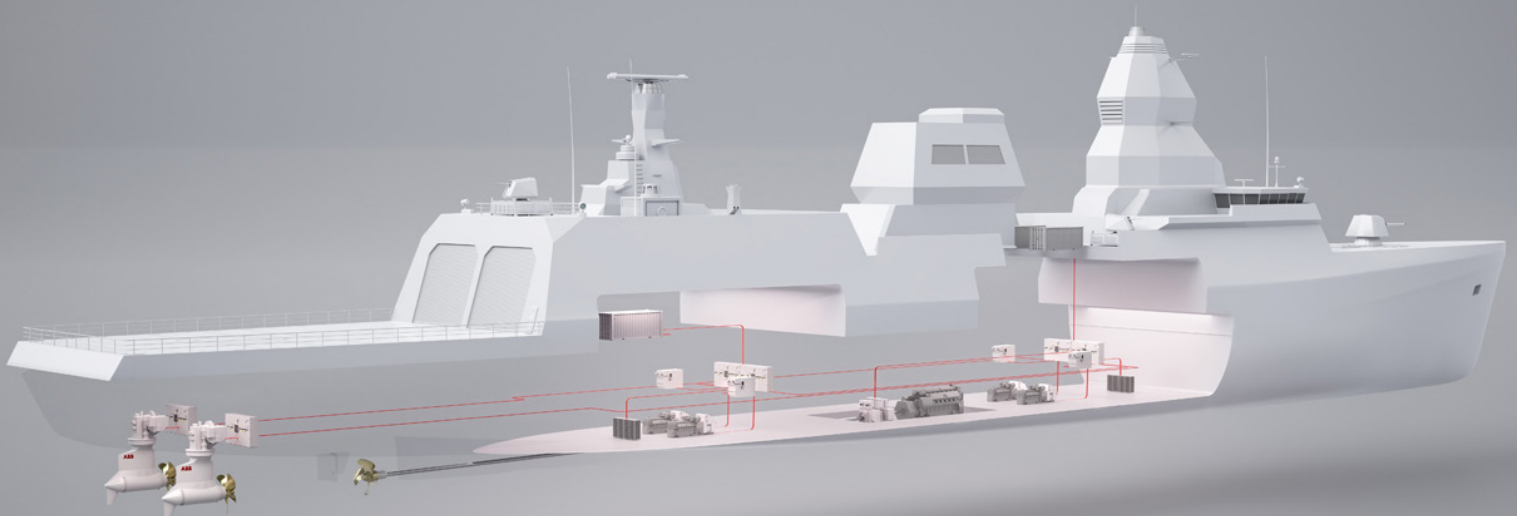
Future energy – readiness and power system selection

Adopting energy-efficient power and propulsion also promotes energy independence by future-proofing power input and distribution for new energy sources as the world comes to rely less on fossil fuels. These are predominantly based on Direct Current (DC), so implementing modern onboard DC grids provides readiness for these future systems, negating the need for intrusive and expensive power-electronics upgrade paths. "DC systems also offer considerable benefits over Alternating Current (AC) configurations, which require more bulky and numerous components taking up space and needing more maintenance," says Johansen.

Outlining the key considerations that naval purchasers need to assess when selecting a power system to optimize adaptable mission demands for a given platform, he says: "As engineers with a predominantly commercial background, we need input from the users to design the optimal electrical system. This is a very important part of the process. Investigating the vessel's operational profile is the starting point to make the best system. These parameters include power demands, duration, mobility needs, and special factors such as environmental constraints."

Depending on mission duration and availability of power sources, energy storage is also becoming an increasingly important element of new solutions. "We need

Render of a fully optimized navy vessel including Azipod® propulsion & Onboard DC Grid



to evaluate different energy storage system options, such as batteries of varying chemistries or, potentially, fuel cells as they reach an increased level of technology readiness. Critical factors include energy density, rechargeability, safety, and lifespan," Johansen says.

"We also need to assess the available power source options, which must align with both mission constraints and requirements. For example, the need to run in silent mode or on pure battery power may require additional storage capacity to serve the required loads."

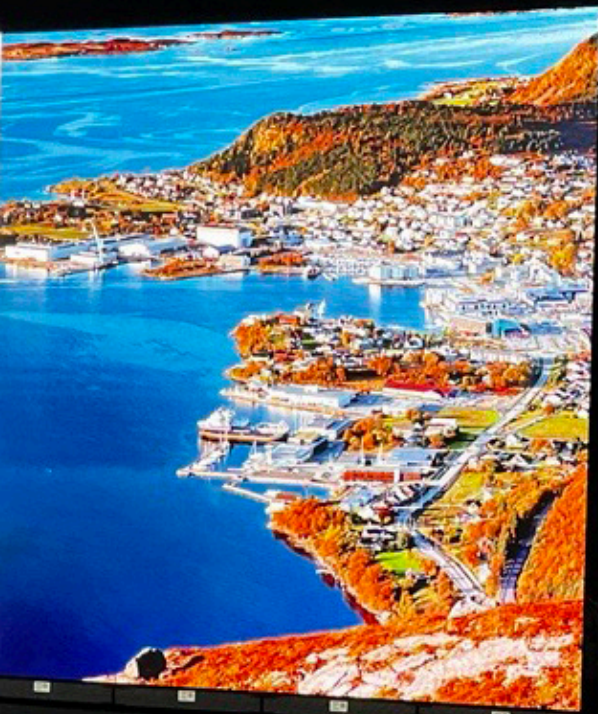
In terms of power system efficiency, the more electrical conversion steps can be minimized, the less losses there will be. "Efficiency is crucial in adaptable missions to optimize resource utilization and minimize fuel resupply needs. Power systems that offer high efficiency and low fuel consumption will extend mission duration and reduce logistical burdens," Johansen adds.

Adaptable missions can require the ability to scale up or down the power system based on changing requirements. Designing power systems that offer scalability and modularity allows for easy integration of additional power sources or load components when needed.

Mission criticality and reliability are additional important factors. "When evaluating reliability, factors like failure rates, maintenance requirements, and the availability of backup and system redundancy should be considered together with the specific needs and constraints of your mission and the platform," Johansen points out.

As a taxpayer myself, I want those responsible to get the most out of my tax contribution to our Navy, but at the same time I want the Navy to have the best capabilities money can buy. This doesn't need to be a choice; with the right solution you can have the best of both.

Meanwhile, the desire for platform flexibility is gaining momentum with the increasing adoption of multi-role capabilities. "Now more than ever this is enabled by the capability of the power and propulsion plant. To achieve this, end-users should be required to interact not only with the yard and Tier One suppliers – the major engine manufacturers – but also with industrial partners supplying critical systems that have the required knowledge of technology," says Johansen. "Today, naval procurement rules often don't allow this when it would be most useful, but I hope that will change."



—
Egil Johansen,
VP Coast Guard
& Navy, ABB
Marine and Ports,
speaking at
Combined Naval
Event – May 2023

Benefits of partnering with OEMs

Johansen believes partnering with an OEM for electrical design and integration is particularly valuable: "Renowned OEMs have a proven track record and deep experience in electrical design and integration. They have likely honed their skills on numerous complex projects over time allowing them to provide the most effective solutions."

OEMs also have rigorous quality-control processes in place to ensure the highest standards. "They have no choice but to adhere to industry best practices and standards in order to minimize risk. Choosing an OEM with a reputation for quality assurance gives you confidence that your systems will perform optimally."

Established OEMs invest heavily in R&D to stay at the forefront of technological advancements, typically with access to the latest tools, software, and equipment for electrical design and integration. Leveraging this base can result in enhanced energy efficiency as well as functionality. "We believe many navy and coast guard vessels could benefit a lot from proven technologies that are already widely adopted, used and proven by the commercial sector. The process of ruggedizing these for naval applications bridges this gap in a cost-effective manner, benefitting from reduced development time and – certainly in the case of ABB – a global service infrastructure," Johansen says.

Strong ecosystem relationships

Furthermore, OEMs typically have well-established links with suppliers and manufacturers. "This is very important especially given uncertainties related to supply chains, with periodic bottlenecks, shortages, and price fluctuations. Having scale and the resulting buying power helps protect customers and programs," Johansen notes.

We believe many navy and coast guard vessels could benefit a lot from proven technologies that are already widely adopted, used and proven by the commercial sector.

Another important consideration is the need for global support and maintenance. "The return-to-base maintenance concept is being augmented for global supportability. A trusted OEM with service centers, parts in stock, and engineering competence around the world provides not only the required service network, but is also able to implement remote support capabilities at pace. This eases the burden on onboard maintenance crews while increasing platform availability," says Johansen.

Another core competence of any large OEM is obsolescence and lifecycle management. "It is imperative for large electrical OEMs that work across industrial sectors, selling tens of thousands of drives, motors, and breakers, to proactively plan for the future, following standards and in turn supporting their customers through the vessel lifecycle," he adds.

Finally, trusted OEMs have built their reputation on delivering successful projects and meeting customer expectations. "Working with an organization that is committed to quality instils confidence for key stakeholders. Established OEMs have the required depth of resources to deal with possible challenges. There's a simple reason why commercial shipowners select reputable OEMs and that's because we reduce their risk and keep them at sea longer, supporting their profitability. The same is true for navies, just substitute profitability with mission capability," Johansen says.

In conclusion, Johansen reiterates the growing desire for energy efficiency among naval stakeholders. "These kinds of projects of course take time to mature. The time spent taking a deep dive into the possible solutions and simulating outcomes helps optimize designs. At ABB, we have been delivering top-rated power and propulsion solutions to commercial shipping and coastguard fleets for decades and have a lot to contribute to the naval sphere, too. I am confident that more of these efficient designs will be realized in the coming years." •

Q4/2024

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Maritime electrification

Revolutionizing marine e-transport with the Megawatt Charging System (MCS)

Megawatt Charging System (MCS) is a universal standard for high-power DC charging, collaboratively developed by pan-industry experts. Its widespread implementation will strengthen the competitiveness of electric and hybrid vessels, as MCS-compatible vessels would be able to charge anywhere in the world. This is of increasing importance amid the pressure to realize zero-emission operations as part of the green transition.

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Leif Algermissen,
Global Product
Manager,
Onshore Charging
Systems,
ABB Marine & Ports

Introduction

MCS is a charging standard that combines selected IEC (International Electrotechnical Commission), ISO (International Standards Organization), and UL (Underwriters Laboratories Inc.) standards. It is specially designed for charging large commercial electric transport applications – everything from on and offroad to aviation and marine.

The standard has been developed by CharIN, the global association for e-mobility. The non-profit organization is dedicated to promoting standards for charging systems for electric vehicles. Several ABB divisions, including ABB Marine & Ports and ABB E-mobility, participate in CharIN working groups alongside other leading vendors and ecosystem stakeholders.

The MCS aligns with the holistic system approach CharIN adopted to create the Combined Charging System (CCS) global standard for charging electric cars, which details basic product and safety specifications. MCS standardizes the shoreside charger (converting AC grid power to DC), cable management and plug, onboard connection inlet and the secure data communication protocol that enables any vessel to 'instruct' the charger what it requires in terms of power.



—
MCS Connector
– the future
standard
interface
(Image credit:
Cavotec)

The strength of the local grid dictates the capacity of the charger itself and whether batteries will be installed for peak shaving.

The main focus of standardization is to achieve charging system interoperability, which in the marine context means that any MCS-compatible vessel can conveniently use a MCS charging station anywhere in the world – typically on the quayside in a port or harbor. This eliminates the need for a bespoke charging solution for each vessel. All vendors are free to design their own MCS setup for a specific location and grid strength, but all key components will be the same.

So far, DC charging solutions have been delivered together with the vessel, with connection and communication elements chosen more or less randomly by the manufacturer, which limits interoperability.

Driving decarbonization

The adoption of MCS will ensure widespread, reliable, and safe high-power energy transfer for battery-driven vessels, accelerating the transition from fossil fuel to electric propulsion and reducing emissions. By simplifying the infrastructure, the highly adaptable standard lowers the barrier to entry and improves the competitiveness of electric vessels in worldwide markets.

The MCS is designed primarily for smaller vessels including road ferries, tugs, yachts, research vessels, and inland waterway vessels (including river cruise vessels) that can be plugged in manually in port or other coastal locations. The standard also opens for automated connection if required, for example a charging station mounted on a wind-farm turbine foundation or any other offshore structure where passing vessels can stop and charge.

Moreover, standardization will lower the costs of charging setups thanks to mass production of components, thus driving business sustainability for operators.

Key features

HIGH POWER: Manual plugs are currently limited to around 1MW of power, which is equivalent to the power needed to supercharge two electric trucks with battery capacity of 500 kWh for 30 minutes generating a further 150-200 kilometers of range per truck.

However, MCS solutions are capable of delivering up to 3.75 MW of power (equivalent to supercharging the two electric trucks for 8 minutes) from a single plug (or double that for two plugs to charge larger battery packs). Delivering power efficiently at this level significantly reduces charging times.

TEMPERATURE MANAGEMENT: The major difference between MCS and other charging systems is stipulating an advanced liquid cooling system to manage heat generated during high-power charging. Level 1 is uncooled, Level 2 is cooling of the cable and plug(s), while Level 3 for maximum power requires cooling of the vessel inlet in addition to cable and plug(s).

RUGGEDIZATION: Similar to heavy-vehicle mining applications, marine MCS solutions will be designed to cope with the harsh environment. For example, the IEC standard plug for land-based charging is currently made of plastic, but marine use cases may necessitate the use of more durable lightweight materials, due to the harsh salty environment. Connecting the plug to the vessel inlet will continue to be manual, although the standard also opens for automation of this process if required.

REGULAR CHARGING: Vessel battery packs should be maintained at a certain range of their capacity in order to extend their lifetime. Easily accessible MCS charging facilitates this requirement, preserving asset integrity and return on investment.

USER FRIENDLINESS: DC charging already reduces the equipment required on vessels (bulky transformers that take up space) to convert grid AC power to DC by transferring conversion to the shore side. The standardized plug, secure

communication protocol and cooled cables in turn make the shoreside MCS solution lightweight and easy to handle.

SAFETY AND SECURITY: Integrated safety mechanisms including overcurrent protection, insulation monitoring, and emergency stop functions to ensure the safety of equipment and operators. The MCS communications protocol is encrypted for cyber security.

Far-reaching benefits

The adoption of MCS can contribute to driving decarbonization in the maritime industry, avoiding greenhouse gas emissions and reducing reliance on fossil fuels.

Noise- and emission-free operations benefit both the broader and local communities, while both ferry passengers and crew onboard other vessel types benefit from improved travel comfort and working environment thanks to less vibration. Global adoption can also help improve local air quality within ports and in urban areas surrounding them.

Adopting electric vessels and MCS can help vessel and port operators safeguard reputation as well as meet sustainability goals, and potentially meet stricter investment criteria.

By minimizing downtime with faster charging, MCS can also enhance operational efficiency, fleet productivity, and profitability. Charging time will of course vary depending on the vessel battery size and operating profile (consumption per trip).

Electric vessels have inherently lower operational costs compared to traditional fuel-powered vessels (diesel engines require constant maintenance), while MCS charging solutions will in future be CAPEX-effective thanks to the lower cost of mass-produced components.

The MCS can also benefit vessel owners indirectly as second-hand vessels equipped with an MCS inlet can potentially hold their value and be easier to sell in a global market where MCS is standard, with the new owners enjoying a cost saving for second life (i.e. no adaptation/retrofitting of the vessel required).

Robust market outlook

Increasing interest in the electrification of marine transport due to tightening global and regional environmental regulations and sustainability goals of vessel operators and ports/harbors, as well as governments, will see growing demand for MCS, with the potential for widespread adoption in ports and coastal areas worldwide.

Public and private sectors are likely to make significant investments to develop and deploy MCS infrastructure. The U.S. government, for example, has allocated over \$220 billion under the Bipartisan Infrastructure Law for various infrastructure projects, including clean energy transport. This includes funding for the development of high-power charging systems like MCS.

In Europe, the European Investment Bank and European Commission have committed over €1.5 billion for alternative fuels infrastructure, including MCS, as part of the Alternative Fuels Infrastructure Regulation. This will incentivize shipowners to order, and shipbuilders to deliver, zero-emission vessels where fully electric operations are feasible.

Amid continuous improvements in battery technology, collaboration among industry stakeholders will be essential to implement MCS across different regions and vessel types.

20+ years history in marine electrification

ABB Marine & Ports can today design and deliver high-power charging stations that can supply up to 2x 3.75 MW power output with two MCS plugs. Solutions will be engineered to fit the location and local grid, but the components will be the same. A full 'grid to propeller' solution would include both vessel-side inlet and DC power distribution, ie Onboard DC Grid™, civil works, as well as the shoreside charging station containing the transformer, if in scope, eHouse, communication controller, and the cable management system.

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Cruise vessels
docked in Port of
Juneau, Alaska,
United States



Customers choose ABB because of our domain expertise and long experience in integrating high-quality power electronic packages. ABB has been providing shore power for over 20 years since an initial contract with Princess Cruises in Alaska.

A pioneering deployment

ABB plans to deliver its first MCS Level 3 charging station in early 2025, marking a significant milestone as an industry leader in marine electrification.

The shoreside turnkey solution will be commissioned by Auckland Transport (AT) in New Zealand to charge its new all-electric and hybrid-electric passenger ferries operating in the Hauraki Gulf. Replacing conventional diesel-operated ferries, the new 200/300-passenger vessels are estimated to help AT cut diesel use by 1.5 million liters annually, and CO₂e emissions by 4,000 metric tons, equivalent to the annual emissions of around 90 diesel buses.

ABB will work with local partners to install complete charging stations in different terminals, each featuring a pair of 1.65MW chargers. The crew will handle the connectors during passenger turnarounds.

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EV Maritime
EVM200 ferry
for Auckland
Transport,
New Zealand
(Image credit:
Auckland
Transport /
EV Maritime)



In terms of charging capacity, the MCS solution in Auckland is similar to ABB's landmark project to support 10 all-electric ferries for public transport agency Transtejo Soflusa in Lisbon, Portugal.

Conclusion

Amid ongoing innovation and collaboration driving the future of marine electrification, the MCS standard represents a crucial step towards the implementation of sustainable and cost-efficient charging solutions on a global scale.

ABB expects more operators to opt for the MCS standardized interface in line with other industries, together strengthening the competitiveness of electric and hybrid vessels worldwide. •

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First all-electric
ferry drives
emission-free
river commute in
Lisbon, Portugal.
(Image credit:
Astilleros Gondan)



Weather routing and voyage optimization

The APAC perspective

ABB invited Esmond Yong, Sales Director, APAC, Routing Services, ABB Marine & Ports, based in Singapore; Sallum Andaya, Senior Route Analyst, Routing Services, ABB Marine & Ports, based in Manila, Philippines; and Capt. Kevin Knott, Fleet Performance Manager at BW LPG, a world leader in liquefied petroleum gas (LPG) shipping, based in Singapore, to share insights into the weather routing landscape in APAC. We discussed the regulations, trends and challenges, and what makes ABB Routing Services unique – as well as other steps BW LPG, a global player with a fleet of around 40 vessels, has taken to improve fuel efficiency and reduce emissions.

Weather routing has already been widely adopted by the shipping industry as one of many measures to reduce carbon footprints and combat the negative impact of shipping on the environment. A leading global provider of weather data for voyage optimization, ABB Marine & Ports recently expanded its portfolio by completing the acquisition of DTN's weather routing business for shipping, and now caters to more than 15,000 vessels globally. New applications include ABB Ability™ Ship Performance Optimization System (SPOS), ABB Ability™ Routeguard – Onshore Routing Service, ABB Ability™ Fleetguard – Vessel and Weather Monitoring, and, most recently, Optimal Speed Routing. The vessel and weather monitoring Application Programming Interfaces (APIs), enabling integration with third-party platforms, were also part of the transaction.



Esmond Yong,
Sales Director,
APAC,
Routing Services,
ABB Marine & Ports

Providing a snapshot of uptake by shipping companies in the APAC region, Esmond Yong says that in a recent survey conducted by ABB Marine & Ports, 91 percent of respondents absolutely agreed that weather data is necessary, but it seems few capitalize on the power of integrated data. "Furthermore, only two out of three shipping companies actually feed weather data into their systems, and of those only 10 percent have fully integrated data for use cases where weather data is required. However, we clearly see that recent International Maritime Organization (IMO)



—
Capt. Kevin Knott,
Fleet Performance
Manager,
BW LPG

regulations such as the Carbon Intensity Index (CII) and decarbonization agendas are accelerating the adoption of integrated weather data to support business-critical decision making," Yong notes.

All three interviewees agree that typically shipping companies in APAC – although not all, of course – are not as quick to adopt new technologies as their Western counterparts. "One example is when satellite communications first became available, Scandinavian and European shipping companies were the first adopters, followed by Asian companies some years later," says Yong. "We see the same general trend in decarbonization, with European companies moving faster given the inclusion, for example, of shipping in the EU Emissions Trading Scheme [ETS]. However, China and the bigger trade partners in Asia are implementing, for example, the IMO fuel data collection system (DCS) within their waters, which is very positive."

Capt. Kevin Knott notes that, historically, shipowners everywhere have tended to be very conservative when it comes to embracing new technology and digitalization, until regulations force the issue. "In the case of weather routing services, certainly when I was at sea back in the 70's, 80's and 90's and before satellite communications, weather routing was viewed with a degree of caution, and justifiably so in some cases because of inaccurate data. A master, for example, may have been sceptical because they may have felt they knew more,

based on their long experience. And there probably were instances where ships being weather routed found themselves in a worse situation than if they had depended on the master's knowledge and skill."

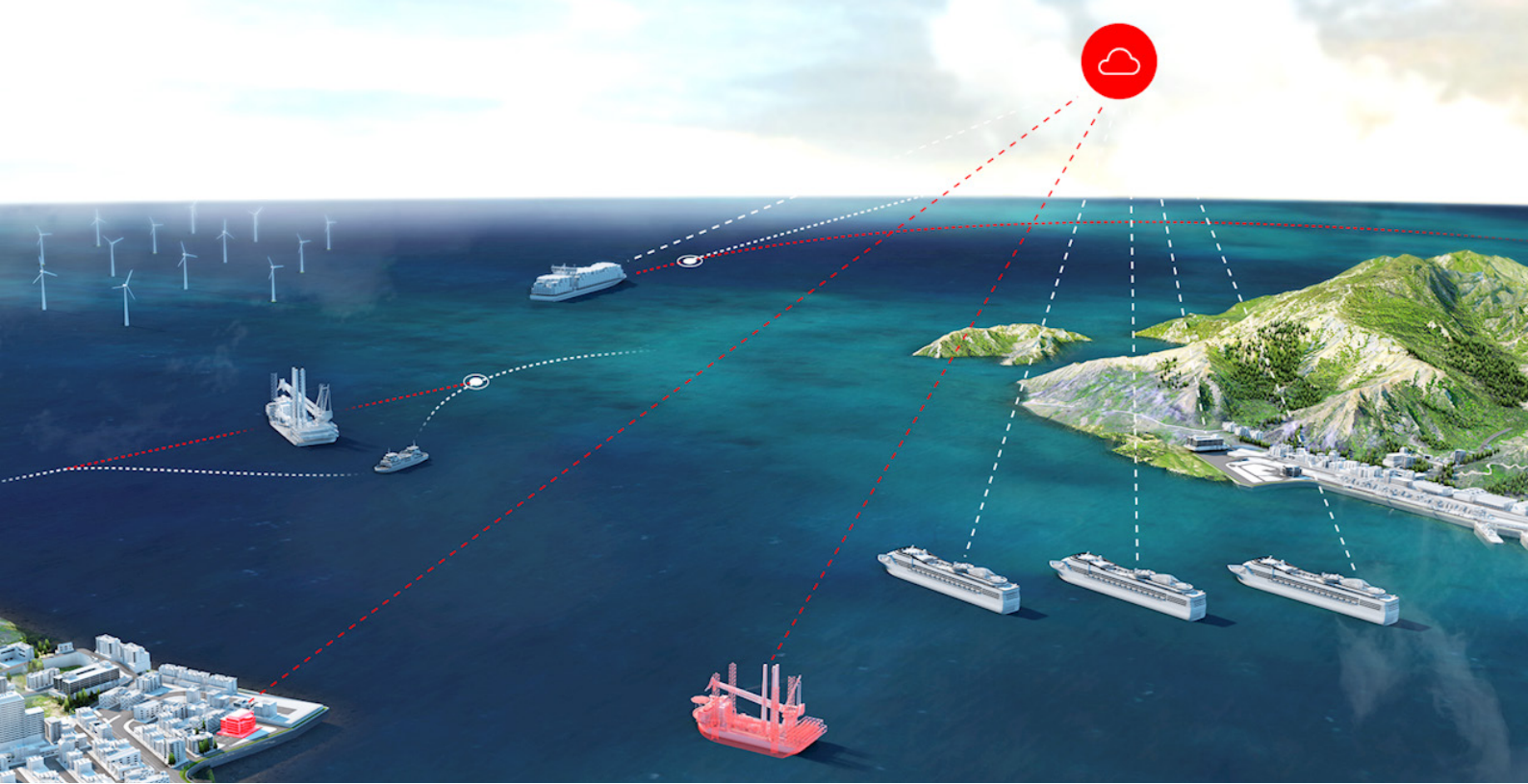
However, he adds that "with the latest forecasting technology, the availability, accuracy, and frequency of the data is exceptional, so it's a great tool for routing and voyage optimization. The primary objective for BW LPG is and always will be safety – of the crew, the ship, and the cargo – but with the additional benefits of just-in-time arrival in port, operational efficiencies, and emissions reduction. Fortunately, BW LPG has always been a first-mover. We recognized quite a few years ago that weather routing is a very viable, cost-efficient, and, as it's turning out, environmentally positive decision."

Only two out of three shipping companies actually feed weather data into their systems, and of those only 10 percent have fully integrated data for use cases where weather data is required.

Although the results may be subjective, BW LPG's many different trials of weather-routed single voyages have shown that, depending on the time of year, fuel savings of up to 5~7 percent are achievable. "I'm comfortable stating that in the years we've been using ABB Routing Services, and before that DTN and MeteoGroup, we have seen some very promising results with regards to fleet annual fuel savings," Knott says.

He also likes to call ABB Routing Services 'traditional' weather routing in as much as there is still human interaction between ABB's route analysts and BW LPG's masters, second officers, and deck officers. "It's by no means a passive process. They can always pick their own route if they have good reason, but they certainly understand the benefits."

BW LPG also uses ABB Routing Services' post voyage analysis for continuous improvement. "We try to optimize all our voyages in terms of increasing or decreasing speed depending on the weather conditions underway and the predicted conditions for the days in advance. This allows the ship to complete the voyage in the most fuel-efficient way and maintain or hopefully even improve its CII rating," says Knott. "Sometimes we see different results from similar ships doing similar voyages at similar times. They aren't huge but it does point to the human factor; for whatever reason the master, chief engineer or other officers are technically operating the ship in slightly different ways. Obviously if the gap was big, we would have to investigate further."



BW LPG has also been instrumental in suggesting new functionality. "After each voyage, in addition to a post voyage analysis, we also receive a savings report. Each quarter we present to our Board theoretical savings utilizing weather routing services. The savings report is very useful as it justifies using the service," Knott says.

We see a general trend in decarbonization, with European companies moving faster given the inclusion, for example, of shipping in the EU Emissions Trading Scheme.

Trends and challenges

Knott says decarbonization regulations have definitely influenced the increased adoption of weather routing and voyage optimization systems as part of shipping companies' sustainability efforts. "The need for vessels to not only comply with present emission requirements but to continually meet or better even more stringent targets in the future has accelerated the need to adopt fuel-efficiency best practices."

He believes weather routing will soon be commonplace for Asia-based operators, too. "Given the tightening regulations, everybody will have to increase their focus on emissions. Until such time that new zero- or low-CO₂ (footprint) fuels are readily available and practicable cost-wise, slower steaming, and voyage optimization are the only ways you can realistically reduce emissions."

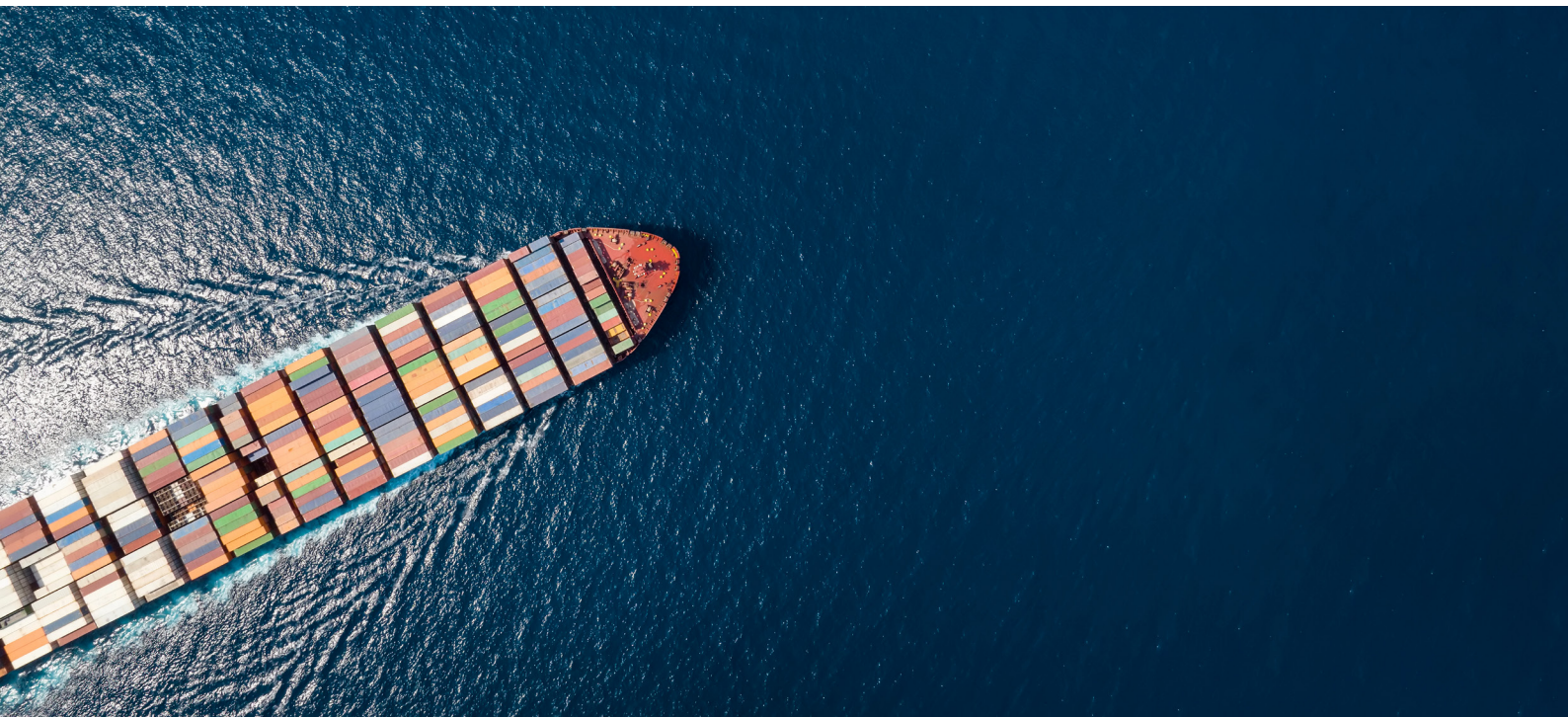


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Sallum Andaya,
Senior Route
Analyst,
Routing Services,
ABB Marine & Ports

Andaya notes that total voyage costs will also increase as result of the cost of emissions and more expensive alternative fuels. "The main goal is to save on fuel while keeping the vessel away from bad weather. This type of optimization is more complex than traditional weather routing as it requires input from more sources. In addition, whereas weather routing companies traditionally dealt directly with the ship's captain, now there is significant involvement of shore-side operators and vessel/fleet performance teams."

He acknowledges that weather routing services can't always be 100 percent accurate. "Most of our advice is based on the personal experience of our route analysts, who are all former seafarers. We should be able to defend why we are recommending a particular route versus just a straight path. Some masters can be hard-headed when you advise them in this way – as a former seafarer myself I understand the mindset that 'this is the route that we've always taken, why change?'. But now with global warming and climate change you have to think differently. That can be a challenge but when we explain our rationale, masters are more than happy to start a fruitful collaboration."

Moreover, climate change will potentially lead to a lot more instances of severe weather. "There is clear evidence of this globally," says Andaya. "For example, recently four tropical systems arose in close proximity off southwest Mexico, which is highly unusual. One tropical storm is already a headache for route analysts, but four in the same place at the same time is very worrying. And right now [at time of writing] there's two hurricanes building up side-by-side off the US West Coast. This is proof enough of climate change for me."



Knott says this strongly reinforces the business case for weather routing, especially in typhoon-prone Asia. "The main driver is safety, and as we enter this uncertain time of dangerous weather systems, it makes even more sense. The weather is by nature dynamic, but weather systems happening outside the normal seasons definitely lend themselves to efficient weather routing and voyage optimization."

Measuring vessel performance

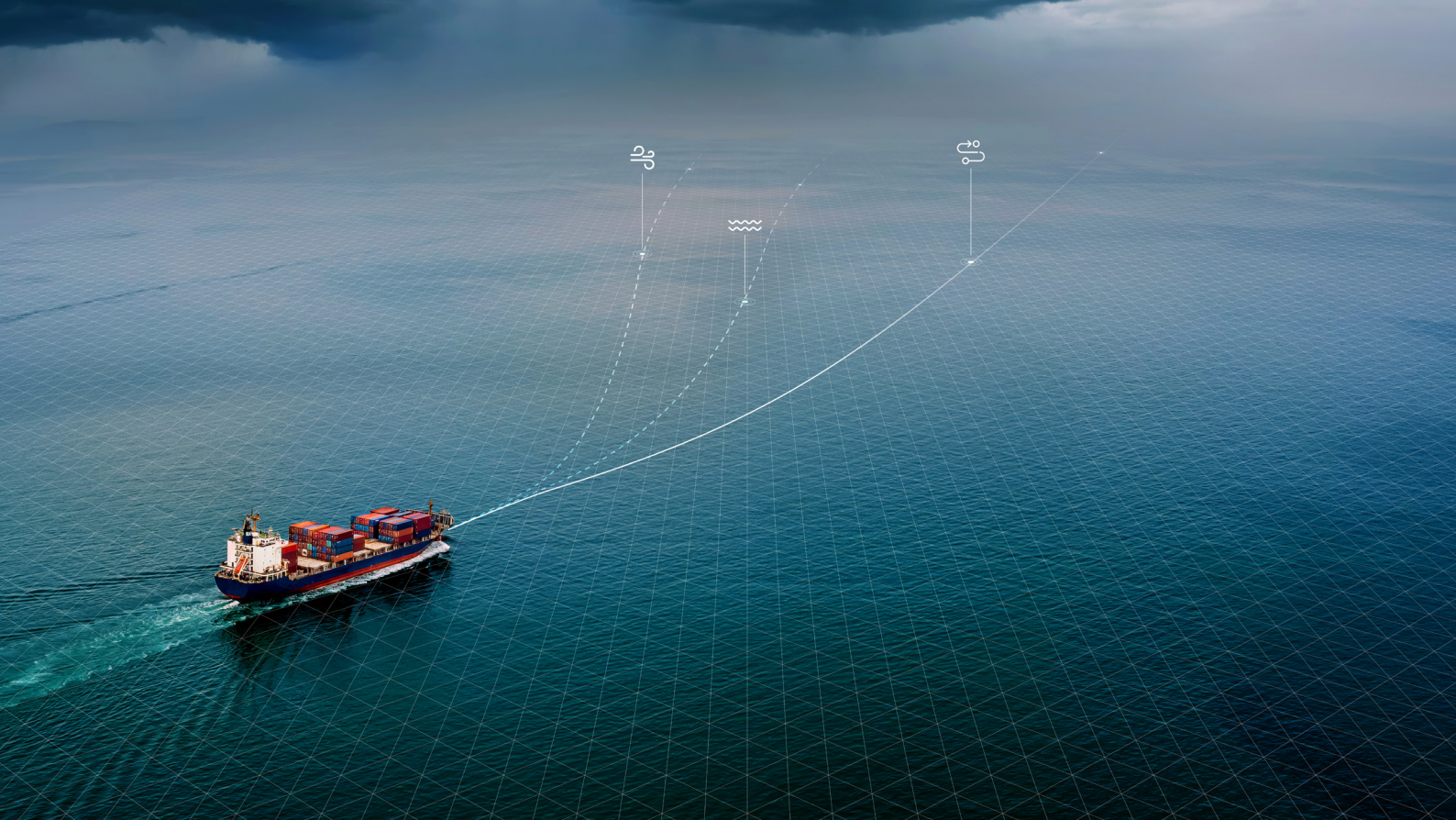
Yong says vessel performance evaluation is impossible without a proper weather routing algorithm. "To put it very simply, we plot the ship's performance through its voyages based on high-resolution weather data, Automatic Identification System (AIS) position and our different standard ship profile libraries of consumption data. But we can improve this further if the owner, like BW LPG for example, provides us with ship-specific data so we can drill down to ship-specific performance."

One aspect of weather routing and predictive forecasting that some may find counter-intuitive is that on any trade the shortest distance is not necessarily the most efficient. "Our routing algorithm runs the vessel based on its condition and the charter party clauses whereby it can actually travel a longer distance, but still save more fuel and reduce CO₂ emissions thanks to proper weather routing. A longer distance with lower consumption gives a better CII rating instantly," Yong says. "Think of it like real-time driving directions for a certain journey you want to make – the app will find an alternative, better route to avoid traffic. Then apply that to a ship deviating around heavy weather."

With the latest forecasting technology, the availability, accuracy, and frequency of the data is exceptional, so it's a great tool for routing and voyage optimization.

ABB sets the benchmark

Post voyage analysis is particularly important for charterers who may be unsure about a particular voyage and ask the client to provide a post-voyage report. "Which we of course are happy to provide," Andaya says. "The three main parameters we set are speed and Heavy Fuel Oil (HFO) and Marine Diesel Oil (MDO) consumption, and taking the weather into account, we can see if the vessel has met the specified performance or not. Sometimes a master on his own judgment has slowed down to 12 knots, for example, when we advised him to proceed at 15 knots. We have to analyze why the ship didn't perform optimally speed-wise on that particular part of the voyage, which could lead to a legal tussle."



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ABB's Optimal
Speed Routing

Yong adds that some shipping companies shop around until they find a weather routing provider that will give a report in their favor. "That's a challenge, because who sets the benchmark? Thankfully, we have been providing the service since 1986, so our reports are trusted and generally considered to be the benchmark."

Further efficiency innovations

Weather routing is just one feature of the technology landscape aimed at improving vessel efficiency and sustainability, Knott points out. "At BW LPG we are also proud that we were the first shipping company, not only in Asia but globally, to convert a total of 15 Very Large Gas Carriers (VLGCs) to dual-fuel capability with Liquefied Gas Injection Propane (LGIP) main engines. We made the investment four to five years ago as the vessels went into drydock. This has resulted in measurable fuel efficiencies due to the lower carbon footprint of Liquefied Petroleum Gas (LPG) – either propane or butane – and the increase in calorific value versus the compliant Heavy Fuel Oils (HFO) or Light Fuel Oils (LFO) they were using before, so we burn less fuel ton-to-ton with lower emissions as a result."

At the same time the vessels went into drydock, BW LPG invested in high-spec anti-fouling hull coatings that have also proven to be very effective. "We inspect the hulls every six months and do a propeller polish at the same time, but so far none of the ships has required hull cleaning. That also means burning less fuel and less emissions, so it was definitely worth the initial outlay," Knott says.

BW LPG has also led the way in adopting a hardware/software system on all its in-house managed ships that streams real-time data from any piece of onboard equipment with a digital output. "This allows accurate and timely data collection, continuous monitoring, and subsequent analysis of equipment performance. All the data is processed in the cloud and presented on a dashboard visible both to masters and chief engineers, as well as the office. The platform integrates AI elements for Total Fuel Oil Consumption (TFOC) analysis and can be used to schedule maintenance much more effectively together with the ships' existing planned maintenance systems."

In the years we've been using ABB Routing Services we have seen some very promising results with regards to fleet annual fuel savings.

First in the market with Optimal Speed Routing

Addressing what ABB can provide that others cannot, Yong flags up the ABB Routing Services' new Optimal Speed Routing endpoint service – a unique route optimization algorithm where track and speed are optimized simultaneously to minimize voyage costs while keeping the vessel safe. "We optimize from waypoint to waypoint instead of the whole journey at a single constant speed. That may mean the vessel slows down for the first half of the voyage, then speeds up to avoid bad weather. As far as I know, no one else is currently offering this capability."

Andaya adds that the core objective of Optimal Speed Routing is to calculate if a vessel is overspending on fuel during a particular voyage. "We look at the difference between routes, for example a direct route and the route we provide, and can demonstrate to the client which is more efficient just based on distance. Again, the shortest route is not always the optimum route, which has resulted in significant savings for many customers."

Digitalization drives demand

Yong says the great benefit of digitalization is that it brings all stakeholders together around one table. "Everything is being simplified, with everybody being able to access the same platforms. With ABB Routing Services you just need to look at the portal and you know what's happening. There's also been a huge reduction in email communications, which not only makes life much easier for all parties, but at the same time transfers a lot of decision-making from the master to the shore. Traditionally the master always bore a big responsibility for the safety and performance of the vessel, but now that burden is shared. A lot of shipping companies have even built their own fleet performance centers where voyage planning is decided. It's a complete paradigm shift."

Andaya adds that there is much greater shore-side visibility thanks to increased connectivity. "This is behind the growing demand we see for integrated platforms where our Route Analysts, office-based vessel operators, and crews can work together to achieve voyage optimization goals. As Esmond Yong says, this not only slashes the number of emails, but also means that instead of software installed only on a vessel, optimization can run in the cloud using much higher-density and real-time updated data sets, which significantly improves the route calculations. So, digitalization is making voyage optimization easier to use, more transparent, accurate, and accessible."



Reducing impact of container losses

ABB weather routing can benefit the environment in other ways as well, Yong says. "For example, our algorithms can integrate with the seakeeping capabilities of ABB Ability™ OCTOPUS – Marine Advisory System to prevent loss of containers overboard due to bad weather. This has been a big problem for liner operators in recent years, leading to considerable negative environmental impact – especially if the container is carrying, for example, batteries or other hazardous cargo that can potentially destroy ecosystems – and not least navigational hazards, especially in busy seaways. Back in winter 2021, the global container only in July the fleet lost 3,000 containers at sea and in July a 18,000-TEU vessel lost close to 44 containers due to bad weather. We are helping to counter this risk with our SPOS seakeeping tool, which calculates routes that avoid significant ship motions (also known as parametric rolling), incorporating ship-specific 3D hydrodynamic modeling into the voyage optimization logic. And we're seeing a lot more lines adopting this solution to help keep containers safely onboard."

We try to optimize all our voyages in terms of increasing or decreasing speed depending on the weather conditions underway and the predicted conditions for the days in advance.

Industry partnerships driving change

An increasing number of industry partnerships are taking shape across the world, embracing stakeholders including government agencies, independent organizations, shipping companies, and other interested or invested parties, who are working to reduce CO₂ and greenhouse gas emissions and promote maritime sustainability. In Asia, Knott highlights the Global Centre for Maritime Decarbonization (GCMD) in Singapore, which is jointly sponsored by shipping companies, the Singapore Maritime Port Authority and others to investigate new fuels and accelerate decarbonization.

"On a more granular level, an increasing number of service providers are willing to share data through collaborative digitalization, benefiting both themselves and the end-users of their platforms. A particular example is sharing live data from ships with paint manufacturers, allowing them to analyze the effectiveness of hull coatings," he adds.

Yong agrees wholeheartedly. "More service providers and system integrators globally are collaborating with shipping companies to jointly develop new sustainable solutions. Many have set up shop here in Singapore not only because

it's a maritime hub, but there's also a lot of government initiatives, including the GCMD, to help with research and tech-start programs."

ABB Routing Services is a case in point. "We're not just a data service for owners like BW LPG. We also provide relevant weather data (historical and predictive), routing algorithms, and voyage performance data through APIs to technology developers, enabling them to offer a range of solutions including safety of navigation. For example, we furnish the A*STAR Institute for High Performance Computing (IHPC), part of the Singapore government's A*STAR Agency for Science, Technology and Research, with certain data sets to help them in their research. Their objective is to increase the sustainability, safety, and efficiency of Singapore's maritime ecosystem by translating research capabilities into deployable maritime solutions."

He adds that ABB has also been engaging with partners under the auspices of the GCMD to study the efficiency of rotary sails in different weather conditions. "We're contributing to research with our 25 years of high-quality weather data in different seasons in different parts of the world, to see if using sails on particular routes at specified times of the year will be effective."

With ABB Routing Services we can now contribute significantly to helping shipping companies reduce fuel consumption and emissions by ensuring the best weather-optimized route for every voyage.

In conclusion, Yong says the inclusion of advanced weather routing completes the jigsaw in the ABB Marine & Ports portfolio. "Up to now, we have focused mostly on energy-efficient equipment to spur decarbonization. However, with ABB Routing Services we can now contribute significantly to helping shipping companies reduce fuel consumption and emissions by ensuring the best weather-optimized route for every voyage. It's exciting because it plugs a missing piece in the holistic model we can offer to the industry." •

Images credit: ABB

Future-ready terminals

AI powers smart solutions for container handling

Amid the growing shift towards more automated operations across the maritime industry, container terminals are facing a key business challenge: how to markedly improve both operational efficiency and sustainability through the automation of previously manual, labor-intensive tasks? ABB technologies utilize Artificial Intelligence (AI) solutions to significantly improve data quality and productivity.

—
Dr. Remus Boca,
Imaging Scientist,
OCR Solutions,
Ports,
ABB Marine & Ports

Zhou Teng,
Imaging Scientist,
OCR Solutions,
Ports,
ABB Marine & Ports

Michael McMinn,
OCR Technology
Manager,
Ports,
ABB Marine & Ports

Introduction

Handling thousands of shipping containers per day requires robust automation often in challenging conditions. Many features of the containers and related equipment must be processed in order to ensure safe, secure, and efficient passage of containers in and out of terminals, as well as on site.

An automated terminal flow involves correct detection, recognition, and processing of identity elements of chassis, drivers, containers and terminal tractors – also known as utility tractor rigs (UTRs) – as an integral part of wider terminal operations. Optimizing terminal flow means getting containers on and off ships at the quay, loaded or unloaded from trucks and rail cars, retrieved from or stored in the terminal yard, and sent to their next destination as efficiently as possible. An optimal flow also reduces energy consumption and emissions. In manually operated terminals, these movements require human supervision. Optical Character Recognition (OCR), using cameras, has partially automated the process of identifying equipment IDs, but now AI has created even more opportunities to improve accuracy, detect additional features for automation, and reduce the need for manual intervention.

This article discusses how using AI together with state-of-the-art software and hardware solutions allows highly efficient and automated processing of



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Figure 1: ABB's Gate OCR system captures information on containers, trailers and chassis entering and exiting a truck gate, significantly increasing gate throughput. The portal is equipped with cameras, providing images on which AI models are applied

complex container handling. Building on its long history providing market-leading systems to ports and terminals globally, ABB has extensive expertise and experience in AI, deploying algorithms and cutting-edge components to provide industrial-quality, high-performance accuracy for many terminal tasks. The trend towards increasing the autonomy of terminal operations requires robust and reliable systems, with AI technology facilitating this evolution.

There are two basic deployment steps for AI visual recognition. Firstly, the system is trained on a specific dataset of images, so that it learns to recognize a multitude of objects in different settings and conditions. As the system developer, ABB always controls and validates what the system learns. After it has been implemented, the system can continue to be intentionally trained with new images so that it can recognize new features and equipment leading to optimal performance over time.

Sensitive cameras are key

The use of multiple corroborating cameras is both a prerequisite for and an advantage of successful AI systems. The cameras are used to monitor and track containers and other assets at different points within the terminal, capturing all the data required for systems to recognize the live images based on what they have already learned.

ABB has deployed AI technologies around the world and continues to build on this experience to create complete systems that meet the demands of next-generation terminal operations. ABB's AI technology-enabled systems are comprehensive, scalable, and flexible, delivering higher performance than anything previously available. Offered as part of newly deployed terminal solutions, or easily integrated with existing solutions as part of a site upgrade, ABB's industrial neural network models run on high-performance computational hardware designed for heavy use and lifecycle durability.



Figure 2:
Server rack
with embedded
computers
dedicated to
solving terminal
AI tasks

Operational benefits

ABB's AI technology-enabled systems not only help reduce emissions and save time and money through an improved container flow, but also prevent containers from getting lost as all equipment is identified with unmatched accuracy. Rapid identification of containers also enhances security – versus conventional systems where increased manual interventions result in containers being 'lost' for longer, thus increasing security risk. In addition, accurately recognizing containers that are quickly moving on and off ships means the TOS can be updated with correct information much faster. Due to significantly better read-rates, ABB's

AI technology-enabled OCR systems also help to eliminate instances of ‘false positives’ (i.e., when a container ID has been misread, but the data captured matches another existing box, the first container will continue to be moved around the terminal or on/off a ship as if it were the expected one). This avoids containers being sent to the wrong stack or destination, further improving efficiency and saving time lost due to errors.

Creating neural networks

As part of ABB’s OCR offering, the AI technology-enabled systems are developed through the creation of ‘neural network models’ that provide high-performance accuracy for:

- Hazardous placard detection and identification (at cranes, gates, and rail yard)
- Bolt seals detection (at cranes, gates, and rail yard)
- Container door direction (at cranes, gates, and rail yard)
- Container ID (at cranes, gates, and rail yard)
- Chassis ID (at gates only)
- Terminal tractor (UTR) ID detection (at cranes only)
- Equipment presence detection (i.e., AI system cameras take over the task previously undertaken by in-ground inductive loop sensors at gates).

In each application, the neural network models are trained to utilize images from multiple cameras that collectively have:

- Multiple directional perspectives of the container, chassis, or terminal tractor (UTR) to provide corroboration of the detected feature or OCR of the text
- A range of image quality reflecting environmental factors and other obstructions, such as changing light and weather conditions
- A range of resolutions that allow the integration of both old and new cameras with various features for light and color sensitivity for day and night operations.

The ability of an ABB AI technology-enabled system to support multiple types of camera technology (designed diversity) makes the solution more robust and provides a path for future upgrades to new-generation cameras.

How AI models are built and used in OCR solutions – the ISO/Domestic container example

Shipping containers are identified by a Container ID, which can be an ISO or a non-ISO format. A non-ISO format is sometimes called a Domestic Container ID as it is specific to the country or region where it is used. Domestic Container IDs are more challenging to detect and recognize because they can vary markedly in font style, size, and color, and location on the container. Their format can also vary, one of the most common differences being the absence of a Container ID Check Digit.

ABB's ISO/Domestic Container ID OCR solution is integrated with state-of-the-art advanced machine learning algorithms, frameworks, and graphics processing units (GPU) technologies. It can accurately read ISO and Domestic Container ID information including owner codes, serial numbers and size/type codes through cameras in real time without interrupting or slowing the containers' handling in the terminal. The solutions can be deployed in different kinds of container handling scenarios. These include entry and exit gates, ship-to-shore and stacking cranes, in the rail either at the entry or exit or on the processing tracks, as well as at off-site distribution centers. They can also handle the most challenging outdoor conditions, such as low light and harsh weather.

Building and improving the neural network models of an AI system typically follows this workflow:



Figure 3: General AI pipeline

A general AI pipeline similar to the one described above runs with the customers' on-site data and images to optimize the previously deployed AI models. The procedure to optimize ISO/Domestic Container ID neural network models after deployment is:

- During the data collection process, ABB collaborates with the customer to automatically and continuously collect and organize container images and image-related contextualized information in typical operating environments at customer sites day and night for a short period of time. The system supports one or more cameras running simultaneously to collect as many container views and perspectives as possible. This information includes accurate and validated information such as seal presence or container ID. The images can be used to create new or update existing neural network models with both known and unknown data sets.
- All newly collected container images are preprocessed with advanced semi-automatic annotation and data enhancement technologies to identify useful ID information and prepare them for use in neural network model generation and as inputs for the subsequent training.
- For model generation, the system uses each input image and predicts a result for the target feature, e.g. bolt seal, then compares the known values to the newly predicted values. Based on the comparisons it will update the model

parameters and repeat processing all the images in the training set until the model parameters converge to values that minimize the difference between the actual and predicted results. New AI models are fine-tuned with the new container images. The Container ID OCR solution has multiple advanced AI models that handle different tasks and all of them will be optimized with new container images. The resolutions and quality of the images vary greatly depending on the site, age of the deployment, and other uses of the technology. Specific techniques are used to optimize the quality of the container elements during pre-processing and training.

- The newly generated AI models are tested and evaluated with a set of images from the site with known results, and different from what was used in the neural network model generation, to demonstrate meeting or exceeding the performance goals.
- The model is now ready for deployment, the final step in commissioning an AI technology-enabled system on site. The ABB system is designed to be easily updated with new models. The graphics processing units (GPU) are used in a pool where the system knows to use the next available unit for processing. As such, if one unit is taken offline for updating with a new model, the entire system is not affected as it will continue to operate with the available units. This allows for a seamless update of models during operations if required.

The on-site performance accuracy is generally greater than 98 percent. Using AI, new models can be easily deployed to the current container ID OCR system, meaning accuracy can be continuously improved as the system is taught to identify more variations.



Figure 4: Example outputs of the container ID OCR system for ISO/ Domestic ID containers

Advanced AI-enabled container handling examples

ABB also provides many other AI technology-enabled systems for different important tasks in port automation, such as hazmat placard detection and recognition, bolt seal detection, container door direction, and equipment presence (truck and chassis) detection using 3D cameras and AI instead of in-ground inductive loops (inductive sensors embedded in the road surface at gates). All these AI systems are integrated with state-of-the-art advanced machine learning algorithms, frameworks, and GPU technologies and deployed in different kinds of on-site application scenarios if needed, at the gates, on the cranes, or in the rail yard.

ISO/Owner chassis ID OCR

The chassis OCR solution can accurately find and read ID information of ISO or non-ISO chassis, also called owner chassis. Owner chassis are not marked or identified in a standard way like ISO chassis, which can create challenges for accurate identification. Figure 5 illustrates the results of the ISO/owner chassis OCR system.



Figure 5: Example results of the ISO/owner chassis ID OCR system

Trailer ID OCR solution

Similarly, the Trailer ID OCR solution can accurately read identification information of certain trailers in which additional image features, such as trailer company logos, are utilized to help locate and recognize challenging trailer identification information. Trailer IDs are unique compared to Container IDs, which are reasonably well formatted. The trailer identification system uses both the logo and the text on the trailer for accurate identification. This requires the AI system to evaluate the entire image, and then match the logo to what it has already learned. The system will combine the AI results of both the logo and the text recognition to create the trailer ID based on local business guidelines. For example, Figure 6 illustrates the outputs of the Trailer ID OCR system for UPS trailers, whose IDs usually appear in small sizes at the corners of all trailers. The system can be trained to identify the trailer type and follow a defined process to locate the ID for that specific trailer type.

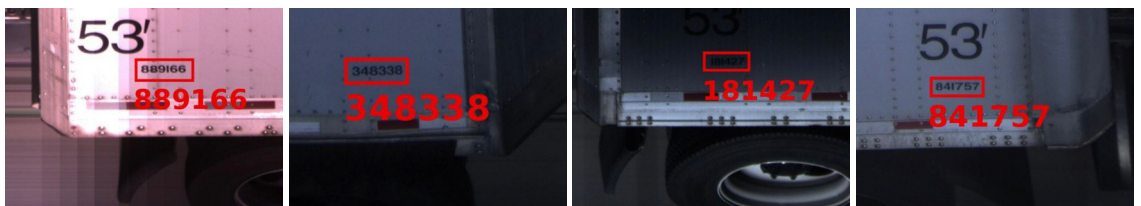


Figure 6: Example outputs of the trailer ID OCR system

Terminal tractor or Utility Tractor Rig (UTR) ID OCR

The UTR OCR solution can accurately read identification information of all UTRs running at customer sites and facilitate the processing efficiency of container transactions. Figure 7 illustrates the output results of the system. In addition to detecting the UTR ID, the system can determine the direction of the tractor based on the tractor features – not the ID – and ensure the correct tractor is being used in the hand-off of the container.



Figure 7: Example results of the UTR OCR system

Container door direction solution

The door direction identification solution can accurately recognize each side of a shipping container and ensure each one is handled and stored in the correct way. This is especially important in the case of tank or refrigerated containers where the machinery end faces outwards for monitoring purposes. The door direction information is also necessary to achieve an efficient container flow in the terminal. Figure 8 illustrates the results of the door direction identification system.

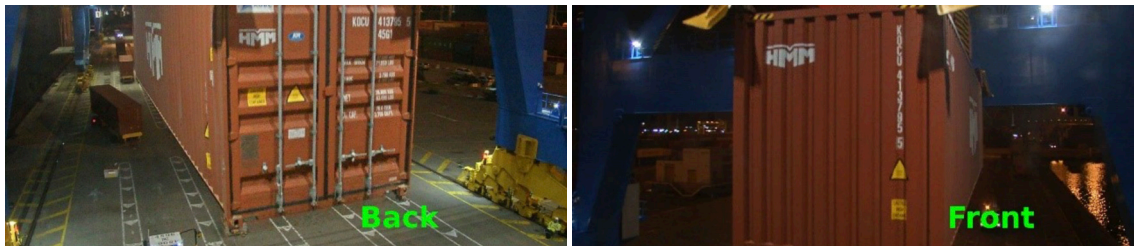


Figure 8: Example results of the door direction identification system

Hazmat placard detection and recognition

ABB's hazmat placard detection and recognition solution can detect and recognize all hazmat placards that are placed on different sides of a shipping container, ensuring the safe and correct handling of containers containing hazardous materials. Figure 9 illustrates the outputs of the hazmat placard detection and recognition system.



Figure 9: Example outputs of the hazmat placard detection and recognition system

Bolt seal detection

The bolt seal detection solution detects if high-security bolt seals appear at locking positions in the container back sides to ensure their safe transportation. Reliable detection of the presence or absence of bolt seals is important for liability protection of terminal operators. Figure 10 illustrates the results of the bolt seal detection system.



Figure 10:
Example results
of the bolt seal
detection system

Equipment presence detection

The AI-enabled equipment detection solution reliably detects the gap between trucks while tailgating. Tailgating with insufficient space between the trucks could previously lead to problems in vehicle detection, disturbing the efficient monitoring of incoming traffic and compromising access control. The high-performance vision sensor triggers IO signals at the start and end of each truck, enhancing reliability. This affordable sensor package can be mounted anywhere on the gate portal. Figure 11 illustrates the sensor package and example of images used to trigger IO signals.



Figure 11:
The AI-enabled
equipment
detection solution

Conclusion

Artificial intelligence has created more opportunities to improve accuracy and detect additional features in automated processes, making it possible for OCR systems to handle exceptional information and special cases with the same accuracy as standard formats. This has considerably reduced the need for manual intervention and improved efficiency.

ABB's AI-powered solutions for terminal operations comprise industrial neural network models using advanced algorithms and strong embedded computing power. The use of multiple corroborating cameras is a prerequisite for successful

AI systems, as they enable the systems' ability to continuously learn and improve. The system supports multiple types of camera technology, making the solution more robust and future-proof.

The accuracy level of ABB's AI systems is among the highest in the industry. Higher accuracy means improved container flow, enhanced security and data quality, and delivering increased terminal throughput. Higher numbers can be achieved for each customer over time through machine learning and AI-based site optimization (model fine-tuning) accommodating changes in the environment or in the features of interest. The system can be easily updated with new models during operations, if required.

All types of terminal AI solutions including text recognition for Container ID, chassis ID and UTR identification, image recognition of trailer logos, detection of hazmat placards, seals and door direction, and equipment detection have been deployed and proven at customer locations around the world. The resulting increase in efficiency saves costs and time, ultimately leading to improved terminal competitiveness.

Machine learning systems work best when they are fed with the correct and relevant information during their training phase, so domain expertise should not be underestimated. ABB's AI technology-enabled systems are robust under different conditions, rapidly providing high accuracy. They require low levels of manual intervention and help to improve the performance of the terminal. Understanding the fundamentals of what OCR systems can deliver, as well as the speed and accuracy following the use of AI technology, brings new insights on the potential of OCR systems. •

Images credit: ABB

Using AI in the marine industry

Artificial intelligence (AI) has made it possible to ask the internet for its best answer to any question. However, the human in the loop remains best placed to offer guidance on how, why and when shipping customers benefit from data-enabled solutions.



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Kalevi Tervo,
Corporate
Executive
Engineer and
Global Program
Manager,
ABB Marine & Ports

Generative AI (GenAI) uses large language models which learn from the patterns and structure of available data. Inspired by its ‘training data’ it can create fresh text, images or tunes based on new data with similar characteristics.

To the general public, it may seem like AI is something new, but this is far from the truth. Like many IT developments, AI's roots extend back half a century or more. What is new from the application perspective are the language models of Generative AI. It is also a tale of trying to find the most useful applications for this extraordinary tool.

We believe in using AI when it makes sense.

Industry stakeholders will know that this longer story includes plenty of content from the maritime industries, but may be less aware that it is ‘analytical’ AI which marine systems have used to improve efficiency, optimize ship performance and advance efforts towards decarbonization.

This type of AI focuses on analyzing structured data and uses statistical methods to mine data for patterns, trends and correlations on which to base the machine learning algorithms that predict output values from a given set of input variables.

Kalevi Tervo, Corporate Executive Engineer and Global Program Manager at ABB Marine & Ports says that ABB has been using its deep sector experience and domain expertise to discover the opportunities with established analytical AI for many years. According to Tervo, Analytical AI has become “a natural part of our automation, service and routing solutions”.



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Image credit:
Adobe Stock

Making sense of AI

“Combining the new possibilities brought by AI and ABB’s domain-specific marine expertise and product knowledge has been transformative,” says Tervo. “We work with and look for opportunities to use AI when it improves safety and efficiency for crew, passengers and cargo, where it can bring unique added value to our customers. We bring to the table ABB systems performance insights, product development knowledge, and service data that nobody else has access to.”

Enterprises focusing on AI alone can respond to marine market opportunities quickly, Tervo adds, but their solutions may not be fully sensitive to the subtleties of the way a ship works as a system of systems, how those systems interact with crew, and what the actual needs of the crew are.



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Osku Kälkälä,
Head of Digital
Business
ABB Marine & Ports

“We believe in using AI when it makes sense,” says Osku Kälkälä, Head of Digital Business, ABB Marine & Ports. “We have pushed at the boundaries of analytical AI, drawing on our role as technology leader in electrical power, control and automation systems, and using our experience in integrated ship systems to capture the complex relationships that can be optimized to improve operational efficiency.”

The combination of analytic AI and ABB’s domain-specific expertise has been key in two ‘off-the-shelf’ ABB solutions which enhance specific aspects of performance of vessels in services. These two example applications in the vast ABB portfolio utilize the AI approach in very different ways.

“ABB Ability™ OptimE learns from the relationship between a vessel’s speed and its toe angle by leveraging accumulated data to optimize propulsion efficiency, reduce power and minimize emissions. In terms of AI, this is quite a straightforward use case, but we are also introducing variables to the mix, such as weather or currents.”

In another case, AI’s probabilistic inferences, ie educated guesses based on probability, have been deployed to develop a model to automate aspects of vessel control – again with the goal of boosting efficiency.

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Analytical AI has become a natural part of our automation, service and routing solutions.

“ABB Ability™ Marine Pilot Control consolidates mission critical vessel controls at one operator position,” explains Tervo. “AI has been used to develop models for predicting future vessel behaviours based on accumulated data. Marine Pilot Control itself is not AI, but the identification of the vessel model is based on measured data and algorithms which are part of the AI toolbox. The resulting state-of-the-art control technology helps to increase safety by automating key operations, such as position-keeping, speed control, braking assistance and docking.”

Bringing products to market which exploit AI in ways that customers find directly useful has demanded what Kälkälä describes as “a laser focus on where our core strengths lie, in power plant optimization, control systems, energy storage and management, vessel stability, weather routing and remote maintenance”. However, he adds: “We have also recognized that others bring unique capabilities. Where AI is concerned, there is no one-size-fits-all for the maritime industry.”

Community is key

A shift in industry thinking is evident in the ABB Marine & Ports' Routing Services. Complementing ABB's existing digital offering, the recently acquired DTN Shipping business brought a market-leading Weather Routing optimization system to ABB. This expands the number of vessels connected to ABB networks to over 5,000, while the total number of vessels served by just ABB Routing Services is approximately 13,000 annually, enabled by the application programming interfaces (APIs) offered to third parties and integrators.

At the same time, Kälkäjä acknowledges that 50 percent of routing business works "through partners" which requires an agnostic approach with respect to the user interface on route selection. "Our routing services collect the data so that the customer can optimize the route. However, there are multiple interfaces available on the market that allow customers to access ABB Routing Services."

Already, in its broader exploration of analytic AI, ABB has identified how collaborating with customers, class societies, third parties and even competitors helps to maximize vessel efficiency, fuel economy and decarbonization.

"We have also used AI to develop the performance condition-based monitoring and maintenance models we use to work with the OVERSEA 'fleet support center as a service' we offer with Wallenius Marine, for example," says Kälkäjä. "Clearly, in these scenarios, data relating to ship engine performance is key."

As the development of data-enabled solutions and AI accelerates, collaboration will become even more essential, if full value is to be realized from ABB's sector expertise. Kälkäjä describes this as "a different business environment than we are used to, where the new added value comes from the community".

Analytic, generative or both?

As part of a broader group which works in open collaboration with the world's leading software developers to maximize the power of data and algorithms, ABB Marine & Ports will be at the forefront of the maritime industry when it comes to putting GenAI to good use.

"Like many of our industry peers, solutions such as Copilot are having a huge impact on our internal processes, for example by speeding up the work we do in documentation or even software development," says Tervo. "This is increasing productivity, for sure, but the human in the loop still plays the critical role of evaluating how data is interpreted and verifying the results. These are benefits that, in the first instance, will be felt by the customer in accelerated product development, rather than in the product themselves."

ABB Ability(TM) OptimE – Toe angle optimization for propulsion is an example of a product which uses AI and is fully ready for market. The subsequent development of the technology will be carried out along traditional lines towards ‘next generation’ software with added functionality in the years ahead. Based on the step change being brought by GenAI, future developments may need to include a more outward looking and fluid collaborative approach, where ‘service-based’ solutions emerge from pooling data, expertise and effort and a shared vision of user benefits.

No company is an island

“The pace of AI development means that maritime stakeholders are beginning to appreciate the benefits of looking at ship optimization as a service, where data models are continuously updated to bring real value to customers over time. Building on this, ABB’s role as a technology leader in developing, supplying, installing and maintaining ship systems also becomes a virtuous circle to collect and interpret accurate, reliable and invaluable data.”

“Our product knowledge, integrated system expertise and accumulated performance data have allowed us to lead on maritime AI. However, part of that leadership has been to understand how collaborating with partners maximizes the benefits of AI for the customer,” Kälkälä confirms. “No company can master everything alone and get the most out of the opportunities.” •

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We welcome feedback and suggestions. If you have any questions or ideas,
please contact us at heli.harri@fi.abb.com.

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