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SHIPPING 4.0

# **Navigating the 4th industrial revolution**



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**SHIPPING 4.0**

# Navigating the 4th industrial revolution

Electrification, digitalisation, and connectivity are converging on the maritime industry in a powerful combination destined to transform the way we move people and things on the water.

**JUHA KOSKELA**  
Managing Director,  
ABB Marine & Ports

Electricity is at the heart of this transformation, enabling simple and efficient integration of alternative power sources, and providing a platform for interconnected digital solutions on board and on shore.

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Digital technology can deliver us into a new era of shipping.

ABB is no stranger to marine electric solutions. We have provided electric propulsion systems on board vessels for more than 70 years. Applying this experience to digital technologies now allows us to deliver vast improvements in vessel and port performance and efficiency, enough to increase profitability and reduce impact on the environment by margins unthinkable only a few years ago.

Together with cleaner power, complimentary policies, and a greater understanding of how people fit into the picture, digital technology can deliver us into a new age. ABB is supplying that technology now, helping companies take the necessary steps on the way to a new era of shipping.

This edition of Generations contains insight from some of the most visionary thinkers of our time, from the shipping industry and without. It also contains practical advice on how smart use of today's technology can help us move toward a cleaner, safer, and more efficient maritime industry.

We hope you enjoy the predictions, the perspectives, and the solutions presented in the 2017 edition, featuring ABB's new corporate design profile. We invite you to share with us Shipping 4.0 – a look at what is being done today, as we strive for what can be achieved tomorrow.





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# CHAPTER 1

## The power of the future

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**SHIPPING 4.0**

# The power of the future

What will power the ships of the future? Will the industry manage on its own to transition out of its dependency on heavy fuel oil, or will regulations be needed to force a change? Is LNG the fuel of the future, or more of a placeholder while greener alternatives ramp up? Will the first movers into new technologies inspire others to follow in their wake?

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## Participants:

**Invited guests**

Rolf A. Sandvik – CEO, The Fjords  
Dr. Tristan Smith – University College of London Consultants Ltd., and director of the RCUK-funded project Shipping in Changing Climates

**Journalists**

Paul Bartlett – The Motorship and Seatrade Green Shipping Guide  
Paul Berrill – Features Editor, TradeWinds  
Michael Grey, MBE – Freelance journalist  
Paul Gunton – Executive Editor, Marine Propulsion

**ABB Marine & Ports experts**

Janne Kuivalainen – Head of Technology  
John Olav Lindtjørn – Global Product Manager Energy Storage  
Jorulf Nergard – Head of Short Sea Shipping

The session was moderated by Peter Lovegrove,  
ABB Marine & Ports

To gather some solid perspectives on these and other challenges and opportunities facing shipping as we enter the 4th industrial revolution, ABB Marine & Ports invited four prominent maritime journalists, a progressive shipowner, and a marine emissions and regulations authority to a roundtable discussion with their own experts in London on 28 February 2017. The following is a subjective account of the discussion.

**Exploring the future**

In these days of paradigm shifts and overnight revolutions, where predictability seems to have left the building, perhaps a philosophical approach is a useful supplement to business acumen. The discussion in London was kicked off by University College of London Reader Tristan Smith: “When navigating the regulatory picture, it is important to start in the present and try to see the inevitable future,” he proposed. “Extrapolating on the current state of shipping, we can assume that volumes will grow, while emissions will decrease.”

Emissions are expected to decrease by 60-90 per cent per tonne mile by 2050, he related, adding: “Many things could contribute to this, including slower steaming, new fuels, and other technologies, but fuel will be the main driver.”



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Tristan Smith (left)  
opened the discussion  
in London

Smith and his colleagues employ this same methodology in much of their work, running scenarios that explore potential future outcomes, and trying to gain an understanding of what they mean. He advises companies to take a lesson from the game of hockey, and “skate to where the puck will be”, or position themselves where they see things moving, based on macro trends and major developments.

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When navigating the regulatory picture, it is important to start in the present and try to see the inevitable future.

One of those doing just that is tourist shipowner The Fjords, operating out of idyllic Flåm on the

Norwegian west coast, and trafficking the UNESCO-protected Nærøyfjord. CEO Rolf A. Sandvik told of how they came to equip their latest vessel, the “Vision of the Fjords”, with hybrid diesel-battery propulsion: “When we built the hybrid ‘Vision’, the spreadsheet told us we should have chosen pure diesel. But we felt an obligation to respect our presence on this pristine fjord. We wanted to make a difference, but also to stand out from the competition.”

While there could be no contesting their idealistic motives, there was never any guarantee that their investment would pay off. But Sandvik and The Fjords decided to “skate to where the puck will be,” and that has proved to be a decision as prudent as it was bold: “We had faith that travellers would appreciate our decision, and a study to be published in the spring of 2017 has confirmed this assumption, that they are willing to pay for the green advantage.”





The Vision of the Fjords in fact has many advantages, not least its striking design inspired by a winding mountain path, and unmatched viewing experiences, both inside the main cabin and on deck. But gliding silently along Nærøyfjord under battery power is definitely a key selling point in the overall experience, underpinned by the environmental bonus of zero emission cruising. “We have not yet marketed the green aspect with full strength, but we will do so in the future,” he related.

As for positioning themselves where they believe things are headed, Sandvik and The Fjords are way ahead of the puck: “What we have done so far is with zero support from the government. We are doing it because we believe that people want a carbon-free future, and that technological advances will eventually bring costs down.”

#### **What makes change happen?**

A comment from the journalists emphasised the impact of market forces and critical mass. The turning point, they observed, comes when technology converges at an affordable point, for example when an automobile manufacturer can turn out mass-produced models with new technologies at affordable prices.

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**Increasing access to knowledge  
is important to driving change.**

ABB’s Jon Olav Lindtjørn conferred: “The transfer of technologies from other industries is speeding up conversion processes in shipping. Perhaps we will see major changes in just 10 years?” His postulation received support from Tristan Smith: “The ‘Hydrogen Hypothesis’ predicts 2030 as a turning point, but this involves several trade-offs, including the de-carbonisation of electricity production.”

Here the veteran journalists weighed in with a healthy dose of scepticism: Could it be realistic to hope for such a major reduction in emissions by 2030, or even 2050? And if so, which fuels will enable such a dramatic reduction in just one new generation of ships?

Tristan Smith replied that fleet renewal would drive much of the change, primarily newbuilds, but with some retrofitting to add to momentum. Still, he cautioned against painting too rosy a picture of an industry not built for rapid change: “Regulations will drive the move to new fuels, but shipping will still be heavily fossil for some time to come.”

Underscoring the slow nature of change in the shipping industry, ABB’s Janne Kuivalainen pointed out one of the major differences between shipping and other transport industries: “Ship construction is more conglomerate than automobiles or planes. This makes it difficult to scale up quickly, because there are so many contributors that have to be on the same page.”

#### **In with the new**

Moving on to new power sources, Jon Olav Lindtjørn elaborated on the expanding role of batteries onboard: “Batteries can contribute to more than pure propulsion. They can compensate for sub-optimal engine operations, or serve as a backup, reducing the need for auxiliary power, and thus reducing emissions.” He was supported by ABB colleague Jorulf Nergard, who pointed out that batteries have the potential to serve these and many other purposes that can improve a ship’s overall efficiency and economy.

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**Regulations will drive the move to new fuels, but shipping will still be heavily fossil for some time to come.**

But batteries need charging, and charging is a challenge, Janne Kuivalainen stated: “We need more cases to achieve standardisation. Each route has its own needs, and the same thing basically applies to each vessel.”

Here Rolf Sandvik turned his attention to regulations as the driver for change: “Regulations are needed to drive standardisation in charging infrastructure. With these in place the industry will adjust, and as we have seen, the customers are willing to pay.”

But regulations can be tricky, especially at the local level, as The Fjords have experienced: “Local politicians are unwilling to implement regulations that could influence competition. If they reward hybrid or zero-emission solutions where we operate, they fear it would give us an unfair advantage. Of course we believe that regulations would push others to move toward greener solutions. Instead, the responsibility is pushed upward, from local to national, then to the international level, and eventually they land with the IMO, where things move slowly.”

“We would like to be able to operate anywhere in the world with our concept, but that requires standardisation, and the road to international standards is a very long one. The industry should take initiatives for standardisation of charging facilities, perhaps working within the ISO regime.”

Sandvik is also looking to other fuel sources in his quest for greener operations: “We are planning to retrofit an older vessel with hydrogen power in a government-funded conversion project, and we have started talks with a west coast yard.”

Janne Kuivalainen pointed out that fuel cells will require further technical development before they take a larger role, emphasising the need for the industry to take control of markets, research, and development. “But for now,” he maintained, “the future is electric.”

#### **Seeing the opportunities**

Addressing the transition from the old to the new, Jon Olav Lindtjørn reflected on the potential life span of diesel, and the factors that will determine how long it takes to achieve a shift from fossil fuel: “Power will definitely increase in fuel cells, but combustion engines will be around for a long time, if perhaps in smaller dimensions. Batteries last between five and ten years, so costs will drop by the time replacement is required. Battery recycling will also improve, and the second life of batteries in non-critical situations in being considered.”

True to form, the press corps posed another sticky question: Will shipowners be able to convince customers to pay more for transportation without a reward for using green solutions?

Tristan Smith offered a reply: "Cargo owners are demanding green transport, with less carbon. I believe containers will pave the way, as their customers are more concerned with maintaining green and clean profiles. With everything from iPhones to automobiles, manufacturers want to be seen as green along the whole supply chain. Eventually, tankers and bulkers will follow, but I am cynical about market forces alone driving change. Regulations are needed to catalyse the shift."

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**Power will definitely increase in fuel cells, but combustion engines will be around for a long time, if perhaps in smaller dimensions.**

Rounding off with perspectives on the 4th industrial revolution and its impact on the power of the future, Janne Kuivalainen assumed a holistic perspective: "Digitalisation will impact R&D, and thus

influence power systems development not just directly, but by giving industry the chance to try out systems in realistic simulated test situations and model systems more accurately. Performance, lifetime, many factors can be made more predictable. In this way digitalisation can help us gain deeper domain knowledge before we move technologies into the field."

Tristan Smith agreed, summing up the discussion with an appropriately hybrid approach, merging virtual and physical realities: "Increasing access to knowledge is important to driving change. But each ship is essentially a prototype, and this is both an advantage and a disadvantage, a blessing and a curse. Ships can be designed to purpose, but not easily standardised."

That would seem a fitting description of the reality of powering ships. When it comes to determining the power of the future, there are as many challenges as there are ships – and as many opportunities.

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Roundtable discussion



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**RIDE THE WIND**

## Round and round we go

Often the best new ideas have the longest history. Norsepower's Rotor Sail Solution fits that bill, an intriguing new application of an idea dating back thousands of years: using wind to propel ships.



**JUKKA KUUSKOSKI**  
Senior Vice President  
for sales and marketing,  
Norsepower

Even the idea of a rotor sail goes back almost one hundred years. Exploiting the Magnus effect, the Flettner rotor was proven viable by its inventor Anton Flettner in 1925, when the first ship outfitted with Flettner rotors made the North Sea crossing from Danzig to Scotland.

Rotor sail power alone proved to be less energy efficient than propeller technology, and the idea lay dormant for decades. Now, the Finnish clean technology company Norsepower has brought it back to the market in a refined version designed to supply auxiliary power to motor ships, providing fuel savings of up to 20 per cent.

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**Modern digital design tools were important in achieving optimal design.**

Founded in 2012, Norsepower saw a growing market demand for green marine technology and found potential in the rotor sail concept. Jukka Kuuskoski, Senior Vice President for sales and marketing, believes the idea is deserving of another look: "Both environmental regulations and fuel prices are drivers for auxiliary propulsion technologies. Even with the price of fuel as low as it is today, fuel is still the biggest operating expense by far."

Norsepower's first commercial installation was on Finnish shipping company Bore's 9,700 dead-weight tonne (DWT) RoRo vessel **Estraden** in 2014. "It was important to get that first contract," Kuuskoski acknowledges. "With that we could perform tests and provide verification. References mean so much more than marketing." It didn't hurt either that Bore was so happy with the results from the first rotor that they soon ordered installation of a second on the **Estraden**.

But what made Bore take the leap in the first place? "Building confidence with owners and investors often starts with contacts," Kuuskoski says, "and the relationship between our founder Tuomas Riski and Bore was good, with both technical and management personnel."

That same sound relationship exists between Norsepower and Viking Line, leading to the signing of a contract for outfitting the **Viking Grace**, their flagship, with a 24-metre high rotor in 2018. "Companies have to be willing to spend time and effort in order to see the benefits of new technologies, and Viking has historically invested a lot in clean tech."

Like the **Estraden**, the **Viking Grace** project will be a retrofit. But unlike other, more invasive technologies, Rotor Sail installation requires only a minimum of modification. "Because the Rotor Sail is mounted on deck, the mounting block is the only modification required besides the low-voltage electrical connection," Kuuskoski says.



Estraden with dual Norsepower Rotor Sails

The sail is rotated using electric power, but energy consumption is low, enabling the sail to provide a propulsive thrust in favourable wind conditions equivalent to more than 10 times the propulsion shaft power than it consumes. With the addition of Norsepower's technology, the LNG-fuelled Viking Grace will further reduce its emissions, fuel burn, and fuel costs, reducing carbon emissions by approximately 900 tonnes annually, or the equivalent of 300 tonnes of LNG fuel each year.

## Simplicity is the key, from design, to installation, to operation.

Digital technology also figures prominently in the overall efficiency of the Rotor Sail. "Modern digital design tools were important in achieving optimal design," Kuuskoski relates. But the main benefit of digital technology is in operations, where control systems tune the rotor sails in response to wind strength, direction, and ship speed. Sensors and automation systems combine to optimise rotational speed and direction, ensuring maximum forward thrust.

Digital technology also makes it easy for the crew to operate the Power Sail within maximum performance parameters, without lifting more than a finger: "There is push-button activation from the bridge. Ease of operation is one key difference from conventional sails. There is no physical trimming, and the rotors can be switched off to avoid unwanted thrust when manoeuvring."

In addition, the units are highly robust, requiring virtually no maintenance. "Simplicity is the key," says Jukka, "from design, to installation, to operation."

- A **Flettner rotor** is a smooth cylinder with disc end plates which is spun along its long axis and, as air passes at right angles across it, the Magnus effect causes an aerodynamic force to be generated.

As with all new technology, or in this case a new application of old technology, there will be resistance, particularly in the highly conservative shipping industry. So how is Norsepower winning over sceptics?

"The best way is for us to prove the value of the technology, and to work with customers who have high standing in the industry." Certainly they have accomplished that in their latest project, a pilot to test wind propulsion technology with Shell, Maersk, and the Energy Technologies Institute of the UK. "We are very happy to be working with these big players. This marks an important milestone for Norsepower, and it builds our confidence when we can learn from the companies with the resources to really evaluate results."

All the right pieces fell into place with the deal, Kuuskoski says: "First, the installation will be on a large ocean-going ship. This holds potential to lead to installation on many ships, and many different ship types. It can also serve as a good example for other shipowners."

The project will be the first installation of auxiliary wind propulsion technology on a product tanker, and aims to provide insights into fuel savings and operational experience. The rotor sails will be fitted during the first half of 2018, before undergoing testing and data analysis at sea until the end of 2019.

Maersk Tankers will supply a 109,647 DWT Long Range 2 product tanker which will be retrofitted with two 30m tall by 5m diameter Rotor Sails. Combined, these are expected to reduce average fuel consumption on typical global shipping routes by 7-10 per cent.

- The **Magnus effect** is a force acting on a spinning body in a moving airstream, which produces a force perpendicular to the direction of the airstream. This is used in backspin to increase range in ball sports. Rotor ships take advantage of this same effect by spinning a large vertical cylinder, typically using an electric motor, and using the resulting force for propulsion.

Any other market barriers to be broken down? "We have managed quite well to communicate and convince the public about the physics. What remains now is for owners to see it working within their business model." In order to help shipowners understand whether Rotor Sails are for them, Norsepower can perform detailed studies on specific ships, routes, weather patterns, simulating potential savings.

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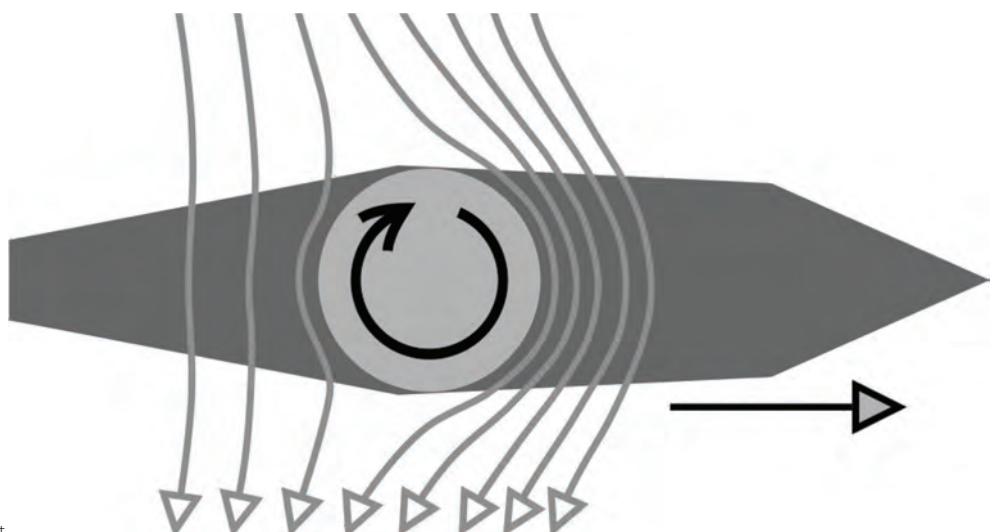
**The best way is for us to prove the value of the technology, and to work with customers who have high standing in the industry.**

"But it is an emotional issue as well, for both owners and passengers," Jukka wisely observes. "It makes the ship look different, and that impacts customer choices. The green tech element is usually an advantage, because it improves the operating profile, and there is no added noise to speak of. Cruise passengers are showing increasing environmental awareness, and they might even see it as a reason to choose one cruise line over another. We are also seeing that the more advanced customers in the freight segment share these views."

Norsepower is also looking to strengthen its relationships with equipment suppliers like ABB, who develop automation and control systems. "It's good if they recognise that our Rotor Sail solution is an integrated part of machinery systems. With the proper exchange of information onboard and integrated automation, we can work together to optimise the entire system for energy efficiency."

On their website, Norsepower lists a formidable string of awards, the latest of which honours founder Tuomas Riski with the Nor-Shipping Young Entrepreneur 2017 award. "We are very happy for these displays of appreciation," Jukka Kuuskoski assures. "We are especially proud of Tuomas receiving the Nor-Shipping award. It confirms not only that we have a good system, but that the idea to invest in Rotor Sails was a good one."

That should provide Norsepower with plenty of motivation to keep moving forward – going round and round.



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The Magnus effect

# Batteries – the next big thing

The world has a growing appetite for batteries, not just more, but bigger and better. How will that demand be met? And what impact will dramatically expanded battery use have on society?



**SIMON MOORES**  
Managing Director,  
Benchmark Mineral  
Intelligence

Addressing the rising torrent of batteries, Simon Moores, Managing Director of Benchmark Mineral Intelligence, starts at the headwaters:

“China’s lithium ion battery strategy will be the key to producing enough high quality lithium ion cells,” he says. “Nearly 70 per cent of new lithium ion battery capacity is being built in China via a combination of Chinese, Japanese and Korean producers. These volumes are also being built out in a number of battery mega-factories around the world, a trend that was sparked by Tesla’s Giga-factory project in Nevada.” Of the 16 lithium ion battery mega-factories tracked by Benchmark Mineral Intelligence, Moores reports that 10 are located in China.

**China’s lithium ion battery strategy will be the key to producing enough high quality lithium ion cells.**

Asked whether we will see a ‘Moore’s Law’ for batteries take effect, with capacity doubling on a regular basis as prices fall, Simon Moores is cautious:

“I think the comparison to Moore’s Law and the computer chip manufacturing is a bit of a leap of faith,” he states. “There is no doubt that battery

costs are plummeting. We have seen cell manufacturing costs fall from USD 1000 per kilowatt hour (kWh) in 2009, to USD 250 per kWh in 2015.” Costs have continued to decline since then, he adds, with some buyers of cells paying under USD 140 per kWh in the first half of 2017. “This is an incredible decline from where we were even two years ago.”

He explains that batteries differ from transistors and computer chips in that raw materials are a more significant portion of the cost of a battery. The cost of manufacturing the cell may be falling as the industry ramps up on scale, but raw material costs are increasingly influencing the price of batteries.

“Raw materials for batteries are specialty chemicals that are mined and processed to stringent specifications. The price of these specialised raw materials will always have a slowing factor on price decline, particularly when new raw material supply is needed to fuel the lithium ion battery revolution we are now experiencing. Lithium chemicals have surged to four times their value from two years ago, with cobalt more than doubling in less than 12 months.”

## Moving on

The age of electric vehicles, or EVs, has dawned. What does Moores see as the next big thing in battery-powered transportation? “I think there has been less focus on electric buses in western



countries than electric cars. Tesla has taken the limelight in terms of media headlines, and they have been the catalyst to get auto juggernauts like VW involved in the space," he observes.

"But pure electric buses with huge battery packs in excess of 300kWh are likely to be a major part of city living sooner than we think. From a psychological perspective in getting a broader public comfortable with pure EVs, this is important."

Benchmark Mineral also sees potential for battery powered transport outside of automotive: "In terms of other forms of transport, we are increasingly interested in the commercial space, particularly maritime. We have seen autonomous, pure electric container ships being planned for Scandinavia, and I would say that short haul shipping will be the first to be realised. The sheer cost of fuel and the environmental benefits of battery powered propulsion offer exciting prospects for the maritime industry."

While the possibility of electric planes is being actively explored, Moores doesn't see aviation applications being widespread anytime soon. "The maritime industry has the potential and the economic and environmental incentives to integrate this technology more quickly."

The Chevrolet Bolt battery pack

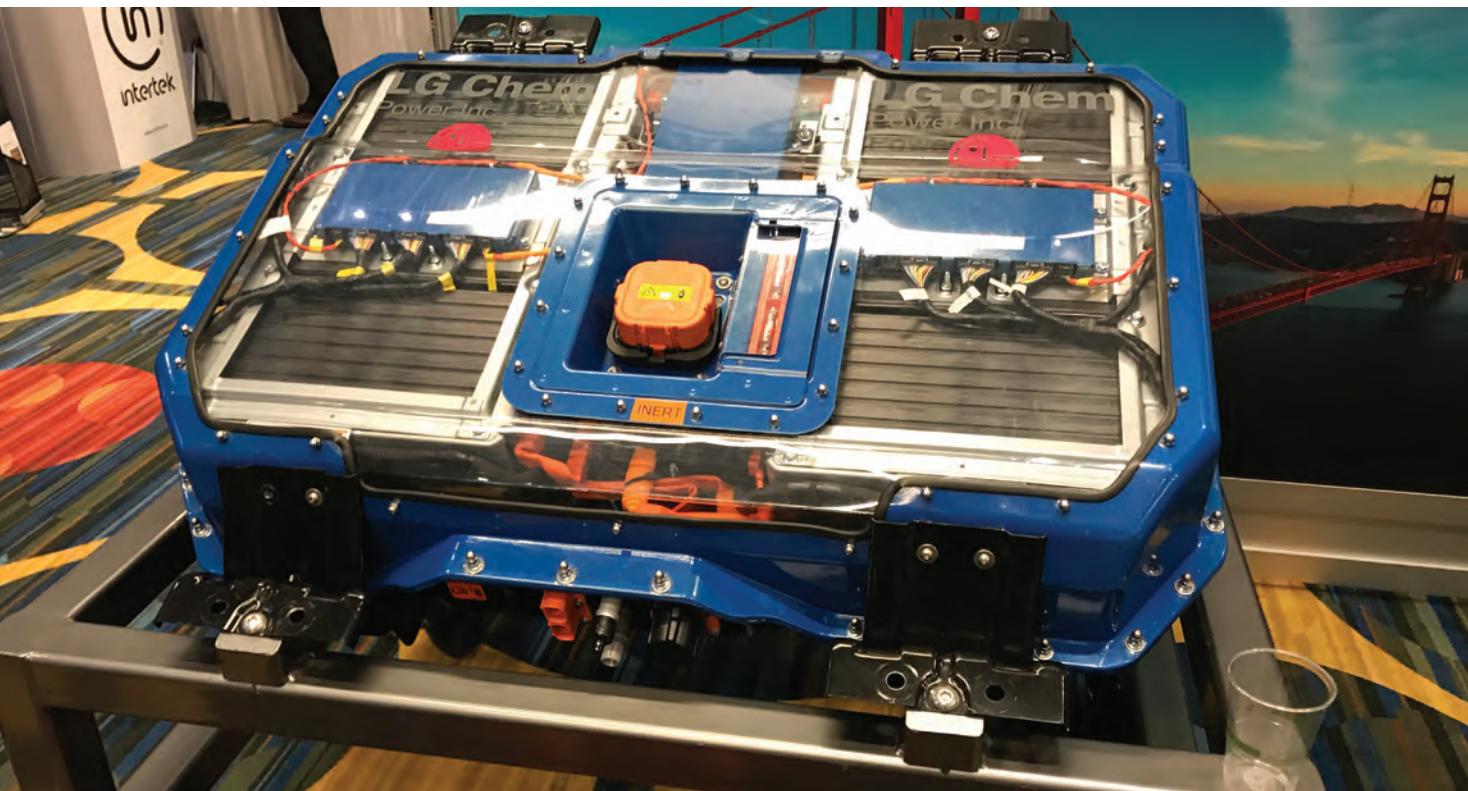
Marine applications may be closer at hand, but the maritime industry is presently experiencing bottlenecks in the production of marine batteries. When and how does Benchmark see this problem being resolved?

"That really depends on what chemistry the marine industry lands on, whether it will be gel or liquid based systems like today, or lithium ion based batteries," Moores observes. "To achieve lower cost, competing energy density levels, and lightweight batteries, it makes sense that marine batteries should see a push towards lithium ion, especially lithium iron phosphate and nickel manganese cobalt chemistries."

Marine consolidation on lithium ion could also help relieve the bottleneck, he believes: "This would tap into the mass scale production that is being invested in today and help marine batteries become cheaper, with larger capacity, and greater availability."

#### **With a little help from my Feds**

Many believe that battery-powered transportation requires more than just more batteries. Governmental support has proven instrumental in getting things moving, as witnessed by Norway with the success of their electric-friendly legisla-



tion for cars. What is needed to mirror Norway's success on a global scale, and across industries?

"The problem is, not every country is like Norway," Moores points out. He cites Hong Kong, where demand for pure EVs surged in response to hefty government incentives. But right next door, China chose not to implement a similar model. Rather than bemoaning the lack of consensus between governments, Moores believes that policy may turn out to be less significant than it appears today.

"Even as recently as three years ago, I would have argued that government incentives were the major factor in the uptake of electric vehicles. But as costs drop dramatically, the reality is that very soon – between now and 2020 – electric cars will be cheaper and better than comparable gasoline powered vehicles."

Recent numbers indicate that the battery-powered Tesla Model 3 is expected to be quicker than its combustion competition, and at the same price or cheaper. "It will also be more desirable to many buyers thanks to Tesla's strong brand. That is why I believe that basic buyer economics like this are the key to mirroring Norway's success worldwide."

What Moores does believe governments can do, is to help improve and expand the charging infrastructure. "First-time buyers will still be wary about being stuck in the countryside with no power. Aiding a uniform charging method and helping to install a broad network of chargers is the final piece of the EV puzzle."

#### **Big Battery – Quo Vadis?**

Moores' colleague at Benchmark, analyst Caspar Rawles, confirms that the battery industry is in a period of significant growth: "In 2016, demand for lithium ion batteries was 70 gigawatt hours (GWh), with over 50 per cent coming from the portable electronics sector. Over the course of the next five years, total demand for lithium ion batteries will have risen to 205GWh, with 60 per cent coming from passenger EVs."

While consumers appear eager to fuel this growth, rapid expansion of battery power is also

raising questions about the life cycle impact of a large-scale rollout. Is it environmentally responsible to ramp up battery applications without fully knowing the long-term consequences?

Here Rawles is pragmatic: "Though the environmental impact of batteries is being looked at more and more, it still requires more work. One of the things making it difficult to understand the impact of lithium ion cells is the relatively early stage of development with the technology, and perhaps more importantly the supply chains."

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#### **There is no doubt that battery costs are plummeting.**

He points out that until recently, markets and supply chains for the specialty chemicals that go into a battery cell were small and immature. "As markets grow, supply chains will become more streamlined and cell production will become more efficient. But until we know exactly how supply chains are going to work it is difficult to examine the future impact once the industry ramps up."

In addition, he notes that the industry still hasn't landed on the dominant form, or mix, of battery technology and chemistry. "This is something that will become more evident over time, but until we know what will be in the cells, it's hard to examine the potential environmental impact."

Rawles and Moores agree that as more battery cells make their way into the consumer market, recycling will become a major part of the industry. But just as with cell technology, recycling technology hasn't yet been refined to one dominant form, making it difficult to determine the overall future impact.

"Ultimately there is every reason to believe that the supply chains of the lithium ion battery industry, once they are refined, will be as efficient as any other," Rawles concludes. "If the global push continues to generate more grid power from renewable sources, meaning clean energy being stored in the cells, then the environmental impact of batteries should be minimal."

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**SOLAR POWER**

## Cleaning up, a little at a time

The idea of solar power on ships is not a new thing, but the enthusiasm building up around marine solar solutions is.

This is due partly to developments in solar and battery technologies, and partly to growing demand for a wider range of clean and sustainable marine power solutions at all levels.

Eco Marine Power (EMP) out of Japan is banking on meeting that demand using a combination of revamped and innovative technologies, with flexible solar panels on rigid sails, and a refined version of tried and true lead-acid batteries.

They are currently underway with an evaluation project on a high-speed ferry in Greece, the Blue Star Delos. The project includes the world's first marine solar power system using flexible light-weight marine grade panels integrated with real time performance monitoring of the solar power array. Fuel oil consumption will also be logged and emissions data calculated.

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**The batteries are 90 per cent recyclable.**

"The ferry project is the key test for EMP right now," says chief technology officer Greg Atkinson. "Delos is just finishing the trial period. After that we believe the time will be right to move toward commercial systems. Photovoltaic technology is seeing significant advances, and costs are coming down."

Valve-controlled lead acid batteries have been chosen for the Delos project. "The batteries are 90 per cent recyclable," Atkinson says. "They are safe, and no dedicated cooling is needed. The solution is simple and robust. Requirements for a full lithium system make weight similar for the two battery types, and safety requirements for marine lithium are stricter."

"Contrary to what most people think, valve-regulated lead acid technology has continued to advance while all the attention around batteries has gone to lithium," he says. "Now they have a life span comparable to lithium ion batteries."

For their next move, EMP is looking at car carriers, largely due to their ample deck space. "Cruise ships are also looking more interesting. There is a lot of space available on the upper decks, and flexible panels can be installed on awnings. And passengers are more and more interested in greener cruising."

Atkinson makes another highly relevant point for the passenger segment: "Solar-battery solutions are also very good sources of emergency power. Even if you lose all other power, you can still run some systems until help arrives."

### **Sailing with the sun**

EMP's most interesting project right now? "I think the most intriguing would be the Energy-Sail. It combines solar for auxiliary use, and sails



THE POWER OF THE FUTURE



—  
EnergySail® by Eco  
Marine Power

Right: Aquarius solar  
array on Delos

for propulsion, which makes it interesting for more ships." As deck space for solar is not readily available on all ship types, EMP is developing free-standing sails with flexible and semi-flexible solar panels mounted on the sail.

The main inspiration for EMP's patent-pending EnergySail was the JAMDA rigid sail from the 1980s, built by the Teramoto Iron Works in Japan. Now the same company will manufacture solar panel mounting frames for one of EMP's projects.

But is the industry embracing solar power on board, or does EMP still meet sceptics? "Some shipowners are looking for megawatts, and that is not feasible with solar." Right now, he says, solar's most practical use is for lighting and other housekeeping functions.

"But when you use solar, you don't burn fossil fuel. That's good for your image, it's good for the environment, and that is good for the people living around ports," Atkinson points out, noting that 60,000 premature deaths are attributed to shipping emissions each year.

"Regulations are starting to work in our favour. Sulphur caps and emission control areas will all lead owners to look for alternative solutions." A ship might have two generators, he argues, but not have to run both, using solar to keep generator use down. They can also reduce reliance on shore power, which is not always available, and not necessarily sustainable or very affordable when it is.

### Bringing down barriers

What does Greg Atkinson believe is the ultimate potential for marine solar, and what barriers need to be removed for it to reach its full potential? "The conservative nature of the shipping industry in general is a key barrier. Even something as commonplace as Wi-Fi is not standard on ships yet."

On the plus side, Atkinson sees demand playing a bigger role in solar implementation. "It's not just supply side any more. Owners and operators are thinking more about how they use power on board." For example, lighting spaces with no people is still commonplace, but it wastes power, which means wasted money and unnecessary emissions, neither of which work in the owner's favour.

"There is a lot of potential on the demand side. It is in the best interests of the industry to get cleaner. But for this we need progressive owners, even though installing solar power to cut fuel consumption is a relatively minor expense."

Pressure to comply with green logistics chain requirements is another increasingly important factor, and many requirements affecting shipowners will come from outside of shipping. "Authorities will be certifying entire supply chains, not just looking at sea or land transport separately. Fuel efficiency then becomes important from the source to the destination, and all emissions become critical," Atkinson concludes, giving EMP the perfect takeaway for their contribution to the greener future of shipping: Every little bit helps.

# A breakthrough in icebreaking

Finland has for decades been a leader in icebreaker technology, consistently designing and building ships that break not only ice, but performance barriers. Now they have delivered a ship that sets the bar even higher for performance and efficiency, while adding yet another innovation: Polaris is the world's first LNG-powered icebreaker.

Aker Arctic Technology was contracted by FTA, the Finnish Transport Agency, to design the new craft, dubbed the Polaris. Mika Hovilainen was in charge of concept development on the Polaris project.

"The target was to develop icebreakers for the most difficult conditions in the Baltic," Hovilainen says. In the northern Baltic, the Bay of Bothnia, ice typically reaches a maximum thickness of one metre, relatively light compared to the Arctic. The challenge, Mika relates, comes from prevailing winds that push ice flows against the Finnish coast, creating what are known as ice ridges. Despite the fact that Arctic ice is typically twice as thick, ridge ice fields are every bit as daunting in their own right.

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The target was to develop icebreakers for the most difficult conditions in the Baltic.

Polaris' predecessors were the workhorses built in the 1970s for the Swedish and Finnish governments, the now-legendary Urho class ships. The Finnish icebreakers Urho and Sisu are familiar fixtures on the Helsinki waterfront, while the

Swedish giants Atle, Ymer and Frej now operate out of Luleå in the northern Baltic. "These were the most powerful and best performing icebreakers in heavy ridge conditions," Mika relates. "Now Polaris is meant to replace these, with even better performance."

As with most icebreaking projects in Finland, the development of Polaris was a national effort. Aker Arctic teamed up with ILS Ship Design & Engineering out of Turku to evaluate concept alternatives, and the vessel was built at Archtech Helsinki Shipyard.

## The LNG breakthrough

So why LNG? "LNG is the cleanest fossil fuel, and the government was interested in building a ship with a greener profile," Mika says. "There was already one government vessel, the Finnish Coast Guard Offshore Patrol Vessel Turva, in operation using LNG fuel. There were also several LNG terminal projects under discussion, and it became clear that we would have sufficient bunkering opportunities. In general, logistics for LNG are steadily improving."

LNG also made it possible to meet ECA, or Emissions Control Area requirements, due to take effect for the whole Baltic, and applicable to all new ships trafficking the region. But innovation



seldom comes easy. “LNG adds both costs and complicating issues to design,” says Mika. “Like how to accommodate larger tanks on the ship.” LNG requires more volume for the same amount of energy as fuel oils, and the pressurised tanks required to contain it take up more space. “The rule of thumb is four times the volume of fuel oils.”

Still the design team was able to accommodate the major increase in tank size with only minor increases in vessel size. The solution: “Build up, not out,” says Mika. “These are the biggest vertical tanks ever built, at 17.6 metres high. That gives the ship 10 days of autonomous operation in the most demanding conditions of a normal winter.” Mika says.

“The design is tailored to allow bunkering and crew change cycles to coincide, and that was the target,” Mika reports. The Polaris also has dual fuel capacity using fuel oil for extended autonomy if needed. “But a section of the fuel tanks is reserved for recovered oil in the event of a spill, so they are not always full.”

Oil recovery, even in ice, is just one of Polaris’ many capabilities, including emergency towing, rescue, and salvage. “But ice breaking is of course paramount, and Polaris has proven to be excellent at this.”

Hovilainen points out one performance enhancing innovation in particular: the arrangement of two Azipod thrusters in the stern, and one in the bow. This selection was made to optimise icebreaking and towing performance, especially in contact towing, where the towed ship is winched up against the towing notch in Polaris’ stern.

Polaris in Baltic ridge ice

“The forward Azipod unit has proven to have a great impact on manoeuvrability. Placing a thruster 100 metres forward of the pivot point gives tremendous steering leverage when towing.” A bow-mounted azimuthing thruster was previously tested on the Baltika, a smaller Russian breaker, but has proven to be every bit as effective on a larger scale.

## The forward Azipod unit has proven to have a great impact on manoeuvrability.

Full-scale ice trials were performed at end of March 2017, and official trials confirm feedback from the crew, that the vessel is over-performing in all aspects. New high marks for Baltic icebreaking have been set in level icebreaking, ridge penetration and manoeuvring capability. (See testimony from a Polaris master on the next page).

Mika Hovilainen acknowledges the breakthrough that LNG represents on the Polaris, but as an engineer, he feels compelled to communicate all the factors that go into making Polaris special:

“Polaris is commonly referred to as the most environmentally friendly icebreaker because of LNG fuel, but in fact that is just the icing on the cake.” Before considering how to produce the energy, energy consumption was minimised, he points out. That meant refining many aspects of design, including hull form, propulsion arrangements, system design, heat recovery, and more. “Our goal was to design the most efficient icebreaker ever,” Mika Hovilainen states, “and we have definitely achieved that goal.”



## A Master's praise:

Polaris Master Pasi Järvelin was asked to report from the bridge on the performance of the Polaris in its first months at sea, including the official ice trials in the Bay of Bothnia, completed on 25 March 2017.

### **How have the ice trials gone this winter?**

In normal winters, ice conditions are worst at the end of March, so these dates were chosen beforehand. The thickest ridge ice during the sea trials was measured to be 12 metres (9½ m below and 2½ m over sea level). We didn't have any difficulties steaming through those ridges at good speed, and without any stops.

### **Did Polaris distinguish itself in any way in particular?**

Polaris is much more agile than any other icebreaker. This is not only due to the dual aft Azipod thrusters, but also the bow-mounted Azipod, which has proven to be an excellent aid for manoeuvring in ice.

### **What is it about LNG as a fuel that makes the biggest difference compared to MFO?**

LNG is more environment friendly compared to Marine Fuel Oil, though we can also use Ultra Low Sulphur Fuel Oil as needed. More importantly, LNG hasn't forced any restrictions on manoeuvring.

### **The height of the LNG tanks has also raised the bridge height above water. Is this an advantage or a disadvantage?**

The height difference compared to other Finnish icebreakers is just under two metres. In extreme foggy weather it might be better to be lower in order to keep direct sight of the assisted vessel, but normally height is an advantage, allowing a better view of the ice field ahead.

### **The bow-mounted Azipod is said to have improved performance considerably, especially when towing. Can you elaborate on these improvements?**

The bow-mounted Azipod unit gives much better performance, especially when going around the assisted vessels in order to ease ice pressure. When towing I myself prefer to steer with the bow Azipod, but some officers have chosen to stick to their old style.

### **The Urho-class breakers are now legendary. Will the Polaris someday become a legend too?**

Urho-class vessels are still very useful and capable, but they are more than 40 years old. The engineers have devised so many improvements during these decades, that for me, Polaris already represents a legendary innovation.



## LNG – a cleaner choice

If you've ever had the opportunity to compare an LNG fuelled vessel with one running on heavy fuel oil, or even diesel, the difference is clear.



KIMMO RAHKAMO  
CEO, Skangas

While heavier fuels blacken the sky with their exhaust, LNG exhaust is barely visible, and probably the LNG vessel is noticeably quieter as well. LNG, Liquified Natural Gas, is obviously the cleaner choice, yet many hesitate to acknowledge it as the ultimate solution, instead categorising LNG as a 'bridge fuel' in the move toward 100 per cent renewable power.

Kimmo Rahkamo, CEO of Skangas, the leading supplier of LNG to industry and shipping in northern Europe, couldn't agree more. Rahkamo has spent most of his career working toward cleaner energy solutions, and he believes that LNG is simply the cleanest option for bridging the gap between fossil fuel and renewables.

**The good news is that technically, LNG works. It can be used on any ship type.**

One of the key contributors to establishing the biofuels business at Neste, Rahkamo sees biofuel as a likely next step toward renewable marine fuel, though volume constraints will make a gradual transition necessary: "Biofuels can be a good solution, but volumes will not be able to meet demand for some time," he points out. "Even if all the vegetable oil produced in the world today was used for fuel, it would barely be enough to meet the energy demands of Germany alone."

For now, he says, LNG is the cleanest available marine fuel, and he believes that common sense will lead more shipowners and operators to the low carbon fossil fuel alternative that LNG provides. "Owners are becoming increasingly aware of the branding advantage that a cleaner choice gives them." As proof of this, he notes that Carnival Corporation has several LNG ships on order.

"Cost is a factor, but for Carnival, public image is more important than saving a penny." End users are more and more interested in their overall carbon footprint, he points out, and this is influencing choices all along the value chain in the entire industry. "It drives owners to go greener, or cleaner."

### If you don't build it ...

"We are building up our infrastructure, expanding both our terminal network and our shipping capacity," Rahkamo reports. Skangas will begin trading with Coralius, a highly advanced, 1A ice classed bunkering and distribution vessel, in the summer of 2017. In addition they have a new terminal facility under construction in Finland.

"We realised that if we don't build the infrastructure, no one will ever use LNG as fuel. These are all relatively heavy investments in the Nordic perspective, but we have faith that our business expectations will be met."

There is good reason for such optimism. Among those who have chosen the LNG option offered by



Fjord Line has chosen the LNG option offered by Skangas.

Skangas are Fjord Line, running two cruise ferries between Norway and Denmark, and the recently launched Finnish icebreaker Polaris. “We also are in dialogue with other cruise ferry operators who are considering a similar solution to Fjord Line.”

“Choosing an LNG ship was risky as little as five years ago,” he notes. “Now that the infrastructure is in place, it has become much less risky to count on LNG as fuel.”

#### **Compliance – and the customer**

Another key driver in the growth of marine LNG is the ever-tightening regime of emission regulations. “The 0.5 sulphur cap on marine fuel coming in 2020 will be a huge issue for oil fuels,” Rahkamo believes.

Though the total impact will not be felt overnight, he notes that changes on the horizon have already spurred some oil companies to change their business models. “Some companies are resisting, but new regulations offer great opportunities for creative and flexible players.”

Even though regulations will be a major force influencing the future of LNG, Rahkamo knows that the customer is king: “Regulations set the stage, but customers are making the moves. They

don’t all have to use LNG, but the clean nature of LNG is an increasingly important factor in many business decisions.”

#### **A solid bridge**

Though the transition from fossil fuel will be determined by volume constraints on alternatives in the near future, Kimmo Rahkamo does see other solutions approaching. “Renewables and better energy management are also becoming priority in developing countries, where growth will come in the next decades.”

But for now, Skangas will continue to concentrate on northern markets, with a strong focus on strengthening the supply of LNG to ships. “Marine is a growth segment for us, and we are talking to a lot of shipowners. The good news is that technically, LNG works. It can be used on any ship type. That gives companies that want to make greener choices a viable option.”

He feels certain that the magic number of 1000 ships running on LNG will be reached – just not as soon as some have predicted. Regardless, the move to the cleanest fossil fuel available is fully underway, with Skangas leading the way in the north: “We have sold 400,000 tonnes of LNG in 2017. We can already be proud of our contribution.”

# Hydrogen – the perfect fuel?

Hydrogen is the most abundant element in the universe, making up about 90 per cent of all mass. Ironically, the one place it is not common – at least not yet – is where it may be of most use to humanity: as fuel.

JON ANDRÉ LØKKE  
CEO, Nel Hydrogen

Yet hydrogen has so many of the right characteristics for fuelling the future that it seems only a matter of time before it makes its way into more areas of society – including maritime.

When hydrogen is cleaved from water, oxygen is the only bi-product. And hydrogen fuel leaves only water when it is burned, completing the natural water cycle. Not only that, this is powerful stuff:

“H<sub>2</sub> has a very high energy density, three times that of gasoline, and 150 times that of a lithium ion battery,” says Jon André Løkke, CEO of Nel Hydrogen, a global hydrogen company delivering solutions to produce, store and distribute hydrogen from renewable energy.

The overall hydrogen fuel vision is about enabling humanity to use renewables on a large scale.

“H<sub>2</sub> solves many of the fundamental energy challenges,” he relates. For example, the time and distance gap between power generation and power consumption is resolved when hydrogen can be produced when power is available and stored or transported to the point of consumption. And when it is transported, weight is not an issue, as hydrogen is 14 times lighter than air, with an energy density higher than any other fuel.

Refuelling time issues are also being resolved by constantly evolving fast-fuelling systems for all transportation modes, ensuring improved asset utilisation.

Perhaps most importantly, hydrogen technology has become more accessible recently, and prices for the technology as well as the gas continue to fall, also helped by renewable energy becoming increasingly competitive.

“These are the two main drivers,” Løkke maintains. “Cheaper renewables mean cheaper hydrogen. With this, fossil parity has been achieved. Now we are working toward superiority.”

## Down to the water

As for the potential for marine applications, Løkke is optimistic, though land-based transportation is still the core of their business. “We are involved in a number of projects related to marine applications, including a cruise line owner looking to convert to hydrogen,” he tells, “with dedicated systems for production, fuelling, and operations.”

The concept involves cruising alternately in the Arctic and Antarctic, traversing the Atlantic in between sailings. “A ship can make the trans-Atlantic run on a single fuelling, and Nel can produce the amount needed for this sailing in 36 hours.”



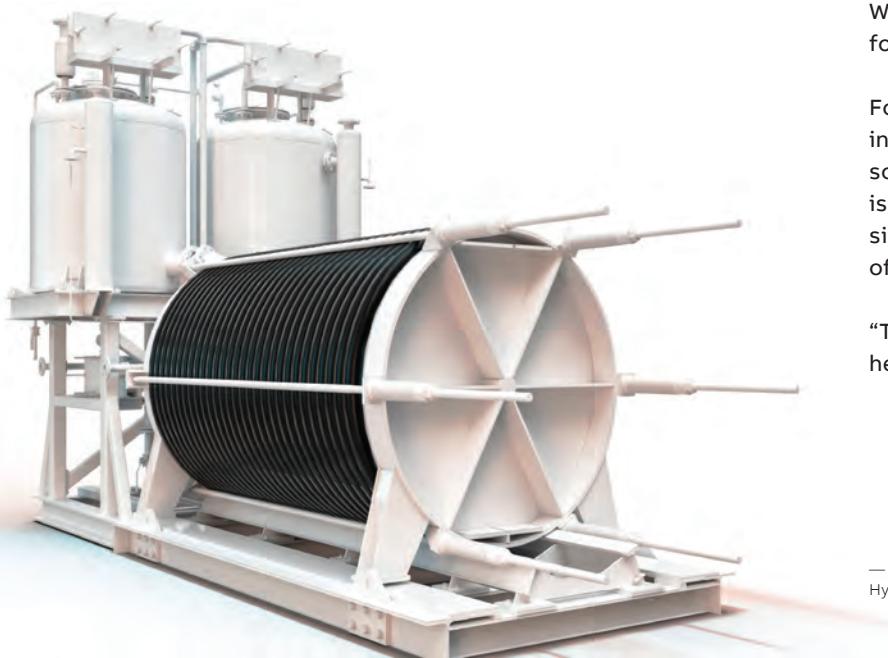
The challenge for marine, Løkke says, is how to apply available technology to marine applications. “There are no standard solutions, this is what we have to develop. For now each problem has to be addressed individually. In addition, you have the issue of permitting when there are passengers involved. This applies to both fuelling and sailing.”

#### Growing up

Contrary to electrolyzers, fuel cell technologies are still relatively immature and there are a lot of improvements to come. The cost will continue to drop dramatically and the operational robustness will improve, Løkke believes.

Nel is a partner in the Norwegian project ‘HYBRID-ship’, where the goal is to establish a knowledge base for longer journeys and operational times in larger vessels, based on battery and hydrogen technology. The target is to have a hydrogen hybrid ferry in operation by 2020. Among the partners are the yard Fiskerstrand, DNV GL, and The Norwegian Maritime Authority.

“The first vessel will be a milestone,” says Løkke. “But once the first work is complete and the permitting is in place, we have established a basic framework and the other projects will follow more quickly.”



Regarding other uses, Løkke paints with a broad brush: “Fish farms need clean power, and they could find multiple applications, using every aspect of the electrolysis process.”

He points out that ports will be the energy hubs of the future, and that ports themselves could use hydrogen to generate electricity for shore power to ships.

“Tank size will be reduced, and storage methods will in general be much more compact. I see more newbuild vessels based on hydrogen. Retrofitting would only be relevant where there is already an element of electric propulsion on board, like diesel electric. Probably ferries with travel time of more than 25 minutes and less time available to charge would be the earliest candidates.”

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**More and more car manufacturers are offering hydrogen technology in production vehicles.**

Also regulations need to get up to speed, he observes. “They are lagging behind the technology in the maritime sphere. Our job now is to educate the regulators.”

Standardisation also presents a challenge. “The last thing we want to do is rush to set a standard. We don’t want to standardise on the wrong platform, as many industries have done.”

For all the hurdles to be cleared, and the frustratingly slow pace of progress toward a hydrogen society, Løkke and Nel retain the resilient optimism of true pioneers. The closing line on their web site tutorial is a jaunty wave goodbye to centuries of fossil dependence:

“Thanks for the ride, dinosaurs. We’ll take it from here!”

Hydrogen electrolyser



The Nikola One

## The road ahead:

There are many drivers on the road to a hydrogen society, including the state of California, with its progressive legislation and support for technical innovations, championed not least by former governor Arnold Schwarzenegger. Norway's hydrogen highway initiative HyNor is another prime mover, and UN sustainability goals increasingly support renewable hydrogen production.

But every cause needs a headliner, and Nikola Motors, with their hydrogen-electric semi-trucks, may be just the ticket. Nikola took the first name of Hungarian immigrant Nikola Tesla, George Westinghouse's partner in the pioneering of alternating current electrical technology, better known as AC, in the late 1800s.

Nikola has rolled out two big rig models and has plans to build hydrogen fuelling stations across the US. They have also devised a leasing program for their trucks that includes fuel costs and maintenance, merging the sharing and sustainable economies in the most unlikely of arenas: long-haul trucking, the citadel of conservative, petroleum-driven transportation.

### Buy a truck, get free fuel

Nikola plans to install solar farms to create hydrogen from electrolysis. They will convert solar energy to hydrogen using only energy and water, creating zero emission fuel, from production to consumption.

Based on the renewable fuel generation model, Nikola can promise buyers free hydrogen fuel for up to 1,000,000 miles. And with 1,200 miles between fill ups, Nikola's sleek rigs beat diesel by up to 500 miles.

Add to this vastly improved uphill towing speed compared to diesel, and charging, rather than braking, on descents, and the Nikola package would seem irresistible to truck owners – if not drivers loyal to the roar of their mighty Macks, Peterbuilts, and White Freightliners. Maybe the 30-second 0-60 mph acceleration will help win over new converts?

# Catching fuel cell fever

“Fuel cells have been the next big thing for 25 years,” says Jostein Bogen, Product Manager in ABB Marine & Ports. “Now it’s really happening.”

**JOSTEIN BOGEN**  
Product Manager,  
ABB Marine & Ports

The industry has obviously missed the mark on that claim before, but Bogen has two tangible reasons for believing that this time it’s for real: “Fuel cell technology has matured dramatically, and the push for zero emission power solutions is only getting stronger.”

According to the 2016 Fuel Cell Industry Review by E4tech, shipments of fuel cell units were up once again in 2016, Japan is pushing development hard, Europe and the US are keeping the pressure on, and in China, “slumbering dragons” are awaking.

## There could be major changes in society.

“There is a lot of movement in the market, and various technologies are being developed in parallel,” says Bogen. “We believe the Proton Exchange Membrane, or PEM technology shows the most promise, and is the most sustainable.” ABB’s own fuel cell program involves market studies, R&D, and program participation together with leading players.

ABB believes hydrogen is a good solution in fuel cells, but Bogen acknowledges that hydrogen must be produced sustainably in order to make it a green fuel. Done right, the advantages start to add up: “Fuel cells have higher efficiency than a combustion engine, and the technology allows energy to be concentrated more densely than in

petroleum fuels. And if you use renewables to produce the hydrogen, the entire energy chain is clean.”

While pilot projects have been completed in shipping, and more are on the way, other industries are further along on fuel cell implementation. In particular heavy transport on longer routes is gaining momentum fast, a good indicator that fuel cells should be a good fit for shipping. Hydrogen trucks and busses are already on the roads, and Bogen tells of one fuel cell manufacturer that claims they will install the same capacity in fuel cells in the next two years as they did for the last 20.

Deliveries for trains are expected to follow soon, and Royal Caribbean Cruise Lines has announced plans to work with Meyer Turku in Finland on fuel cell use in its new LNG-powered cruise ships, with testing already underway.

### Complementary technologies

For ABB, their Onboard DC Grid solution has served as a platform for expanding into fuel cells, as the technology is compatible with a wider range of energy storage solutions. “We have had good help from shipowners in advancing the technology, and we are now looking into larger vessels, like cruise ships and ferries.”

Because of fewer moving parts, fuel cells represent huge savings in maintenance, Bogen points out, and the first projects would not have to be exclusively hydrogen. He envisions a hybrid solution for cruise, with traditional fuel for propulsion



and fuel cells supplying the hotel functions. “Fuel cells could be used for hotel needs in port too. Cruise owners could skip the step of equipping for shore power by simply having a zero-emission power source on board.” The next step would be pure fuel cell technology, once it becomes competitive with fossil fuel.

Bogen adds that the marine industry has also learned a lot from the development of LNG as fuel. “Just as the big shipowners went in for LNG and the infrastructure eventually followed, the same could happen with fuel cells and hydrogen.”

#### **Small steps toward big changes**

Hydrogen handling techniques and infrastructure are also improving. ABB is participating in the Maranda research vessel fuel cell project, where a mobile hydrogen storage container will be developed, improving access to hydrogen for marine applications.

“Maranda will be operative next year, with others following closely, both newbuild and retrofit projects. There are four or five commercial marine projects underway right now, with three in Norway alone,” he notes.

With this steady progress on fuel cells, what are the implications for society, and the shipping industry?

“There could be major changes,” Bogen observes. “If hydrogen emerges as a significant fuel, it could even mean a shift in the geopolitical map. If we move away from big oil, then the oil nations lose influence, and oil companies lose power. Virtually anyone can produce hydrogen.”

As for the shipping industry, moving hydrogen could emerge as a new business, in addition to hydrogen fueling greener ships. “Overall, the scenario with hydrogen and fuel cells is that shipping becomes greener and more attractive.”

The EU, Japan, the US and now China are all moving on hydrogen fuel cell technologies and promoting their use in various applications. Does this mean we are seeing the emerging contours of a hydrogen society?

Jostein Bogen’s reply is measured, but optimistic: “For ABB, the future is electric power. In this scenario, the ideal ship would be hydrogen electric. This would allow us to move away from combustion in 20-30 years, probably with a combination of batteries and fuel cells.”

There is much to accomplish, he assures, noting that the entire value chain needs to mature, and rules and regulations for marine applications need to be further developed. “But this is the trend of the future, and it is really happening. It’s not just a vision any more.”



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# CHAPTER 2

## The pace of technology

**036–037      Shipping 4.0 – The pace of technology**

**038–039      A digital journey**

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**SHIPPING 4.0**

## The pace of technology

From its origins in government laboratories, to the smart phones in everyone's pockets and up into the Cloud, the development of digital technology has taken us places we could hardly have imagined when it began.

ABB Chief Digital Officer Guido Jouret's message is all about the journey. Speaking via video link to a group of journalists gathered in ABB Marine & Ports' Helsinki office, Jouret pointed out that the 2000s have seen innovation in digital technology spill over into the consumer space, leading to explosive improvements in computation, storage, and connectivity.

"Those technologies are now reaching the industrial markets," he observed, creating massive opportunities for new value creation. "And this value migration is just beginning. Many industrial companies have been held back from embracing digital transformation because digital technologies needed to unlock value were too expensive or unavailable."

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**The technology innovations that have been transforming our lives as consumers since the beginning of this century are now being applied to the industrial space.**

What the consumer technology revolution has done, Jouret said, is to make massive quantities of computing and storage available at dramatically lower cost, via the cloud. "Now developments

like artificial intelligence and 3D printing are finding applications in the industrial space. This is why we believe that many of our markets are currently primed for a dramatic acceleration in their adoption of digital technologies."

Jouret assured that ABB is ready to help, with their new concept of ABB Ability™. Basically a hierarchy of automation, from sensors to connected devices to cloud distribution, he explained that ABB Ability is set to allow customers to enjoy greater uptime, higher speed, higher yield, improved safety, and enhanced security.

### Closing the loop

Not just cloud computing, ABB Ability is based on the concept of cloud interconnectivity. "We believe that we need to connect the clouds to create an 'intercloud' that enables interoperability of systems. This is much easier to do at a cloud-to-cloud level where digital resources are plentiful and cheap. This is the technology that allows us to close the loop between sensing, analysing, and acting."

The best part of all this, Guido Jouret assures: "The digital opportunity is here today. The technology innovations that have been transforming our lives as consumers since the beginning of this century are now being applied to the industrial space, and customers are already benefiting. ABB Ability solutions are ready now."



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## Question and answer with Guido Jouret and selected maritime journalists and editors:

### **ABB is ready for digital shipping – but is shipping ready for ABB?**

I think regulations will restrict moves in the industry more than the players themselves. That means in some cases we would have to implement incrementally, but much of what we can offer is compliant today.

### **Will the kind of data sharing you have been talking about require more standardisation?**

The cloud will enable adaptation of common platforms, exchanging data to enable interoperable solutions. Also we are seeing that Blockchain technology can ensure trustworthy interactions between players.

### **Wouldn't it be better to have an industry-wide standard to ensure interoperability?**

We will have to start with manageable partnerships and move up the stack. Technology moves faster than regulations, and I don't think any industry wants to wait for a single uniform standard before taking advantage of today's technology.

### **Regarding the human element in shipping, how can you involve more traditional crew that have practically no relation to the digital world?**

Of course not all jobs will be affected, but many people will move into new kinds of jobs. There will be more jobs on shore, involving varying degrees of human-machine interaction.

### **Are there limitations on sensor technology that is imbedded in ships with a lifetime of 30 years?**

The usefulness of such sensors at the lowest level will become limited over time. It's easier to upgrade further up the hierarchy. The cloud will compensate for some of these problems, and then we have to address sensor and lower level problems as they arise.

### **How will digitalisation change the workplace?**

More collaboration and more complex problem solving require new insight, and that will require a higher level of training, and higher skill levels. Previous industrial revolutions displaced muscle power. The 4th industrial revolution is displacing brainpower, and it is moving much faster. We will have one generation to adapt, not one century.

# A digital journey

ABB Marine & Ports' Mikko Lepistö, SVP Digital Solutions, followed Guido Jouret at the gathering of journalists in Helsinki, bringing the message of digital transformation from a purely marine perspective.

"Our future view of ships is very simple. They will be electric, digital, and connected," he stated.

"First we must electrify the power train. Then we establish collaborative operations. This will enable the implementation of digital operations. But we are talking about evolution, not revolution," Lepistö predicted. "Shipping will not change overnight."

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The electric ship is more efficient, simpler, more flexible, more digital and better connected.

The first step on the way to intelligent shipping, Lepistö emphasised, is electrification. "An electric ship is an intelligent ship. The electric ship is more efficient, simpler, more flexible, more digital and better connected. Electric ships are the natural platform for more intelligent, digital and automated shipping."

#### Moving on from mechanical

Mechanical ships with combustion engines are complex and require major auxiliary systems to support propulsion, Lepistö argued. "These systems are not naturally connected and they are very labour intensive."

By contrast, he pointed out, electric ships are easier to maintain and more reliable. Smaller and

simpler systems require much less maintenance and supervision, and problems on an electric ship are easier to handle than on ships with internal combustion engines. "Almost everything can be diagnosed remotely, and many faults can be fixed remotely."

Lepistö added that automation systems on electric ships are 50 per cent smaller than on mechanical ships, measured in number of inputs and outputs. "But even though automation systems are 50 per cent smaller, that does not mean that capabilities are 50 per cent less. Quite the opposite."

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With the proper simulation tools instead of physical testing that would take hundreds of hours and thousands of dollars, we can quickly and easily change between motors, engine rooms, bridges.

By removing non-intelligent components like tanks, piping, and valves, smart functionality can become the focal point. "Functionality of electric ships is created and updated with software, not with mechanically connected parts. This removes many obstacles to automation."



—  
Mikko Lepistö,  
SVP Digital Solutions,  
ABB Marine & Ports

He also noted that a fully electric power train is already a viable choice on smaller ferries and coastal ships, and that these are the most likely to become the first fully automated vessels.

#### A new reality on shore

Keeping pace with the rapidly evolving digital reality means that ABB needs to be able to accelerate their own pace of development, and still keep their customers up to speed. The answer lies in a new generation of interconnected simulators.

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**This facility will help us maintain a leading role in maritime digitalisation.**

“With the proper simulation tools,” Lepistö told the group, “instead of physical testing that would take hundreds of hours and thousands of dollars, we can quickly and easily change between motors, engine rooms, bridges. Instead of on site training we can gain an understanding of connected solutions in the virtual space. This opens

up for collaborative design of spaces and equipment, together with our clients.”

“Today we are launching our newest simulator facility and collaboration centre. This facility will help us maintain a leading role in maritime digitalisation,” Lepistö declared, inviting the journalists to join him and his colleagues on a virtual tour of the new centre’s capabilities.

The group witnessed a series of demonstrations simulating everything from ship design and building to maintenance, operational assistance, and remote operations. In all the scenarios, fast and efficient concept development, real time remote collaboration, and remote access to expertise were prominent features.

“The new centre makes it possible to uncover real possibilities using the virtual experience,” Lepistö concluded. “Only a holistic approach that allows us to understand how ships move, how they are powered and operated, and how they are connected, can help us create value from digital opportunities.”

## HYPERLOOP

# A new way

Why not start with the takeaway? Hyperloop Transportation Technologies is out to revolutionise transportation on our planet.



**BIBOP GRESTA**

Chairman / co founder,  
Hyperloop

The Hyperloop vision has thousands of magnetically levitated pods containing people and goods shooting at supersonic speeds through a system of vacuum tubes supported by pylons. And the Hyperloop organisation itself is every bit as innovative as the vision they are setting out to realise.

"Hyperloop is an incredible thing the way we created it. It's not a normal company," says Bibop Gresta, chairman and co founder of Hyperloop. In fact, Hyperloop is more like a crowd-sourced consortium, or as they say on their website: "Instead of starting a company, what if we launched a movement?"

Hyperloop is yet another brainchild of Elon Musk, the PayPal billionaire who founded Tesla and SpaceX. Musk published the first Hyperloop white paper on the SpaceX website, and Gresta and Hyperloop co-founder Dirk Ahlborn reposted it on Jumpstart Fund, their crowdsourcing space. Gresta recalls asking Musk, "What happens if we actually do it?" Typical for Musk, his reply was: "Do it."

Gresta and Ahlborn put out a call to action, and the responses started rolling in. "Our idea was not just raise and spend as much money as we could. We were asking people to work for stock options, and giving them the opportunity to invest." One hundred scientists requested to join the team, and each of them gave input on specific points in the white paper. Their conclusion: "It can be done."

### Heading to sea

Bibop Gresta was recently in Oslo for the bi-annual Nor-Shipping maritime exhibition and event week, and gave the closing remarks at the opening conference. Does that mean Hyperloop is moving into the ocean space?

### Elon Musk said: "Do it."

"In Oslo we were discussing with maritime players about marine solutions. The Norwegian government invited us to do the presentation, and this is part of a number of governments of different countries working together to move the concept forward in various arenas," Gresta informs.

"Norway has a very interesting vision about shipping, and I think Norway can represent a revolution in the shipping industry. We will start from Oslo to launch a message, that we can build a new infrastructure not based on energy consumption, but on renewable energy."

The idea is that Hyperloop will produce as much or more energy than it consumes, he says, based on a passive magnetic levitation system developed at Lawrence Livermore National Laboratory that requires no electricity to operate. "Aside from that, the technology is not complicated," Gresta assures. "Most of the concept is based on existing technology. It will be largely serial engineering."



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Hyperloop test track

Pretty mundane talk from a man who wants to change the way things are moved, on land and sea. “Shipping is fundamentally based on shipping companies using land in ports, where they stack unused containers and cargo in transit. Hyperloop can completely disrupt this concept by creating platforms in the sea, where collectors would come and gather the requested containers. You wouldn’t need a port any more.”

If the idea of travelling in a tube with a loaded container following behind you at 1000 km an hour sounds a bit worrying, fear not. Gresta assures that passengers and cargo will not be mixed. “We would move passengers at peak times, and cargo at down times. A lot of work is going into achieving passenger and cargo harmony.”

Working at peak capacity, Hyperloop stations would depart a capsule every 40 seconds. Artificial intelligence will call up and depart capsules on demand, predict traffic, and respond in real time. The balance of passenger and freight traffic, Gresta says, would be a function of the volume of passenger traffic. Above all, it would be safe. “The goal is to make Hyperloop the safest form of transportation on earth.”

### **First by land**

Though the system would be essentially the same on land and sea, marine installations are still prohibitively expensive, he acknowledges. “We will start with land solutions before we take that learning into the oceans, but the goal is to have the infrastructure of the future cost less and be more sustainable, on land and sea.”

So where does Bibop Gresta see Hyperloop in three years? “We are building the first test track in Nevada now, and the first installation will probably be in Abu Dhabi, where we have entered into an agreement with the government to perform a feasibility study.” Gresta is keenly aware of the symbolism of this choice: “I think it is significant that the most progressive transport system in the world is going to be built in a developing country.”

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### **The technology is not complicated.**

And in ten years? “A land-based network will have been built for passenger and freight transport, connecting several capitals around the world,” he predicts. It may just be true, what Hyperloop says on their website: “The future of transportation is closer than you think.”

## BINARY BOSS

# Putting the numbers to work

The corporate position of Chief Digital Officer, or CDO, remains something of a novelty – particularly in shipping, one of the industries where it may be needed the most.

“A company like Google will never have a CDO. Everything they do is already digital,” says Klaveness CDO Aleksander Stensby. “But it is much more important for shipping, where digitalisation is only just beginning. The shipping industry needs to flag the importance of digitalisation.”

So what is a CDO? Here’s a definition from TechTarget:

**A chief digital officer is an executive charged with helping a business transform its traditional information technology policies. The CDO focuses less on running infrastructure and more on creating the procedures required to leverage that infrastructure.**

“In Klaveness it is more than just an isolated project. We are out to change the company, and even help change the industry,” says Stensby. That’s a pretty hefty statement coming from someone who joined Klaveness with no background in shipping, having worked instead with software engineering and applied machine learning.

“It’s always a challenge when you come in from the outside,” Stensby acknowledges. “Some of those who have spent their lives in shipping are naturally sceptical, and not everyone is open for change. To bring about change demands clear vision, and a will to pursue the goal.”

The vision he attributes to CEO Lasse Kristoffersen, who years ago stated his intention to con-

vert Klaveness into a digital shipping company. The hiring of a CDO was an important step in that direction. Now it is up to Stensby to apply the will to move.

“It’s important to get everybody along on the changes,” Stensby underscores. “There will always be some resistance, but we are taking it one step at a time. We need to keep enthusiasm up and build support, and that means delivering tangible results along the way.”

**The shipping industry needs to flag the importance of digitalisation.**

### Innovation inside

One of the first tools for delivering results was established in 2015, the Klaveness innovation lab, or KLAB, the company’s incubator for development of new digital solutions and services. “A lot of people thought that KLAB should be established outside the company, as a separate business unit. But we wanted to take advantage of the experience we had in the company,” he relates. “We don’t want to wait to go forward with new developments. We are looking to see where we can make a difference, and then make a move.”

Shipping is an acknowledged slow mover, but there are other industries to learn from, and other



Aleksander Stensby  
CDO, Klaveness

business models, Stensby says. "Many examples of new business models are from the consumer segment, like the sharing economy, with Airbnb and Uber. Klaveness has been sharing for 50 years, running dry bulk pools, but without the benefit of digital technology. Now we can see how digitalisation can improve on what we already know."

Analysing data from the Automatic Identification System, or AIS, is another key driver. "Transparency and technology have made information on every ship sailing everywhere around the globe accessible. We can look at speed, position, port calls, traffic patterns, anything that can give us a better understanding of how to coordinate the resources that we manage, analyse market trends, and optimise our operations."

Technologies from other industries are also enabling change. Blockchain is one of these, best known to date as the foundation of BitCoin, the virtual currency. Now Maersk and IBM have teamed up to use Blockchain in the first industry-wide, cross-border supply chain solution.

"We have a good relationship with Maersk, and we are following this project closely," Stensby says. "We have several people with backgrounds from Maersk, and we regularly exchange R&D visits

with them." Not just Klaveness, but the entire shipping industry has much to learn from the Maersk-IBM collaboration, Stensby believes.

#### **Make the most of what you have**

"Sensor technology will be an increasingly bigger part of the changes that are coming," Stensby says, reflecting the three new Klaveness vessels that will employ ABB's OCTOPUS software, collecting data from onboard sensors and providing insight into key performance parameters. "But right now most ships are not digital, so we have to figure out how to include them in our digital plans." The key, he says, is to find out which new opportunities are present in the data that they do have access to.

"Vessel and fleet performance is a priority project in Klaveness. Now we are looking at how to use existing information, such as the noon report, to analyse performance. Often it is not so much about new data, and more about finding new ways to use it."

They look at commercial and other sailing-related data as well, but an ongoing challenge is to clean up the data they do have access to: "The quality is not always good enough," says Stensby. "But we have found that improving data quality is almost always a good investment."





The KLAB meeting room

As for those who believe that digitalisation is better achieved in the business units, rather than being the domain of a digital director, Stensby couldn't agree more: "We have achieved our goal when my position is no longer needed," he says.

Along with data scientists, the specialists who sift through mountains of data looking for the gold nuggets, the CDO's days may indeed be numbered as digital fluency makes its way into the entire organisation.

Until then, CDO Aleksander Stensby will help Klaveness to follow CEO Lasse Kristoffer's motto of 'Try a little – learn a lot', continuing on the road from analogue to digital, until they become what Stensby calls 'digital inside': "It could well be true what they say, that someday we will all be data scientists."

## CARGO in real time:

Klaveness have themselves spun off digital products and services, the latest being CARGO in 2017. Aleksander Stensby tells the story of CARGO by Klaveness:

"The overall ambition of CARGO is to enable all cargo owners to reduce the costs and risks of their logistics by making better-informed decisions.

"The inspiration for CARGO came from our long-term CABU service being an integral part of the supply chain of our customers. Apart from competitive freight, the success of CABU is largely due to us working closely with our customers and the continuous effort of assisting them in monitoring and improving their logistics.

"Today, our customers rely heavily on manual collection of information and data entry in spreadsheets to stay updated. Providing our customers with real time, updated and complete information pertaining to their inventory and cargo flow, gives them complete visibility and allows them to take early preventive action to reduce total logistics costs from fuel, freight, demurrage and storage. Also, manual exchange of operational information such as cargo and vessel nominations, notices of ETAs, etc. can be automated and provided in 'real time'."

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## CYBER SECURITY AT SEA

# We've only just begun

If you think cyber security issues in shipping have been resolved, think again – or be prepared for a rude awakening.



**JORDAN WYLIE**  
Founder and principle  
consultant,  
JWC International

The maritime industry is in fact among the most vulnerable to cyber attack. Ironically, shipowners are among those least concerned with cyber risk, according to Jordan Wylie, founder and principle consultant at JWC International, a global cyber security advisor.

"The term 'cyber attack' means many things to many people," says Wylie. "While the protection of personal and financial data is critical, shipping companies face additional higher profile risks."

"As we increasingly turn to hyper-connectivity, where machines communicate with each other, we join every other sector that wants to conduct business faster, distribute goods cheaper and operate more efficiently," he says. "We are doing this with little to no understanding of the security implications related to internet connectivity, and therefore we place our vessels, crew, systems and operations under increasing risk by joining this connected network without segregation or separation."

Despite this dire, or at least dour warning, Jordan Wylie can see why many do not take this present danger seriously:

"Understandably, people and businesses are sceptical. This is probably one of the most misrepresented risks in history, and it is largely misunderstood by a majority of people and businesses alike." The problems, Wylie claims, are often considered to be over-dramatised by the

cyber security industry in order to sell security technology products.

But if you don't consider cyber security an issue, he warns, then consider the many cyber-attacks on businesses in the past few years, particularly the hacking cases that affected Yahoo. Despite its significant cyber security resources and budget, this internet giant was the victim of a breach affecting over 1.5 billion personal accounts, demonstrating the vulnerability that every company faces when it comes to security.

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**While the protection of personal and financial data is critical, shipping companies face additional higher profile risks.**

Wylie reports that thousands of new malicious software and viruses are being discovered every single day, along with new software vulnerabilities, meaning that managing a company's exposure to cyber risk has never been more demanding. Far from being a retired issue, Wylie warns: "I would certainly not consider the cyber problem to be resolved."

### **The new reality**

As the reliance on smart and automated operational technology systems increases within both



the shipping and offshore industries, so do the vulnerabilities of these critical systems to cyber-attack as they become increasingly connected to the Internet.

Another problem seems to be one of attitude, rather than technology. Owners and operators tend to feel their ships and cargo are not of interest for hackers. So what can be done to change attitudes and help owners prepare for the reality of cyber attacks?

"Attitude is linked to understanding," says Wylie. "Cyber space is largely misunderstood, yet it is the backbone of the modern economy. The Internet is one of the most powerful creations in human history, yet 99.9 per cent of us do not understand how it works and therefore we do not understand how to defend our very dependence on it."

On the other hand, Wylie concedes that hackers are probably not after a ship's cargo or interested in taking control of a vessel. There are significantly easier and less risky ways for cyber criminals to make money, he says, like a simple ransomware infection on a shipping company's system, encrypting cargo manifests and allowing the attacker to hold information hostage. The ransom cost in these cases is compounded by the loss of productive time until the data is recovered.

In addition, many companies underestimate the value of employee personal information that can be sold by hackers on the black market. "For this reason, every person, company and organisation is considered a potential target to hackers who comb the Internet to find soft targets to breach," he says. In addition to the financial impact of cyber extortion, or the safety and operational impact of operational systems being compromised, companies also face significant legal and reputational impact from a cyber breach.

#### **Get serious**

This is where Wylie's message gets serious for management: "Education about the emerging cyber security risk is not only necessary for crew members and employees, but also at the executive management level." The sooner the boardroom recognises information and cyber security as a top business risk, as opposed to being "just

an IT issue", the sooner appropriate planning, manpower and resources can be prioritised to mitigate this growing risk, he says.

He advises shipowners to identify their business-critical systems and sensitive information assets and conduct regular risk assessments to ensure adequate controls and resources are in place to protect these systems and assets as a priority. "It is essential that these controls and resources be clearly defined in a corporate information security policy which should be complied with across the company and supply chain," Wylie maintains.

But, do owners and operators have any real hope of keeping pace with hackers and cyber terrorists?

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## Online is quickly becoming the new front line.

"The technological environment on which our industry has become increasingly dependent, is a dynamic one with security vulnerabilities being discovered on critical systems and software on a daily basis." It then becomes a race for the vendors and security practitioners to develop fixes or 'patches' to eliminate the identified vulnerabilities before hackers can exploit those gaps in security to gain access to a company's critical information and systems.

#### **Stay smart**

For all these technological weaknesses, the weakest link of all may be the people themselves. "One of the most common security vulnerabilities for all companies, including shipping and offshore organisations, is their employees," Wylie says. "Uninformed employees can easily be exploited or tricked into downloading malicious software onto company networks or conned into providing passwords to accounts and systems, all of which will provide the attacker access to your critical information."

The development of a strong security culture through regular training and awareness cam-

paigns is Wylie's recommendation as the most effective fix for this vulnerability. He is a champion of the maritime and offshore industry initiative "Be Cyber Aware At Sea" campaign, designed to provide shipping and offshore companies with the tools, advice and products to help develop a strong culture and equip crews with the knowledge to identify, report and manage common cyber security threats to the workplace.

Another pitfall Wylie warns against is the once-ubiquitous USB stick, which he says can be pre-loaded with near invisible viruses that open a computer to hackers without the user being the wiser. In other words, be as sure of what you are putting in your computer as you would of what you put in your mouth.

Even with adequate precaution, Wylie says the maritime community still needs to be prepared for the worst, and even for the not-so-bad:

Jordan Wylie brings the message home

"The most likely attack scenarios we can expect against the industry in the near future will continue to be the common indiscriminate activity of very simple 'phishing' or 'water holing' attacks, where a user is duped into visiting a malicious website," he relates. "Whilst these are very easy to defend against with education and up-to-date anti-virus, they are still rising in occurrence."

And as the maritime industry's business and safety critical systems become more connected to the internet, so do maritime operations become more exposed to worst case attack scenarios such as the targeting of navigation, safety and communications systems in order to disrupt the systems or deny access to them.

"Online is quickly becoming the new front line," Jordan Wylie concludes, but he has a lifeline to throw out in the churning cyber sea: "The reality is that fortune favours the prepared."



# Managing risk in a digital world

The digitalisation of the maritime and offshore industry is both an inevitable and welcome development. But as the industry accelerates its migration from analogue to digital solutions, many owners have the same question: Can we trust the data?



**BJØRN-JOHAN VARTDAL**  
Program Director  
for Technology and  
Research, DNV GL Group

Increased investments in on-board sensor technology and land-based digital platforms are changing how shipowners manage and operate assets and interact with suppliers and regulators. Digital tools enable a broad range of benefits touching almost every aspect of fleet operations and management, from ship design to on-board condition monitoring, decision support to cargo tracking, automation to class approval, and many more. Digital tools have also created new business models where data – not hardware – defines the parameters of contracts.

## Data overload

According to Bjørn-Johan Vartdal, Program Director for Technology and Research at the DNV GL Group, a combination of weak shipping markets, evolving technology and a new generation of managers are all driving this rapid shift to digitalisation. "Access to vast amounts of data offers new opportunities for reducing costs and improving performance," he says. "But more doesn't always mean better. Digital information can be an effective decision support tool, but many owners struggle to manage their data effectively."

Vartdal explains that owners face three big questions while migrating to digital platforms: Can they trust the data? Is it safe to share data? And how best to secure and monetise their data? "If owners are using these new data streams to make

business-critical decisions, they have to trust not only that the information is accurate, but that it is secure and has been analysed correctly," he says. "And while sharing data with suppliers can generate efficiencies, some owners may resist exchanging sensitive fleet information and worry they are more exposed to having their data hacked."

**Access to vast amounts of data offers new opportunities for reducing costs and improving performance.**

## Performance based contracts

In the case of performance-based contracts, data integrity is especially critical. Unlike more traditional fee for hardware or service agreements, performance-based contracts rely on a pre-determined set of criteria based on shared data. "In such contracts, it is suppliers – not owners – who are responsible for condition monitoring, service and maintenance, so these types of contracts help incentivise manufacturers to ensure their products are fully optimised and work as advertised," says Vartdal. "But if either party cannot trust the data, the validity of the contract is at risk."



DNV GL®

Another area where digitalisation has raised questions has to do with liability. "There remain some questions – especially among marine insurers – as to what parties are responsible if an incident occurs as a result of corrupted data, faulty sensors, a cyber attack or poor data analysis," says Vartdal. "We don't think of machines making mistakes, but humans do – and humans are still responsible for data inputs. Junk in is junk out."

#### **The role of class**

Vartdal notes that while the issue of trust applies to all parts of the industry, much of the burden is on class, which the industry relies on for verification and approvals. Like many class societies, DNV GL is working with different industry stakeholders to try to manage a broad range of digital risks, from data assurance to cyber security. "We offer tools to help owners verify, organise and secure their data more effectively," he says. "And as in everything we do, it is vital that the industry trusts that we offer truly transparent and independent third-party services."

For example, DNV GL recently announced a pilot programme, in cooperation with other key stakeholders in the design and commissioning phase, to automate the approval process. "Rather than exchanging drawings, we can upload 3D simulation models to the cloud, providing all stakeholders with access to the design and allowing us to verify any changes in real time," he says. "This not only dramatically streamlines the approval process, but helps to avoid potentially costly mistakes at an earlier stage."

#### **Embracing a digital future**

For all the uncertainties, Vartdal insists that the digitalisation of shipping will lead to a safer, more efficient and environmentally friendly world fleet. "Many owners have struggled to develop workable digital strategies due to institutional inertia or silo thinking and a lot more work needs to be done to standardise systems," he says. "But the benefits so outweigh analogue practices that we anticipate digitalisation will accelerate rapidly in the next five years, completely transforming the industry. And from our perspective, the sooner the better."

## MARINE INSURANCE IN THE 4TH INDUSTRIAL REVOLUTION

# Testing the digital waters

The impact of digitalisation on marine insurance could potentially be huge, but even then it won't be mainly about the technology. It will always be about what insurers have always cared most about: knowing risk.



ALEM JASAREVIC  
COO, Skuld

This is the take from Alem Jasarevic, chief operating officer at Skuld, the underwriting giant based in Oslo.

Jasarevic has spent most of his career in land-based insurance, a background that gives him valuable perspectives from industries that are currently running a nose ahead of the maritime industry in exploiting digital technologies.

### It's possible to combine many more risk factors using big data.

"Insurance is about distributing risk. An owner wants coverage against potential accidents, and insurers want to cover the customers with the lowest exposure to risk. Then the key is putting the right price tag on risk."

Jasarevic compares marine underwriting to automobile insurance, something nearly everyone is familiar with. "Just like with car insurance, there are reasons for the different prices for premiums," he says. In automotive insurance, pricing variables can include power, size, age, driving habits, and history.

"All these things go together to make up an overall risk picture, and companies have to be good at evaluating that risk and putting a number on it."

And though the variables are different at sea, the same basic principles apply.

So how can digitalisation help reduce risk?

"With precise information you get a better risk description. What you had to assume before is now knowable. In this way, telematics are contributing to reducing risk, because they allow you to gather so much more information." This is already impacting automotive insurance, as companies gain a clearer overall picture of car performance and driver behaviour. "But you still have to process that information in order to gain value from it," he observes.

And that is where big data comes in. "It's possible to combine many more risk factors using big data. In that sense it is an enabling technology. Digitalisation becomes about meeting customer needs more efficiently and more accurately with the help of technology."

The digital world also facilitates changes the nature of businesses, and that in turn presents insurance companies with new risk pictures. "Just like Uber challenges taxis using new technology, we are seeing the contours of change in shipping," he says, referring to the emergence of integrated and remote operations, automation, and even autonomous ships.



On that last one, Jasarevic reflects his industry's cautious optimism: "Autonomous ships are an enticing prospect, but time will tell whether the concept is truly feasible. Is there more or less risk when man meets machine on the water? Perhaps the turning point will come when there are 80-90 per cent unmanned ships, and no one is predicting when, or even if that will ever happen."

Another take on autonomous vessels is that not having people on board means there is less to insure. This is countered by many factors, however, not least the increased risk of cyber crime, or physical take-over of an unmanned vessel. Addressing the latter, Jasarevic cites current studies on how to equip ships to defend themselves, with barriers, water cannons, or electrical fields. "All this impacts the owner's cost, though, and that influences their choices," he adds.

But the industry doesn't have to look as far as autonomous shipping to begin to see the benefits of increasingly digitalised shipping.

"The use of sensors is already making a difference. If predictive or preventive maintenance leads to less repair or replacement, it will mean less expensive premiums, but insurance companies will have to see the effect first."

Even with remote access reaching many ships on the water, insurance companies are not yet following ships directly. "We sell policies for one year at a time. Costs are based on assumptions, recognisable patterns, and the history of the owner or operator. Of course we can make adjustments in response to developments during the insurance period, but with 15000 vessels in our portfolio, tracking them individually 24/7 would be a huge task, even using big data."

While suppliers are delivering remote surveillance and advisory systems, actual remote operations have yet to kick in, Jasarevic observes. "But if or when they do, if they can provide improved control, it could be interesting for both parties. Lower risk for insurers, and lower premiums for customers."

Though employing digital technologies can mean lower risk and lower premiums for shipowners,

Jasarevic realises that insurers cannot demand that customers install the latest equipment onboard. "In today's picture, we will continue to insure all types of ships, while we wait and see how digitalisation affects the risk profile."

"The benefit has to be apparent in the balance between cost and reward. Safety has a cost, and if you invest in systems to reduce risk of breakdown or accident, then you want the same reduction in premium. The insurer has to agree that your investment makes you that much less of a risk, and there is no guarantee that they will do that," he points out.

Then there is the potential downside of connectivity. "Theoretically, we could see digitalisation affecting safety, for example if crews do not get sufficient rest because they spend too many off duty hours online, or if onshore intervention distracts or disturbs command on board. But it would be too invasive to monitor crew behaviour on board in real time, or communication between the bridge and home office," he says.

And for all the buzz around cyber security, Jasarevic still believes that cyber threats are not yet a principle risk. "How many major incidents of cyberhacking impacting ships have we seen?" he asks, referring to the few documented incidents to date. "When it becomes an apparent threat, it will be addressed, but of course we have it on our radar."

Whether ships are continuously monitored, remotely controlled, manned or unmanned, Alem Jasarevic knows there will always be one main factor in reducing risk: running a tight ship.

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We will continue to insure all types of ships, while we wait and see how digitalisation affects the risk profile.

"Bad luck and bad operations are two different things. Anybody can have bad luck, but if you have bad operations, no amount of digitalisation is going to help," he concludes.



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## The data is there – but how to handle it?

Tore Forsmo has spent most of his career assessing and managing marine risk, with a background from Det Norske Veritas (now DNV GL) and 10 years as managing director for the Nordic Association of Marine Insurers. His present capacity as Area Manager Norway with The Swedish Club gives him the opportunity to apply this depth of knowledge to the digital revolution currently shaking up shipping.

Reflecting on the enormous amount of information that goes into determining risk factors and putting a price tag on risk, Forsmo observes: “The insurance business has always been about big data. What’s new is, the 4th industrial revolution is making big data available in real time.”

That being said, Forsmo maintains that the marine insurance industry is not yet actively using all the data it has access to. “For example, car manufacturers log millions of hours of vehicle activity, and they can already prove that safety improves with assisted driving. Once that claim is verified, insurance costs go down accordingly.”

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The insurance business has always been about big data. What’s new is, the 4th industrial revolution is making big data available in real time.

But a ship presents different challenges: “In automotive, the car is all theirs. The same applies to aircraft. Ford, Boeing, GM, Tesla, they all collect all the data, analyse it, and apply the resulting knowledge to their products. But a ship is more composite, made up of parts from many different manufacturers, with no single point of responsibility. So who should handle all the data, and how should they use it?”

Forsmo acknowledges that there are some companies claiming the capability to gather, process and utilise huge amounts of data in a common arena, but as of yet there have been no major commercial deliveries of comprehensive data handling systems.

If anyone is to assume such a role, Forsmo speculates that it might be the classification societies. But again, enigmatic human factors overlap with the rigid binary world:

“It will come down to who trusts whom. Trust and regulations will be the factors that determine whether such a complex responsibility can be handed over to a third party.”

## Shifting gears in Shanghai

As shipbuilding around the world adjusts to new market realities and the digital shift begins to impact nearly all aspects of the industry, China is well underway on a new course, with higher-value, cleaner, and more efficient ships and construction as their beacons.



**PROFESSOR  
XING WENHUA**  
President, SSNAME

Leading the way is the Shanghai Society of Naval Architects and Marine Engineers, SSNAME. President of SSNAME, Professor Xing Wenhua, shares some thoughts on the current shift, and the future prospects.

Starting with the digital revolution, Prof. Xing relates that his members are taking their cue: “Digital technology is developing rapidly, and the Chinese shipbuilding industry has seized the opportunity for transformation by applying digital technology to ship design and ship construction. This will allow us to promote the development of environmentally-friendly ship types and raise the level of modular construction.”

For decades known as a producer of large, less sophisticated and inexpensive ship types, China has had growing success in penetrating high end markets in offshore, tankers and container ships. How can emerging digital technologies help the Chinese industry to achieve even better performance at the high end?

“China has made great progress in building ultra large container vessels, ultra large ore carriers, LNG carriers and VLGCs, which have been received favourably by shipowners. Along with the development of the Internet and communications, digital technology will surely bring great changes for Chinese shipbuilding, especially to design, operation and management.

“The level at which digital technology is applied will define the industry’s capabilities,” Prof. Xing continues. “It is recognised that information and digital technology is driving the modernisation of shipbuilding, and that the Chinese shipbuilding industry will inevitably leverage these technologies to catch up. To reach its goals, the Chinese shipbuilding industry will seek to develop the most advanced intelligent construction methods and transition towards the ‘intelligent shipyard.’”

**The level at which digital technology is applied will define the industry’s capabilities.**

### Cruise in the news

The cruise market is growing faster in China than perhaps anywhere, and Chinese interests have taken ownership of European yards in order to meet demand. How does SSNAME view opportunities in cruise construction for its members, and for the domestic market in general?

“The cruise market in China has grown rapidly in recent years, and the strength of demand creates a base for China to develop the sector further, as well as related activities. In fact, in addition to attracting more travellers, the cruise sector has drawn attention from the Chinese government.

Chinese authorities have announced several policies to develop equipment and facilities for cruising, and this has served as a great encouragement for the Chinese shipbuilding industry to diversify into designing and building cruise vessels."

Cruise is known as a highly demanding segment for designers and builders, with European yards establishing a clear lead in experience and expertise. How can SSNAME close this gap?

"Shanghai has inherent advantages in design and construction when it comes to cruise vessels. Our members mostly come from shipyards, designers, research institutes, universities and equipment manufacturers. They are surely expecting the boom to continue and will raise their capabilities to benefit from the current upturn in cruise ship building," says Prof. Xing.

#### **Seeing the bigger picture**

As with many things in China, once they take hold, developments are bigger, faster, and more comprehensive than in the rest of the world. Now the focus in China is shifting to the environment. How will the shipbuilding industry be affected?

"China's government has been paying great attention to environmental sustainability, as witnessed by our commitment to the Paris Agreement. Some of our members have taken part in formulating international rules and regulations at IMO, and others have taken effective measures to respond to the new requirements. The challenges at present for our members include development of green ships and how to get rid of the slump in shipping brought by the low oil price."

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Shanghai has inherent advantages in design and construction when it comes to cruise vessels.

Another shift well underway is in international cooperation. What are some of the most interesting international partnerships and cooperation for SSNAME members?

"After years of development, SSNAME has won both reputation and influence in the shipbuilding industry. To have more exchange and cooperation, the organisation has taken part in many international academic events and set up friendly relations with 14 well-known foreign societies involved in the industry.

"SSNAME is one of the sponsors of the Pan Asian Association of Maritime Societies and has hosted the PAAMES conference twice, playing an important role in the development of PAAMES. In addition, SSNAME is a member of World Maritime Technology Congress and was selected as the host Society of WMTC 2018."

Another noteworthy international initiative for the SSNAME is Marintec China. What is your role there, and how important is this event to your members?

"SSNAME is the organiser of Marintec China, but we are also proud of having founded the event. With the great efforts made in the past 30 years, Marintec China is recognised as the largest maritime event in Asia Pacific.

"In accordance with the developing trends and hot topics in the industry, the theme for the 2017 forum is 'Innovation, Smart Manufacturing and Collaboration', which corresponds to the theme of the exhibition: 'Strengthening, Leading, and Connecting'.

"At the same time, there will be a special area for presentations and discussions on cruise vessels. SSNAME will invite enterprises and experts to give their comments on both the building procedures and equipment on cruise vessels."

What do you see as the single most important challenge to be met in Chinese ship design and building going forward?

"I think the most important challenges to be met in Chinese ship design and building relate to reducing pollution from ships and developing the unattended bridge. These are the challenges that need to be met, but they are also historic opportunities for the Chinese shipbuilding industry to develop."

# Autonomous in the Arctic – fortune or folly?

Arctic shipping is hot, but the climate is definitely not. Does that make it a good idea or a bad one to send ships to the far north without crew?



**MARTIN BERGSTRÖM**  
postdoctoral researcher,  
Aalto University

Martin Bergström is a postdoctoral researcher at Aalto University in Finland, currently focusing his work on Arctic and autonomous shipping. Rather than seeing harsh Arctic conditions as an obstacle to autonomous shipping, he sees the climactic challenges a prime reason to take a closer look at the unmanned option.

“So far, there has not been much discussion specifically on Arctic applications. In any case, because I am convinced that the Arctic is well suited for autonomous shipping, perhaps even more so than non-Arctic areas, I think it is good we start the discussion.”

To Martin’s mind, the current main barrier is probably legal: “Because most rules and regulations were developed before anyone had seriously considered the concept of autonomous ships, references to specific crew tasks like the human lookout are lacking.” In order to overcome these issues, he believes the IMO will need to develop a new, goal-based regulatory framework specifically for autonomous ships.

Typically, development of any new IMO regulatory framework is a slow process, and the approval of any autonomous ship solution will require extensive real-life evidence of its safety. “Also, we need to consider that most Arctic shipping will occur in waters regulated by the Russian Federation. Because of these complicating factors, I expect that autonomous shipping will start small in territorial waters, for instance in the coastal waters of Norway and Finland, which would also mean that

autonomous shipping from the very start would be adapted to semi-Arctic conditions.”

## To crew or not to crew?

Sending a ship and crew on a solo voyage through a passage with virtually no infrastructure, and days away from rescue, would seem a fool’s game. Is this the primary reason for thinking autonomous in the High North?

“The fact that ships in the Arctic often are days away from rescue is a good reason for thinking autonomous. Safety risks, or immediate risk to humans, exist only where there are people. By eliminating the onboard crew, crew safety issues are eliminated as well.”

The fact that ships in the Arctic often are days away from rescue is a good reason for thinking autonomous.

At the same time, Arctic waters are often poorly charted, and ice poses a constantly shifting threat. Can a machine deal with such unpredictable complexities?

“Arctic ship operations are indeed complex and associated with many uncertainties. An autonomous ship would be controlled and monitored from a shore control centre, or from a mothership. Whoever is in charge would have access to the



same information as an onboard crew, and therefore I do not see why any Arctic-specific uncertainties would be significantly more challenging for an autonomous ship than for a manned one."

Certain functions, such as active measures by the helmsman to minimise the ice exposure of a ship, would likely be less efficient when performed by an autonomous system. Here Bergström has a novel solution: "For improved autonomous safety and efficiency, methods should be developed to allow autonomous systems to learn from experienced Arctic shipmasters and officers."

#### **When mind meets machine**

In considering the sharing of the seas between human and machine-controlled vessels, many are sceptical. What happens when a human pilot and a computer "captain" find themselves on a collision course?

"I am confident that autonomous and manned ships can and will coexist. To enable a safe co-existence, I think autonomous ships need to be clearly identifiable as such, so that manned ships, when operating in their proximity, can take appropriate precautions if necessary."

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**Concerning risks to humans, the replacement of manned ships with autonomous ones could have an adverse effect on the available search and rescue capabilities.**

He also believes that division of labour will be a factor: "Autonomous ships will surely replace some manned ships, but they might not be efficient for all types of operations, especially those requiring a high degree of flexibility and situational awareness, like icebreaking services or special cargo transport."

The level of automation of manned ships will gradually increase as well, he believes, potentially reducing crew sizes. But with even one crewmember onboard, the argument of eliminating risk to

crew falls flat. Will there ever be truly autonomous ships, or is the future hybrid? "At least for the foreseeable future, I suppose we are talking about a hybrid solution, with a gradual transfer towards increased autonomy."

Even with no crew on board, Bergström is certain that humans will have a role to play. "For better or worse, humans will remain in control and continue to play an active role. Exactly what will be controlled remotely, and what will be autonomous, will be determined based on cost efficiency and regulations. Autonomous or not, all engineering systems are made by humans, and in essence autonomy is about predetermining appropriate actions for various situations. That means humans need to teach autonomous systems how to behave."

#### **The risks**

"Concerning risks to humans, the replacement of manned ships with autonomous ones could have an adverse effect on the available search and rescue capabilities. The ability to identify small objects in the water, such as a lifeboat or a person, as well as the ability to assist persons or ships in distress, could be reduced, resulting in an increased safety risk for any remaining people in the Arctic."

Regarding risks to nature, Bergström sees at least three possible adverse effects: "First, the ability to carry out immediate oil spill response measures like deploying booms, would be limited. Second, due to the absence of a human lookout, a vessel's ability to detect any oil discharges would be reduced, potentially increasing the amount of illegal discharges. Third, if autonomous Arctic shipping turns out to be profitable, an overall increase in Arctic shipping is expected, resulting in an increased environmental load from exhaust and noise emissions, which would have an adverse effect on sensitive Arctic wildlife."

#### **The rewards**

"The most obvious safety benefit would be the elimination of crew safety risks. In addition, by going autonomous, a reduction in trivial human errors, which are behind most accidents, can be expected. The most common type of accident in winter navigation is collision between ships and

icebreakers." Bergström points out that fatigue, at least partially caused by extreme Arctic conditions, is often a contributing factor to such accidents. "A well-rested shore based crew that is able to make objective decisions could reduce the risk of accidents."

As to the environmental benefits of autonomy, Bergström believes the main effect would be higher energy efficiency and consequently lower exhaust emissions. Improved energy efficiency could be achieved by removing the superstructure housing crew facilities, resulting in lower air resistance, lighter ships, and reduced onboard

energy consumption. "In addition, by removing the crew, related environmental loads such as grey water and garbage, especially problematic in the sensitive Arctic environment, would be eliminated."

"In terms of economics, the most obvious gain would be the elimination of onboard crew-related costs," Bergström says. "In any case," he concludes, "the biggest potential economic benefit lies in new business models and markets, resulting in an overall increase in Arctic shipping. The winners will be those that are able to make the most of this disruptive development."



# Seeking intelligent shipping

Kalevi Tervo, Global Program Manager of ABB Marine & Ports has a high-level vision for shipping.

It is a vision fuelled by relentless and rapid developments in technology, but tempered by human nature. “Technology will appear in and invade every link in the value chain,” Tervo says, “from developing and making, to experiencing. The flow of information will transform the ability of systems.”

But for this to be realised requires open platforms and sharing, and that demands the most human of elements: trust. “Shipping 4.0 embraces open systems, but it can only happen on a broad scale if all the players in the picture are willing to trust what their data is telling them.”

While binary data may be absolute, Tervo observes that trust is intangible. “Some achievements come only through experience. In many ways it’s the same as with self-parking cars. At first you might not trust the technology, but once it has proven itself, you trust it more than you do your own abilities.”

For ships, the “self-parking” system utilises data from multiple sensors to create a dynamic picture of the vessel and the surroundings. The ship’s state of motion is visualised in relation to the static and dynamic objects around the vessel to help the operator in controlling the ship.

“At the moment there are people on land as well as on deck who shout instructions in a walkie-talkie for the captain who does not have full visibility of the ship.” Once the crew learns to

trust the assisting solutions, Tervo says, those can be utilised as part of closed-loop control to perform automatic operations. “But it requires trust that the machine can see better than a human can see – and without human error and fatigue.”

## We can make a ship react optimally.

He relates back to the early days of computers in shipping: “It was the same when we introduced digital technology in the marine business. Our clients only trusted the naval architect. They didn’t believe in the computer. But once they experienced the benefits, they came around.” There will always be someone willing to take those first risks, he says. “Then the rest will follow with smaller risks in order to reap a larger benefit.”

### In data we trust?

But trusting data-driven performance also requires trust in the quality of the data. There are ways to cultivate this trust, Tervo says: “The first is to evaluate the quality of the data and make sure it is reliable, or take steps to make it reliable. Then there are redundant data sources to avoid having to rely on a single source. Continual diagnostics can also be run to ensure an uninterrupted supply of healthy data.”

When all this is done, data can often give a more reliable view of a situation than humans. “Through machine learning and artificial intelligence, ma-



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Kalevi Tervo,  
Global Program Manager,  
ABB Marine & Ports

chines can recognise objects and situations that they have never actually encountered,” he says.

Empowered by this technology, Tervo points out that ABB has the ability to control all the ship’s systems, from autonomous control to new digital services, to engine and control room design, to power train efficiency systems. “We have progressed in all these areas, to the point where we can build entire integrated ships systems, from bridge to propeller.”

ABB is currently developing a novel control system for dynamic positioning, manoeuvring and open sea operation to help the crew to control the ship more intuitively, safely and with higher efficiency. “The solution enables the user to focus on controlling the ship, while the system takes care of which assets are used to perform the control.” He notes that current solutions do not fully utilise the manoeuvring potential of ABB’s Azipod propulsion system. “But we know how Azipods work, we know how the ship reacts to changing impulses from the unit, so we believe that we can create a unique product for controlling a ship with Azipod propulsion.”

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## Technology is helping us understand what the user’s role will be in the future.

“We can make a ship react optimally, telling it how and when to generate and consume power, where to navigate, and how fast to steam. We are ready to take this from the planning stage to reality, but ABB does not expect to do everything alone.”

### Better together

Working from a holistic perspective, Tervo says that ABB sees the need to understand the customer’s value proposition, acknowledging that each client has specific needs, and working with them to fulfil those needs. “There is still room for considerable improvement. Our next move will be from advisory services to closing the loop of decision making, and this will require even better customer insight. With this, we can help them calculate predictions, optimise resources, and connect this knowledge to actions.”

Data from operations can also be used to make decisions at higher levels, he says. “We can enable strategic changes in operations. This gives connectivity more added value. We are learning to use our experience to connect the dots, to complete the picture of overall benefit.”

“Technology is also helping us understand what the user’s role will be in the future.” This, he maintains, is necessary in order to respond to changing roles in the value chain: “Retailers like Amazon already have their own logistics services down the entire supply chain,” he observes. That in turn moves the supplier’s products and services down in the value hierarchy, and increases the importance of the retailer.

Regardless of how disruptive this may seem to original equipment suppliers like ABB, Kalevi Tervo assures that the move toward intelligent shipping will be sustained by the same basic principles that have always driven quality OEMs like ABB: “Our goal will always be to increase customer value, to provide maximum benefit from the application of technologies.”



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# **CHAPTER 3**

## The force of policy

**066–069      Shipping 4.0 – The force of policy**

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**SHIPPING 4.0**

# The force of policy

How powerful is policy, really? The reply from Eero Lehtovaara, Head of Regulatory and Development in ABB Marine & Ports, packs a punch:



**EERO LEHTOVAARA**  
Head of Regulatory  
and Development,  
ABB Marine & Ports

“If you don’t comply, you don’t work.”

Lehtovaara represents ABB Marine & Ports in an array of trade associations and classification society working groups, perhaps most notably IACS, the International Association of Classification Societies, which serves as the principle technical advisor to IMO, the International Maritime Organization of the United Nations.

“We are trying to lead the discussion and promote action to advance shipping on all fronts,” he says. “The underlying idea with ABB’s participation is that technical and digital development is moving so fast that it is having major implications for safe operations. This requires regulations to evolve quickly, but that won’t happen without cooperation from equipment manufacturers.”

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**Non-compliance with IMO regulations means you don’t operate in flag state nations.**

If original equipment manufacturers (OEMs) are not involved, Lehtovaara says, “We risk a situation where we have good and safe technology, better than what’s out there, but we can’t implement it because regulations do not accommodate it.” That is why he believes that OEMs and classification societies need to cooperate earlier in the development process, to allow class to learn about

capabilities and improvements as they emerge, and be ready to respond when the technology is ready for use.

## **The policy pyramid**

Taking a look at the institutions entrusted with the task of regulating the shipping industry, Eero Lehtovaara starts at the top:

“The IMO was established under the United Nations Geneva Convention of 1948 to ensure the safety and security of international shipping. Today there are 172 flag state members,” he explains. Unless flag states stipulate otherwise, ships operating between these countries must be flagged, and all ships trafficking state ports are subject to Port State Control to assure compliance with international regulations. “Non-compliance with IMO regulations means you don’t operate in flag state nations,” Lehtovaara says.

He describes the relationship between IMO and the classification societies as fairly straightforward: “IMO determines the code, and IACS looks at the consequences of that code and sends a unified interpretation to its members. IACS also recommends actions or responses to member societies. Basically, IMO says what and why, and the class societies figure out how.”

Digging down to the roots of regulation, Lehtovaara relates that the IMO’s SOLAS Convention, Safety of Life at Sea, was established to ensure safe operations at sea. Compliance with



Eero Lehtovaara in the new simulator facility at ABB Marine House

the tenets of SOLAS is at the core of all maritime regulation designed to protect life and assets in maritime operations. “If a technology or a product is as good or safer than an existing one, it should be accepted. On the other hand, we also want to hinder features or developments that would weaken safety.”

The current challenge, he says, lies in closing the gap between the possibilities blossoming in the bright light of the 4th industrial revolution, and the abilities of the regulatory system to respond to the accelerating pace of technology.

#### **Proceed with caution**

As automation and remote operations lead the industry ever closer to the Holy Grail of shipping – autonomous vessels – Lehtovaara cautions that the prize may be best admired from a safe distance:

“Automation can reduce the burden of monotonous operations. An unmanned engine room is feasible, with escalating levels of alarms and responses,” he reflects. “But what about an unmanned bridge? If we could do the same there, is it necessary to have someone sitting on the bridge at all times?”

Continuing on the path laid out by technology, Lehtovaara inevitably arrives at the fork in the road defined by humanity: the issue of responsibility.

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## Automation can reduce the burden of monotonous operations.

“If we connect surveillance information to a computer, the degrees of warning can be escalated, and theoretically, the ship can eventually make decision on its own. But when the ship makes a decision, who is responsible? Today the captain delegates navigation to the officer of the watch. What if it is delegated to a computer?”

Under SOLAS and other regulations, the captain has the ultimate responsibility on a vessel, and he or she needs to be informed of all decisions made

on board. “Either they give the order, or they confirm someone else’s orders. Anything that alters that system needs to be addressed,” Lehtovaara states.

Closing the loop of decision making when a machine is doing the thinking is a new challenge for shipping: “This is only one of many issues that have to be acknowledged and resolved before we can transfer decision-making to machines.”

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New technology enables remote real time inspection, and that will change business models on both sides.

#### **Fit for fight**

“A class society evaluates equipment for fitness for purpose, and nearly everything we sell needs to be classified,” Lehtovaara says. “But the rules have to allow for growth in the business arena. New products need to be discussed and regulations adjusted. With digitalisation widening in scope and accelerating development, we need a broader framework of evaluation.”

Lehtovara elaborates on a scenario likely to emerge from digital evolution: “Currently, surveys are performed on a stationary ship. You can measure plate thickness, rust, and cracks, but that information tells you nothing about what happens when the ship is sailing. New technology enables remote real time inspection, and that will change business models on both sides. Robotic inspection and remote surveillance, focusing not so much on what, but how things are done, will impact business models.”

Many OEMs are already rising to the challenge, with remote services representing an increasingly larger part of their revenue. Will regulators be obliged to address these evolving offerings? “Service should be regulated, but the definition of service is still open to interpretation. Just looking at something and offering advice does not require regulation, but making a decision or taking an action does.”

Does he believe that the current regime is able to handle the current pace and sheer volume of technological development? “Not all data has equal value. We need to narrow down and classify that technology which has a bigger effect. Business models also have to be adapted to a new reality, and that applies to owners, OEMs, and regulators.”

### The big question

Eero Lehtovaara cuts to the rhetorical chase: “How much of what can be done by technology, do we accept should be done by technology?”

Answering that key question demands a process, he maintains, always with accountability as the bottom

line: “At the end of the day we need to be able to verify fitness of purpose. Automatic or semi-automatic systems need to be tested in real life for extended periods of time. You cannot just snap your fingers and implement everything that is possible.”

For those expecting the tempo of change to match the pace of technology, Lehtovaara has this steady advice: “The speed of the discussion is by far the fastest right now. Then comes development, and after that regulation.” And it is here he believes that the force of policy will make itself felt: “We need to test and verify before we implement. The speed of these processes will regulate the pace of change.”

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The new simulator facility at ABB Marine House



# When is a ship not a ship?

This real-life riddle is one that the shipping industry is going to have to solve as the vision of autonomous, or even assisted vessels, edges closer to reality.



**CHRISTIAN BJØRTUFT ELLINGSEN**  
Partner,  
Simonsen Vogt Wiig



**THOMAS OLSEN**  
Senior Lawyer,  
Simonsen Vogt Wiig

In many ways, the traditional perception of a ship has already been altered. Automation and remote operations have forced the industry to reconsider issues of rights and responsibilities, on board and on land.

“Automation changes responsibility,” says Christian Bjørtuft Ellingsen, partner in the legal firm of Simonsen Vogt Wiig, specialists in maritime law. “A vital aspect of safety at sea has historically been to ensure that the ship has a qualified master and crew, and many liability issues are linked to their actions. But with the ever-increasing automation of operations, questions will inevitably arise, such as when is the master responsible, and when is the software? And is it still a ship if there is no acting master?”

In other words, when the hierarchy of responsibility is altered, the nature of a business is altered as well. “We are operating more frequently in the space where shipping meets technology,” Ellingsen says of his firm’s work. “We see that a new risk regime challenges the structure of traditional, standard format shipping contracts.” That space looks to become exponentially more complex in the 4th industrial revolution, as digitalisation moves in to steadily more areas of operation.

## Opportunities and threats

“Combined operational and information technologies offer great potential for both new and established players to develop products and services with their own commercial value,” says Ellingsen.

“But when you create value, ownership rights and security need to be considered. Intellectual property needs to be patented or copyrighted, and we advise companies to devise an IPR strategy. Security and commercialisation have to go hand-in-hand, and that requires preparation.”

## Automation changes responsibility.

Cyber security is another area where the new digital reality raises issues of responsibility. “IMO, BIMCO and others have developed guidelines for keeping data safe,” Ellingsen says, but notes that the guidelines remain fairly rudimentary, leaving responsibility for protection against cyber attacks largely in the arena of owners and operators for now.

Meanwhile the larger focus continues to be on the more physical threats such as piracy, theft or terrorism. “Shipping is a conservative business, and they don’t generally take steps before they have to. Major initiatives in international regulation have a tendency to come only in the wake of major accidents or incidents. It may be that it will take a big cyber event to trigger reactions, and force the industry give the necessary attention to securing its data and systems.”

## Keeping it personal

When it comes to protection of personal data, Ellingsen’s colleague at Simonsen Vogt Wiig,

senior lawyer Thomas Olsen, can present a somewhat more structured picture, if no less complex: “The legal system is more up to speed here,” he assures. “Norwegian law has since 2001 set out binding responsibilities for companies based on EU directives. However, following a major legal reform the new General Data Protection Regulation, GDPR, will be applicable from May 2018, with stricter sanctions for non-compliance.”

Strict indeed: penalties can reach as high as 4 per cent of global turnover, enough to demand executive-level attention. And companies, including suppliers, will have to document that appropriate measures and internal procedures are in place. “All companies will need to comply eventually,” Olsen predicts, “but they need to find the level that is right for them.” Regardless of level, compliance will become increasingly harder to evade in international cooperation: “Big partners will demand compliance from smaller suppliers, and their choice of supplier will be influenced by the level of security.”

The international nature of shipping presents specific challenges. The need for transfer of personal information across borders is one: “Binding Corporate Rules, or BCR, allow for secure transfer of personal data within corporations with an international footprint,” Olsen says.

Personal data protection will also have to be considered when it comes to privacy. “Different owners have different needs for surveillance of

crew, and sometimes they might want to do more than is allowed. Both crew and owners need to be prepared to state their cases.”

But while accessibility of data presents a risk for violation of personal privacy, it also makes it possible to set standards for protection. “When everything is open, information protection gets more attention. Rights and rules become more standardised, and personal rights can be better protected. Individuals now have the right to protest abuses where they may not have had an arena before.”

Screening of onboard crew is one of these areas, where private information is exchanged between companies, and across borders. “This information can be used for virtually anything, and those responsible for handling it must also be held responsible for its protection.”

In order to ensure the security of data, Ellingsen says, contracts will become more complex, and this in turn will complicate the risk picture. The digital world offers new opportunities, he concludes, but also introduces new risk.

As the 4th industrial revolution continues its rapid advance, the shipping industry will have to define that risk, put a price tag on it, and decide where the ultimate responsibility lies.

At the dawn of Shipping 4.0, the industry is only just beginning to find answers to many of the big questions brought on by big data.

# The American perspective, as seen by ABS

Jamie Smith, ABS Americas Division President, offers their take on the current and future outlook for shipping in the USA.



JAMIE SMITH  
Americas Division  
President, ABS

**Shipping has been battered everywhere around the globe over the past few years. How well have shipowners weathered the storm in America? Better or worse than their international colleagues and competitors?**

Access to capital has been difficult, impacting new investments in the marine sector, and further complicated by the changing regulatory landscape. If you talk to any owner, US or international, I do not think any of them would say that they have not been affected by the market challenges in the marine industry over the past few years. Some have done better than others. Those that have done better have found new ways of operating, whether that be through a new operational model or through finding new efficiencies.

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**By preparing today and selecting the right technology and strategy for their unique fleet profiles, owners will be in a stronger position tomorrow.**

**Have American shipowners taken any noteworthy measures in order to survive the downturn, and prepare for the future?**

Similar to international owners, US owners are looking for every opportunity to find an edge in a competitive landscape, while also maintaining

regulatory compliance. US owners are considering innovative techniques and technologies to help make their fleets more efficient and productive. By working directly with owners, ABS is helping them prepare for the future by supporting more informed fleet decisions on many of the regulatory compliance challenges that they face today, such as selecting the right ballast water management technology and developing an effective air emissions strategy. By preparing today and selecting the right technology and strategy for their unique fleet profiles, owners will be in a stronger position tomorrow. For new vessels, we are seeing an increased focus on the application of LNG as fuel and further development of bunkering infrastructure to support that application. We will likely continue to see more adoption of LNG and other types of alternative fuels as the industry prepares for the future.

**The Jones Act remains firmly in place. This unique piece of legislature is sacred to many in the industry, and sinful to others. Just how big of an impact does it have on the competitiveness of American shipbuilding, and American shipping? Do you see the Jones Act evolving, or even disappearing, over the next years?**

As a classification organisation with a mission to promote the safety of life, property and the natural environment, ABS is focused on supporting a safer and more sustainable fleet. ABS cannot predict the future of the Jones Act, but is well positioned around the US to support this unique trade.



**As the focus of trade shifts toward Asia, and the equatorial countries began to enter the global economy, how will American shipping respond?**

**In terms of risks to the US shipping sector, the opportunity is also the biggest challenge.**

The US has a considerable contribution to make to the future of shipping, even though this may not be in the direct provision of tonnage. The US will continue to play an important role in many areas, including operational technology, financial services, communications, information technology and software. As shipping adopts more digital and data driven solutions, there will be more opportunity for US companies to contribute to the global shipping industry.

**America is a leader in the digitalisation of industry. Is American shipping keeping up?**

The answer is that shipping in general has not yet realised the full implications of digitalisation, but its adoption as a means of competitive differentiation will make this essential. Digitalisation will have a transformative effect on the industry's

operations and competitiveness as well as reshaping supply chains in ways we have yet to fully appreciate. The installed communications infrastructure and logistics expertise provide a platform for shipping to adopt a data-centric approach to their operations that could increase efficiency and simplify compliance, as well as potentially attracting the next generation of mariners and shoreside staff the industry needs.

**What do you see as the brightest spot in American shipping going forward? The darkest?**

One of the brightest is the ability of American companies to innovate and even to disrupt established ways of working and communicating. We have seen this in consumer technologies and other sectors with companies such as Airbnb, SpaceX and Palantir Technologies. While shipping sometimes lags in adoption of technology, the pace of change is faster than ever. Constant innovation is a differentiator going forward.

In terms of risks to the US shipping sector, the opportunity is also the biggest challenge. If US shipping and shipbuilding do not embrace innovation at the right time, it may be difficult to catch up with those who are able to transform their operations with new technologies and digitisation.

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**GREENER SHIPPING**

# Willing to move

Shipping's reputation as a conservative industry is well deserved, earned by generations of simply sticking to what works.



**MARIUS GJERSET**  
Technology manager,  
ZERO

But technology manager Marius Gjerset of ZERO, the Zero Emissions Resource Organisation, detects a growing willingness to adopt new, green technologies – if not by choice, then by force.

Regulations are driving adaptation of environmental protection technologies like ballast water treatment and exhaust scrubbers, and the 4th industrial revolution is playing a part in the greening of shipping.

"Big data can help enforce regulations," Gjerset says. "It gives us new knowledge, and that gives us leverage we did not have before. A larger data resource also informs the debate, and brings greater precision to the design of regulations."

Satellite tracking of ships is one example of an environmental game-changer in shipping: "Using AIS data and advanced analysis together, almost anything can be monitored – fuelling, discharge, spills – and that leads to increased accountability, whether voluntary or mandatory."

With nowhere to hide, the motivation to comply increases. Regulation at a more detailed, and more nuanced level also becomes more feasible. Tailor made solutions may be seen as fairer, and this in turn may help reduce resistance to implementation, Gjerset argues.

Between the carrot and stick, he believes that the carrot can be effective, but the stick is unavoidable. "Ultimately, markets respond to pressure.

Many available technologies need to be regulated into use." The secret, Marius says, is not just to make demands, but to provide rewards as well.

## By land and by sea

Ports are a key element in the overall picture of green shipping, Gjerset points out. The electrification of ports will not only clean up onshore operations, but help ships to play their part in the cleaner future of the logistics chain: "Charging technologies are advancing rapidly, and shore power is getting a boost from regulations."

He cites an example from just outside the Oslo Fjord: Color Line is currently building the world's largest plug-in hybrid ferry, designed to serve the route between Sandefjord in Norway and Strömstad in Sweden. The ship will switch to battery power upon entering the narrow Sandefjord, thereby reducing emissions to the local environment.

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## Big data can help enforce regulations.

In addition to facilitating greener port calls, many ports are aiming for zero emission operations. But Gjerset notes that requirements must be implemented on a regional scale in order to avoid skewed competition: "If environmental regulations make one port less economically attractive, ships will call at cheaper ports nearby, and green investments will be punished, rather than rewarded."



The Ampere ferry, Norled

With ship and shore regulations working together with technological developments, Gjerset believes that the goal of zero emission ports can be realised in the not-too-distant future. “The IMO moves slowly in its regulation of ships, but ports can move faster. Regulations can be differentiated to suit local needs as well.”

Whereas environmentally friendly operations are often seen as incompatible with profitability, environment and economy have now begun to mesh in the regulatory realm, he says. “The Norwegian NOx fund is a good example, where ships trading in Norwegian waters pay into a fund that is used to finance emissions-reducing measures. Initially there was resistance to this form of tax, but now we see that shipowners are willing to pay into the fund, partly because they can benefit when they invest in green technology on board, allowing them to comply with regulations.”

#### **One size doesn't fit all**

“Maritime covers so many niches. With everything from ferries to fishing and cruise to containers, there can be no single solution,” Marius maintains.

“Standardisation can be a good thing, but it can also be a hindrance. It can slow progress and divert interests. We must avoid forcing everyone into the same solution,” he says, citing charging systems for electric cars as an example.

“Charging systems needed time to develop, and newer technology has provided better standards than if the industry had rushed to the early solutions. The road to standardisation must be market-driven and dynamic, and that requires a pragmatic approach,” Gjerset believes. “We don't want to slam the door or commit to the wrong standard.”

#### **Push/pull**

When it comes to the relation between regulations and technology, Gjerset envisions the ideal partnership: “There are examples of one or the other leading the way, but it works best when they work together. Early phase R&D needs public support. As technology matures, commercial markets become the main driver, then regulations can help keep markets in line.”

He cites the example of ferry tenders in Norway, all of which must now address zero emission requirements. Advances in technology have made such demands reasonable, and the demands themselves serve to stimulate new investments in technology. “We still have many old ships and dirty ports. New technologies can stimulate more investment to resolve these issues, and regulations can drive implementation.”

He emphasises that regulations must support, not hinder, development. “Gradual implementation of regulatory policy is critical in the early stages of emerging technologies. They must be allowed to achieve critical mass before regulations are applied.”

#### **Reasons to believe**

One example stands out in Marius Gjerset's mind to give hope for the future: “Developments in battery technology are coming at an exponential rate. When the Ampere ferry was launched, it marked Norway's entry into the marine battery arena. Now, just three years later, little Norway is a world leader in zero emissions marine transport. Political, industrial, and commercial interests working together have given us a new reality in just a few years time.”

He points out that the rapid development of solar power and battery technology in such a wide range of applications took many by surprise. “Now fuel cell technology is looking like a future fast mover, and hydrogen is becoming more feasible as prices come down. I think there is every reason to expect that advances in other technologies can follow batteries on the fast track, and the maritime community has shown that it will move to green solutions as they become practical.” Even if it does take that last little regulatory nudge.

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**Q&A WITH CHAIRMAN ESBEN POULSSON**

# The International Chamber of Shipping on policy

Speaking on behalf of the ICS, what is the shipowners' perspective on regional vs. international policies? Are regional policies strictly a threat to efficiency and profitability, or are there some cases where they may promote improvements in shipping, e.g. regarding the environment, safety, or technology?

Shipping is one of the great global industries, and it cannot function efficiently if the rules are not truly global. National and regional requirements that differ from the internationally agreed standards cause confusion and increased bureaucracy, and do not promote the raising of standards across the world's fleet. Ships need to be able to leave one port, make the passage, and arrive in the next port under the same rules.

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**Shipping is one of the great global industries, and it cannot function efficiently if the rules are not truly global.**

We understand of course that regional vulnerabilities can be quite specific, and in these cases, nations should approach the IMO to have their particular characteristics addressed in a global framework. A good example of this is the SECA, where regional exposure to sulphur emissions are addressed in an arrangement that forms part of MARPOL Annex VI.

There are many aspects of digitalisation that will require regulations to ensure compliance across the board. What are the issues getting most attention among shipowners right now? Cyber security? Reporting?

Cyber security has been well addressed in industry-wide guidelines, and is a good example of where industry self-regulation is able to keep up with fast-changing developments, where national or international mechanisms simply could not keep up with the growing threat.

ICS is fully supportive of the single-window approach to reporting. Unfortunately the much discussed single window has become 'multiple windows', all with differing approaches as states move at different speeds toward digitalisation. The whole idea of the concept was to provide ships with a standard reporting system wherever they were operating in the world, the ideal being an on-board data base from which ports could extract the data required for, say, port entry. However, the variety of systems employed worldwide has actually increased the bureaucratic burden for shipmasters.

**In general, is the regulatory focus on the effects of digitalisation appropriate in relation to its actual impact on daily operations?**

Digitalisation is a growing fact of life, and some form of regulation is obviously helpful, especially if it leads to global standards. The greatest problem today is the lack of standardisation.



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Esben Poulsen,  
Chairman, ICS

If you are advising your members on which regulations to focus on now and in the near future, which would they be? In the longer term?

Compliance is compliance! We expect all members to promote compliance with regulations as the operative dates approach. Unfortunately, identification of the specific requirements and the applicable dates is not always straightforward. The confusion over compliance options for the Ballast Water Convention, the length of time taken to achieve the ratification criteria, and the problem of understanding which equipment will fulfil both international and US requirements are very serious concerns. ICS has been working since 2004 on trying to get some clarity in this area and has had some success through resolutions that address specific aspects of entry into force, but the focus now has to be on making supportive changes to the Convention as soon as it enters into force.

ICS is also very mindful of the upcoming switch to lower sulphur fuel on 1 January 2020, which on paper requires all ships to switch at the same time to lower sulphur fuel, or to have a scrubber in operation. Clearly some form of transition is required in both cases, and we are not quite there yet in regulatory terms.

Any other perspectives on regulations and policy that you would like to share on behalf of your members? Based on your own observations and experience?

Digitalisation is a growing fact of life, and some form of regulation is obviously helpful, especially if it leads to global standards.

The extended entry into force of the aspirational Ballast Water Convention and the lack of clarity on the sulphur requirement around 1 January 2020 both suggest that the regulatory system needs some enhancement. We would like to see IMO take ownership of a cost-benefit analysis and impact assessment as regulation is being developed. Some people criticise this aspiration as a potential source of delay to implementation. However, we say that time spent at the beginning of the process would be time well spent. It would lead to a much faster transition from adoption to entry into force, as governments would have greater confidence in the enforceability of regulation and much more knowledge of the impact on the global supply chain.

## Regulations under siege?

On many fronts, yes. But no need for panic, assures Dr. Tristan Smith, Reader in Energy and Shipping at University College of London, and an acknowledged authority on environmental regulations in shipping.

While political developments such as Brexit and the Trump presidency have led many to speculate that the face of maritime regulations may be subject to dramatic change in the near future, Smith foresees a steady course for the most significant elements of maritime environmental policy.

"Political developments will always be important for shipping, as it derives its demand from trade, which is in turn sensitive to politics," he acknowledges. Brexit could potentially impact UK shipping, he notes, and Donald Trump's election in the US could affect decision making in the UNFCCC and IMO, at least in the short term.

"But in the long run, I doubt whether either of these, or similar 'waves' in the political sphere, will have a significant impact on the direction or development of environmental regulations," he states. "The reason is that the underlying driver in environmental regulation is civil society's pressure on industries to cover the environmental and eco-system costs of the industry. That driver is relatively disconnected from the short term fluctuations of agendas set by individual administrations."

### Parallel agendas

Not only individual administrations have been pressuring maritime regulations in the past year. Regional interests have also come into play, with the US reaffirming the standing of the Jones Act, the USCG and the EU both drawing up their

own ballast water treatment requirements, and several regions around the world enacting special emission control measures. Are increasingly stronger regional regulations detrimental to international shipping, and where is this trend headed in the near future?

The underlying driver in environmental regulation is civil society's pressure on industries to cover the environmental and ecosystem costs of the industry.

"It's become a bit of a mantra that international shipping needs a 'level playing field', and the basic logic for this, derived from the international and mobile nature of the industry, is hard to fault." In an ideal world, Smith says, all else being equal, that mantra makes sense.

"But certain regions experience greater pressure from civil society than others, and they may have stronger political will. Sometimes, despite the best efforts to achieve multilateral consensus in organisations like the IMO, because of a difference in ambition, or a vested national interest, it's not possible to reach a common global way forward.



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Dr. Tristan Smith,  
Reader in Energy and  
Shipping, University  
College of London

“This is not to trivialise the fact that the greater the complexity in the regulatory regime, and the less interchangeable ships are with different routes, ports and areas of operation, the greater the burden on many in the industry, and the less efficient the deployment and operation of ships,” he acknowledges.

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**So often opportunities are missed that could ultimately lead to better global regulations and lower costs in the mid-term, as well as preventing the loss of precious negotiating time.**

Smith finds it difficult to predict whether the current trend of regionalisation will persist or desist. Regardless, he says, it may be important to move on from the over-simplification of the debate of ‘global good – regional bad’.

“So often opportunities are missed that could ultimately lead to better global regulations and lower costs in the mid-term, as well as preventing the loss of precious negotiating time.”

#### **The impact of the environment**

The overarching themes colouring the current regulations debate would seem to be the environment and climate change. Does Tristan Smith believe that the industry truly understands the ramifications of ever-widening environmental regulations?

"Increasingly, yes, the industry does understand. Especially in the last year there has been a notable increase in prominence of the GHG topic at events and conferences, and there have been some very pragmatic and progressive forums of industry stakeholders trying to come up with solutions."

But there's a lot to take in, he points out, making it understandable that companies would prioritise the most manageable regulations. "IMO has not necessarily helped the industry, either, by tackling each environmental impact in turn and within its own 'silo', when in practice the solutions needed and the associated technology may be highly overlapping."

How might intensified marine environmental regulations impact society, apart from hopefully cleaner air and water? Will consumer prices or availability of goods be affected, or could there be other 'hidden' consequences of cleaning up shipping's act?

Smith cites a number of trends driving trade patterns: "Counter-intuitively, distance from markets, a commonly used proxy for transport cost, is rarely detectable as a dominant influence." For that reason, he believes that increases in transport cost resulting from higher capital and operating costs, would not necessarily result in significant changes in trade.

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**Counter-intuitively, distance from markets, a commonly used proxy for transport cost, is rarely detectable as a dominant influence.**

"The politics of protectionism, trade agreements, changes in differentials of labour cost between regions, and developments in manufacturing automation may all prove more significant over the coming decades," he says. "With increasing transparency of supply chains, and the growing prominence of sustainability concerns and climate risk, leadership on these topics may actually help to grow rather than shrink demand and market share in some cases."

### Keep calm

If Tristan Smith were to paint a picture of the regulatory seascape in 2030, what would be the motif: stormy night, or rosy dawn?

"I believe it is self-defeatist to be anything but optimistic. I think we can be aware of the risks of bad regulation, and we have more than enough data and knowledge in the sector, which if harnessed properly, can help ensure constructive and cost-effective development of regulations. So I would paint a picture of a rosy dawn – which also gives us something to aim for!"

One of the key risks, he warns, is an industry forced to accept interim 'stop gap' solutions as an easy way out of political deadlocks, but doing little to help the industry look and plan ahead.

"For example, if we set targets for GHG reduction that are too low, and therefore need revision and increased stringency over time, this will both prompt the development of regulations not fit for purpose, and provide the wrong signal for investment decisions and selection of technology."

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**I would paint a picture of a rosy dawn.**

Smith sees two options that could aid in plotting a positive regulatory course for shipping:

"One is consensus on realistic and scientifically robust, long-term objectives. For example, is reduction to 0.5 per cent sulphur in fuels sufficient, or will this ultimately require incremental reduction over time? What is the long-term objective for the sector's GHG emissions? Will ballast water stringency need to be incrementally increased, or will we simply reach practical limits?"

Another is an approach that integrates co-benefits and objectives across different types of environmental impacts, while simultaneously advancing details important to each issue: "There seems to be room for considering this philosophy in the IMO's GHG Roadmap, where in fact the impact of wider regulation is an action point. Happily, interest in a more nuanced type of approach is growing."







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# **CHAPTER 4**

## The people in the picture

- 084–089      Shipping 4.0 – The people in the picture**
- 090–093      The people are ready – but is the industry?**
- 094–095      Tony Seba: Disruption in all directions**
- 096–099      View from the crew**
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**SHIPPING 4.0**

# The people in the picture

Once again ABB Marine & Ports gathered a group of veteran maritime journalists to speak with leading industry voices and ABB's own experts on a topic impacting the maritime industry. At the first such event in London, the topic was 'The power of the future'. On June 21st in Helsinki, the topic was: 'The people in the picture'.

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## Participants:

**Invited guests**

Tuomas Sipilä – Head of VTT Marine Laboratory Services  
Martin Bergström – Naval Architect,  
University of Aalto

**Journalists**

Anastassios Adamopoulos – Lloyds List  
Paul Bartlett – Various publications including  
The Motorship  
Rob O'Dwyer – Digital Ship  
Katherin Lau – Ship and Offshore, Schiff & Hafen  
Paul Gunton – Riviera Maritime Media

**ABB Marine & Ports experts**

Mikko Lepistö – Head of Digital Solutions  
Kalevi Tervo – Global Program Manager  
Eero Lehtovaara – Head of Regulatory  
and Development  
Palemia Field – Digital Services Manager

The session was moderated by Peter Lovegrove,  
ABB Marine & Ports



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Kalevi Tervo engaged in discussion

Starting in the belly of the beast, moderator Peter Lovegrove kicked off the discussion with a question on the changing state of the engine room in an increasingly digital world, and the impact of that change on those charged with keeping the ship moving.

Tuomas Sipilä of VTT Marine Laboratory Services fielded the lead question, stating that one primary requirement will be an increased awareness of what is happening in the engine room: “With fewer people in that space, more monitoring will be required. That information can also be used to keep the people still working in the engine room better prepared.” He noted that new digital technologies can supply technicians with augmented reality solutions to help enhance knowledge and improve preparedness. “This can help them to predict and avoid the worst consequences of an incident.”

ABB’s Palemia Field commented that it isn’t just digitalisation leading to a reduction in the number of crew on ships: “Staff reduction has been coming on for a while. It’s not a new thing. The increase in computing power accelerated the trend, and now cheaper sensors and connectivity are driving it even faster.” He noted that ships already operate roughly 90 per cent of the time on autopilot, adding that this fact has “probably made the industry safer, including working conditions on board,” pointing out that remote technology can help to remove crew from the most dangerous on board environments.

Martin Bergström of the University of Aalto added that all crew members need to broaden their thinking in light of the growing connectivity between on board systems: “Everyone needs to see their role as being part of a larger system.”

Responding to a question concerning the business consequences of taking more people off the ship, ABB's Mikko Lepistö offered a 'glass is half full' perspective: "Even though old patterns of communication and cooperation may be going away, there are new ways for us to connect, with the machinery, but also with customers. We can support them at a higher level, and help them to increase their situational awareness. But with fewer people, and more information coming from the machines, the biggest issue is how to use the data in the best way."

#### The nature of power

The move to more electrical power on board would seem to be a natural, even irreversible progression. But for owners, economic issues often weigh more heavily than technical capabilities. The group agreed that owners will always need a valid business case to support change, but if the

fit is good, the move to electrical has the opportunity to simplify many aspects of ship operation.

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**Staff reduction has been coming on for a while. It's not a new thing. The increase in computing power accelerated the trend, and now cheaper sensors and connectivity are driving it even faster.**

Palemia Field pointed out one shoal in the path of this progress: "The present skill set is not up to the transition we are talking about here." The IMO minimum skill level is inadequate and out-dated, he pointed out, going back to the early 1970s, adding that high voltage requirements were not addressed

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Roundtable discussion



until the 2010 Manila regulations. With this skills gap, “An operator can choose to sail without the right competence, and that increases risk. That means that an OEM like ABB needs to provide proper training guidelines together with the equipment.”

### The weight of responsibility

Assuming that humans have the power of reason, giving them the ability to choose the action with lesser consequences in a complex situation, the question was posed whether smart machines could do the same?

In his reply, Eero Lehtovaara of ABB got straight down to basics, addressing perhaps the most fundamental human consideration in running a ship: “When you move the responsibility on board from the captain, it has to be placed with someone else. Who should that be, and where? When can a machine be given responsibility for a decision?”



Machines will always be programmed by humans, he pointed out, and humans can prepare machines to make the ‘least bad’ choices. “Then it becomes decision support, more than handing over full responsibility.”

Most accidents are triggered by trivial causes, Bergström observed, and most situations are simple to resolve. “These are the scenarios where machines could take over decision making.” Lepitsö added that technology could play the role of helper in the first stages: “Then everybody learns. And when trust is established, we can take the next step. But whether we move slowly or quickly, it is important to take the next step.”

### Leap of faith?

To the question of how much learning shipping can take from on-going experiments with self-driving cars, Sipilä acknowledged that cars on roads might present an easier case to solve than ships at sea, but still believed that some learning can be taken from the road.

But while cars simply have to be driven, shipping is much more than just navigation. “There are many aspects to be handled in running a ship,” Lepitsö commented. “If we are going to have a fully automated ship, we need to work toward replacing present technologies with solutions that do not require human interaction, like batteries instead of combustion engines.”

Even though old patterns of communication and cooperation may be going away, there are new ways for us to connect, with the machinery, but also with customers.

Kalevi Tervo of ABB raised the issue of how much faith humans should have in technology: “Automation can be safe. It just depends on how you implement it. In order to do it right, we need to understand how ships behave.” Humans are not good at understanding very slow, or very fast things, he noted, where machines perform better

at both ends of the speed spectrum. "Machines are already making a lot of decisions that humans cannot. What we need now is to build trust in automation, and that starts with advisory systems, not complete machine control."

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**With fewer people, and more information coming from the machines, the biggest issue is how to use the data in the best way.**

#### **The right skills**

However close autonomous vessels are to being realised, there will still be people on board for some time to come, and running a ship in the future will require different skill sets than today. What considerations need to be addressed when matching crew competency with ever-smarter ships?

Margins are getting smaller in modern ships compared with more traditional vessels, Field noted. "Before there was more redundancy, and a higher tolerance for failure or error. Now design parameters may be too narrow, and that forces us to rethink what we need the crew to do."

"Look at our own company," Lepistö added. "We have gone from mechanical to digital in just a few years. Our competency profile is changing, and education levels are getting higher. We will see the same thing happening on ships, and that means we will need different skill sets."

On counterpoint, the journalists observed that the opposite is occurring, that skill levels on board are falling, rather than rising. Crew are increasingly pressured by time constraints, they argued, leading to a lack of training time.

"It has already happened," Lehtovaara confirmed. "Nobody can repair anything on the bridge anymore. Crews either cannot, or are not allowed to fix many things. This has been coming on for a while, but we are just starting to react now."

#### **One size doesn't fit all**

Addressing the need for increased standardisation in order to realise automated ships, Palemia

Field commented that standardisation is still foreign to shipbuilding: "Ships are unique, not like planes or cars. I have heard stories where you couldn't find the toilet if you went from one sister ship to the other. Standardisation will eventually be stipulated by the operators, but we have yet to see it."

While cloud computing could aid in the work toward standardisation, making it easier to compare different solutions and learn which functions best, the problem remains that shipping is steered by the bottom line. "Shipping is too cheap," Lehtovaara claimed. "They will not invest until they see that standardisation gives a higher return than what they are getting today."

The group agreed that sharing data could help owners share expenses in the move toward standardisation, but that the most progressive players would have to go forward and set a good example. But are shipowners genuinely interested in sharing data?

"Some data will be protected, and some shared," Lepistö offered. "It should not be a problem to share data that can benefit all parties."

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**An operator can choose to sail without the right competence, and that increases risk.**

#### **Keep in touch**

The question was put to the group whether advisory information was eroding the captain's control over the ship.

Lehtovaara, a licensed ship's captain with many years at the helm, observed: "The crew has too little information about their workplace. Before, they knew everything about the ship, and they could fix anything. Now decisions are being removed from the bridge, and in some cases, technology is not necessarily enhancing, but rather restricting decisions on board."

He added: "Ship performance is being evaluated by many interested parties now, and not just within shipping. That will have consequences. The way

we use data is affecting the entire industry, and crew and captains will have to adapt. They will need to become more competent in different areas than today."

Referring to the 'millennials', those born around the last turn of the century, Field observed that the new generation only knows a world that is connected. "They see shipping as a more of a calculation, not an art form. But there is an art to knowing how far to trust yourself, what you need to learn, and where to learn it. Even with all the data we have available, we still have to learn from experience. We still need people who can find ways of solving problems on their own."

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### What we need now is to build trust in automation, and that starts with advisory systems.

But as steadily more analysis is done remotely and processed by team members on shore, creative problem solving might just as well occur on land as at sea. "Remote operation is happening

now, and many do not realise just how far it has come," Lepistö underscored. "We may still need on-site care in order to satisfy customers, but that service can be more efficient, and resources can be used for other benefits."

For now, though, good seamanship still requires many hours at sea. Yet digitalisation, connectivity, and remote operations are increasingly removing many seafarers from direct contact with the marine environment.

Addressing this paradox, Eero Lehtovaara took the day's last look into the future of shipping, and the people in the picture:

"When will ships be fully autonomous? No one really knows. The technology has already moved so much faster than anyone thought. At the same time, legal requirements on crew experience are dropping. How much longer will you have to sail on a ship in order to keep your certificate? Or will simulation eventually take over?" And if that day comes, he mused, posing perhaps the most poignant question of the day, "How will seafarers keep in contact with the sea?"

The journalists in  
Helsinki



# The people are ready – but is the industry?

As society rushes to surf the surging waves of connectivity that are changing the way we live and work, many shipowners seem content to let their crew ride the gentle swells further out at sea, removed from the revolution taking place on shore.

“Only around 50 per cent of seafarers have access to the Internet onboard,” says David Appleton of Nautilus International, “and when they do it is often poor quality, and then they have to pay through the nose for it.”

Does this sound like a recipe for attracting the next generation of seafarers to the next generation of shipping? Appleton is Professional and Technical Officer with Nautilus, a global crewing company operating out of London, and his reply is a resounding ‘No!’

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Only around 50 per cent of seafarers have access to the Internet onboard, and when they do it is often poor quality, and then they have to pay through the nose for it.

“I remember when the e-mail server on the ship was turned on once a day, and all e-mails went through the captain,” he recalls. “In 2017, the youngest of those leaving school and embarking on their careers at sea will have been born in 2001. These young men and women literally do not know a world without the smartphone, Facebook, Twitter or Instagram. They are not only used to being connected 24/7, but they demand it.”

This might sound like the echo of a youthful lament from connected millennials, but put up against the reality of crewing in the 4th industrial revolution, it becomes one of the major issues facing shipping and crewing companies today, and into the future.

“The current and predicted shortage of officers to meet demand is a well-known issue, but not one that is going away anytime soon,” says Appleton. According to the latest BIMCO/ICS manpower report there is currently a shortage of some 16,500 officers, predicted to rise to 92,000 by 2020 and to 147,500 by 2025.

“Far and away the biggest challenge today is ensuring that there is a ready supply of seafarers to meet demand and, more importantly, ensuring that those seafarers are competent and appropriately trained to operate modern ships,” Appleton maintains.

These challenges can only increase in the future as technology changes the way work is carried out on board, he says, and the way we live our everyday lives, all of which will have a dramatic effect on the expectations of prospective new entrants to the industry.

“This is the crux of the issue,” he says. “It is not that ships will not sail. It is that standards will fall across the board, and therefore risk will be greatly increased.”



—  
David Appleton,  
Professional and  
Technical Officer,  
Nautilus International

Now, back to those connected millennials: by not keeping them happy, shipowners may in fact be increasing the risk of accidents at sea. Doesn't sound so superficial when you put it that way.

#### You get what you pay for

Then there's the issue of 'pay for play'. Shipping can be noisy, dirty, vulnerable to economic unrest, and with long periods away from home, friends and family. "People want to sail, but it needs to be made worth their while," says Appleton.

The root of the problem, he says is a well-known symptom of shipping: "Shipowners always can find something cheaper. In fact, many shipping companies are not sure just what they want. Any cost drivers are resisted, yet they still complain of lack of qualified new officers."

Exaggerating the problem is the fact that training is often slow to catch up with the fastest-moving technological developments in shipping. With more technology onboard, a different skill set is required. Some companies are advancing fast to meet these challenges, while others are still keeping a slower pace – more typical of shipping, at least historically.

#### Keeping up, keeping safe

In this way, the impact of digitalisation and connectivity on safety at sea as it relates to training

can be even more dramatic than the impact on recruiting and crew welfare.

Statistics show that maritime safety in general has improved, but there are still too many accidents, says Appleton. "90 per cent of accidents are caused by human error. Only this year has Electronic Chart Display and Information System (ECDIS) training become mandatory, after the system's first approval in 1995," he reports.

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Far and away the biggest challenge today is ensuring that there is a ready supply of seafarers to meet demand and, more importantly, ensuring that those seafarers are competent and appropriately trained to operate modern ships.

"In these cases, the IMO can be excruciatingly slow. It has taken nigh on 22 years for it to be made mandatory that a navigation officer has had some kind of training in the use of what is in most instances the primary means of navigation,"



Appleton explains. "As usual, the changes only came about as a result of numerous accidents attributed to incorrect use of the equipment."

With more and more technology coming aboard, suppliers are looking at ways to make it easier to use, including improved displays to ease operations, augmented reality, and shore connectivity.

Virtual reality and advanced simulator training represent a big boost in training capabilities, and they are becoming more and more common, Appleton observes. "Now you can take a theoretical discussion and convert it into a realistic scenario for training."

Joining the more cautious observers of the on-rushing digital future of shipping, Appleton has his reservations about the highest of ambitions: autonomous shipping.

"Autonomous basically represents a risk. In order for it to be feasible, it will have to be not just profitable, but practical. Right now it is easy to place responsibility on a ship. But interaction from shore can actually add risk, with the possibility of interference or unclear responsibilities. Until these uncertainties are resolved, the legal responsibility will remain unchanged: the Master is responsible for decisions on board."

Appleton even believes that 'autonomous light', or assisted shipping, will not come overnight. "It will be a long process, and we will see a gradual introduction, mostly with menial tasks at first. As the pace increases, we may see jobs being moved to shore."

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Now you can take a theoretical discussion and convert it into a realistic scenario for training.

But moving jobs ashore also has its consequences, "When a change comes about, initially everyone has experience from the old system. Then eventually no one has hands on experience, because no one has done these jobs at sea."

"There are a lot of different opinions on how things will shake out, but whichever way it goes, the new ships of 10-15 years' time and the way of work onboard is likely to be very different from how it is now," he assures. "There may be fewer seafarers per vessel but the skills and expertise required by those seafarers is likely to be at a significantly higher level than it is today."

Appleton also recommends looking outside of shipping for solutions, pointing out that maritime competency requirements and training programs lack ambition compared to other industries. "For example, the British police now require degree-level qualification. They saw a need to raise training levels in order to be prepared for the demands of the 21st century. Shipping will follow suit, but probably more cautiously."

So what are the most likely solutions to these problems of maritime recruiting, attractiveness, and training in the 4th industrial revolution?

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Shipping will follow other industries, but probably more cautiously.

Appleton knows there are no quick fix answers, but he believes one thing is certain: "As the operation of modern ships evolves, so too will the recruitment, education and onboard working conditions of the seafarers employed on them."

Rather than recruiting seafarers on considerations of cost, he believes it will become necessary to recruit based on skillsets, many of which will fall outside of standard training requirements, or STCW.

Appleton trains his future focus on two key points he hopes will stick in the minds of shipowners and operators: "Training will need to be seen as more of a holistic process where knowledge is kept continually up to date, rather than waiting for mandated requirements, and working conditions will need to change to ensure that a maritime career remains attractive to future generations."

# Disruption in all directions

Tony Seba calls himself Chief Disruptor. Technically he is an author, lecturer and entrepreneur, but his passion is for things that change things.

Together with partner James Arbib, a London-based technology investor, Seba has predicted the demise of the private automobile, and the end of big oil, by 2030.

Seba and Arbib founded RethinkX, a think tank to study disruptions in different industries, and begin advising policy makers and business leaders accordingly. “We saw that they did not have the right information to make decisions regarding future investments. The big consulting companies were predicting linear extensions of past developments, and they were getting it wrong by huge margins.”

One example is the pundits’ take on solar power. “Just a few years ago they were predicting solar costs twenty years down the road that the market has long since reached. They were making the wrong assumptions, and that led to the wrong decisions.”

In fact, Seba says that solar power from photovoltaic panels has gotten 300 times cheaper since 1970. “Installed in the right element, it beats anything on the market today, and that is without subsidies.”

## **Be prepared**

Seba studies not only disruptions, but their implications for society. “With every disruption there will be jobs lost and jobs gained. There are always upsides and downsides to disruption. What we have to do is prepare to mitigate the downside.”

Take the disruption of the automobile as we know it today. Cars will not only be electric and autonomous, he says, they will no longer be privately owned. “This will bring the cost of transportation down. A family can save thousands on sharing an autonomous electric car, and that will trigger a boom in consumer spending, the biggest ever. It will make tax cuts seem like small change.”

**With every disruption there will be jobs lost and jobs gained.**

What he calls a “trillion dollar” boost in savings to the economy will compensate for loss of three million driving jobs, and time saved on driving less can be used for productivity. “That’s another trillion dollars in productivity gains.”

Transportation will be disrupted, Seba says, but there will be many other benefits to compensate. “We drive our cars only 4 per cent of available time. The other 96 per cent they are idle. It ties up capital, and it’s a waste of real estate. Three and a half cities the size of San Francisco could fit into the parking space that will be vacated in Los Angeles alone.”

So what to do with all that space? “Green parks, businesses, housing. Society can benefit from vacated government land used for public parking today. For example there will be room for more bike and pedestrian lanes.”



—  
Tony Seba,  
Chief Disruptor,  
RethinkX

More disposable income. More green space. Less pollution. “Even those who think they will lose out will probably win,” Seba states. “Transportation will become 10 times cheaper. The elderly, the youth, the disabled and the poor can’t drive, or can’t afford to. This will give them easy, affordable, efficient transportation.”

### Remember, disruption is not linear.

Tony Seba has a timeline for this scenario, based on the timing of the first autonomous vehicle approved for general traffic – an event he believes is just around the corner. “From the moment that autonomous vehicles are approved, which I predict will be 2021, there will be a 10 year disruption period. Since every job lost is important, we need to start mitigating now.”

#### **Shaking up shipping**

Not just land based transportation is in for a shakeup. “The main elements that apply to trucking apply to shipping too. And with so many fewer moving parts on electric machinery, there will be much less maintenance, and for many engineers, that will mean an alternative future. But we will still have people on board, and more operating

from land.” He also predicts that the boost in the economy that will trigger more consumer spending will also lead to more goods being shipped, thus driving volumes in the shipping industry.

But the mechanics of marine transportation are destined to change, he believes. “Electric vehicles being transported could be charged before shipping and used to power the ship.” That means no more engine room, and no more engine room jobs. For some, that might sound like a good thing: “I’m not passing value judgement on good or bad jobs, but some of the dirtier jobs today are going to go away, so we might as well be ready.”

The future of shipping is sailing more miles and moving more goods, but cheaper, and on ships very different than the ones we know today. “Google is building an operating system for autonomous cars – why couldn’t they do the same in shipping? Digitalised shipping is as attractive as digitalised driving.”

In summary, Seba sees energy and transportation disruptions spreading in all directions: “Amazon is buying their own planes. They are in the logistics business now, and getting better every day. For them going into shipping would be just another logical step. Remember, disruption is not linear.”

## View from the crew

How is the advance of digital at sea impacting on crews, crew management providers and their interactions with vessels and onshore teams? Tommy Olofsen from OSM sees opportunities, but also problems. If vessels and their systems are changing, he says, then the industry must follow suit.



**TOMMY OLOFSEN**  
Head of Crew  
Management, OSM

Tommy Olofsen is a busy man. As Head of Crew Management for OSM he leads a business division providing experienced seafarers to over 500 vessels worldwide, with a crew pool of around 10,000, directed from 30 offices across the globe. It's a company that's grown by 25 per cent in the past year alone and, with an emphasis on tailoring solutions for individual vessels rather than segments, that curve looks set to continue. With that in mind just getting through to Olofsen, rather than his phone's constant engaged tone, is an achievement.

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### The potential of increasingly widespread vessel and fleet digitalisation is huge.

Once connected he's affable and keen to talk, but it's immediately clear he doesn't have the time for platitudes concerning the seemingly inevitable rise of digital at sea.

#### A question of complexity

"The potential of increasingly widespread vessel and fleet digitalisation is huge," Olofsen begins, before adding a sobering caveat. "But, there's a but ...

It's all a question of what you're going to do with these systems and the data they capture. Are you actually going to empower the crew on board to make better decisions? Can you change the relationship and interplay between those on and off shore? Or look at the whole fleet and find out how to generate better performance as a company?

My experience so far is that most shipping companies have just added a column or two in their Excel sheets. There's extra data points, yes, but the industry needs to see actionable operational change based on that data. Without that you're not making things easier, you're just adding complexity."

#### Standard issues

And shipping is, Olofsen believes, complex enough already, leading to challenges in finding the optimal crew for each individual vessel. He puts this into perspective by referring to another high value asset transport sector.

"Consider aviation," he notes. "Here you have very clear standards and, comparatively speaking, very few suppliers. This means one plane has interchangeable equipment and structures with another. So, if you fly an A380 for Emirates, British Airways or Qantas, it doesn't matter, it's the same plane. Now, over to maritime ...



Moving from one ship to another can require very different training, experience and skillsets because the systems and structures can be completely different – even when the ships look the same, are in the same segment and conduct similar operations. There's a growing ecosystem of competing systems, suppliers and approaches locking horns. Individually you can argue they are intended to make life easier, but together, with the lack of standardisation and clarity, they just increase complexity. This is a big problem."

#### **Individual understanding**

So how does a crew management business like OSM tackle this? Olofsen rightly says it's an industry challenge rather an individual supplier issue, with a joined up approach needed to enable a shift towards uniform standards. However, in the meantime his company focuses on a "one size fits one" approach rather than "one size fits all".

He explains: "As crew management businesses grow and look towards increased efficiency and economies of scale they may opt to create a 'package' approach, whereby they look at a segment and offer a solution. At OSM we take the time to focus on individuals – individual vessels and systems, individual customers, and individual crewmembers. By considering all operational parameters, vessel and customer requirements, and then matching them with the crew that have the best profiles and experience, we can enhance overall understanding and performance.

We may be a growing global business, but we have personal service at our core. That's something increasing digitalisation won't change."

#### **People power**

In terms of what it will change, or should change, Olofsen is clear. OSM has created a vessel 'focus group' whereby it works closely with clients and teams on and off shore to understand how more connected systems can form the foundations for a future operations model – one that drives enhanced performance and delivers competitive advantage.

The OSM man believes empowering crew members to make optimal real-time decisions, based on big data analysis facilitated by systems and

shore-based organisations, is at the core of this new way of working.

"The companies that lead this race," he says, "these will be the ones that win. But it will call for a changed mind-set."

Olofsen says that with greater automation and connected organisations manning levels will inevitably decrease, both on board and on land:

"There's so many functions that don't have to be carried out on vessels, needlessly tying up crew resources – with administration and reporting duties being the most obvious culprits, and perhaps the easiest to digitise. With seamless connections across fleets on shore systems could take care of these, playing a greater role in managing everyday operations. I don't think we'll head towards full vessel autonomy in the near future, but we will see greater automation and reduced manpower."

Is that a problem for a crewing provider such as OSM?

Not according to Olofsen:

"You'll have less people, so the requirement to have the very best people – to handle that increased responsibility – is crucial. That's what we provide. As our company slogan states 'it's all about the people', and that's just as applicable when it comes to smarter, more automated operations."

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## Digital connectivity at sea is increasingly important.

#### **Anti-social networking?**

With more than 10,000 crew on the books, OSM has as much of an insight into what they expect from digitalisation as to what the industry needs. Olofsen's observations are broad-based – "I visit a lot of ships," he stresses – and, to some extent, almost 'paternal' in tone.

"Digital connectivity at sea is increasingly important, especially to those that have experienced it before and especially to the younger generations

of seafarers," he says. "It provides, for some, a better quality of life and can be a key factor in crew retention – it is, after all, an important benefit. But it is changing how people interact with one another.

## Social life on board is changing.

There's now more of a tendency to retreat to your cabin and connect with family and friends, whereas before you might have congregated in a communal area to connect with co-workers. So, social life on board is changing. There's also the question of if someone is meant to be resting after a shift and they're in their cabin interacting with a screen, is that really 'rest'?"

Olofsen isn't a disciplinarian, however, merely raising the issues because, he says, they should be openly discussed. Furthermore he believes it's potentially counterproductive to try and impose restrictions on internet use, as it may create resentment, opting instead to educate crew in appropriate behaviour so they themselves understand what it is right and wrong.

"We, and our clients, want to retain the best crew," he imparts, "and the way to do that is by creating the best environment for them."

## Promoting progress

With our opening in Olofsen's busy day about to close, it's time for a final insight. With increasing digital habits on land does that translate to increasingly digital savvy seafarers – eager to take advantage of the latest systems and, where possible, data-enabled decision making?

Yes and no seems to be the answer. He argues that as long as crew positions have to be filled according to rank and experience it could limit the progression of the most digitally savvy and ambitious seafarers.

"Say you create a digital environment onboard a vessel. Now, is the most important indicator of a crewmember's competence to utilise it the number of years they've spent at sea? I doubt that very much," he opines.

"So new systems place new demands on the structure and composition of crew. This is something, again, that the industry has to consider as a whole.

"If we really are going to realise the potential of digital," he concludes, "then we have to be open to change. We shouldn't be trying to just add systems to existing models, instead they should be the foundations for the models of tomorrow."



# Hacking the human element

Technical treachery often steals the headlines when data systems are breached by hackers. But Ilia Kolochenco, CEO of High-Tech Bridge, a leading web security company, says the human element is the hacker's most useful tool.



ILIA KOLOCHENKO  
CEO, High-Tech Bridge

"People are easily deceived, and they are easily distracted," he observes. Then there are those who are simply out to make a quick buck. Combine the two, and it adds up to many open doors for hackers with a bit of insight into human nature.

It can start with technology investors looking to diversify with a minimum of risk: "They invest venture capital in startup security companies, but they have only limited knowledge of cyber security. The solutions they are presented with might be smart, but they are often impractical or too expensive to for the market. And when investors put pressure on their companies to make money, they seek out clients without the proper knowledge to recognise ineffective solutions."

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**People are easily deceived, and they are easily distracted.**

Enter the client – or the victim: "Many managers understand cyber security, but many more do not. Either they do not assess, or do not understand their risks," Kolochenco says. As proof of this, he cites examples where companies have been hacked almost weekly after installing expensive but inadequate cybersecurity solutions. "Instead of identifying and meeting their top ten security

requirements, some security companies lead them into random priorities. They spend huge amounts of money on mitigating the wrong risks, while many of their key risks go unaddressed."

## Holes in the wall

Kolochenco cites incomplete inventory of digital assets as one global weakness, whether it be assets represented by the hardware, software, the data, or the users. "With cloud computing, shared data, and connectivity, it can be really difficult to gain a comprehensive and up to date overview."

Armed with this knowledge, hackers seek out the weakest points in a company's data defence, often profiling associated parties and attacking through them, rather than going for the big companies head-on.

"Companies build their castle, and then they build a wall around the castle. But all around them are villagers and farmers and merchants with access to the castle, and they either forget or cannot keep track of all their connections. In this case, a wall, or a firewall, does not give much protection."

Any business can be of interest to hackers, and ransomware makes them all potential sources of income. But this is a human problem, not software problem, Kolochenco emphasises. "Now it's about using humans as entry points in to the castle."



### Defend the choke points

The core business of High-Tech Bridge is machine learning and artificial intelligence in application security, and testing web and mobile applications for vulnerabilities. This is certainly a timely focus, at least according to the 2016 edition Gartner's Hype Cycle for Application Security, representing the gold standard in ICT consultancy:

**Applications, not the infrastructure, represent the main attack vector for data exfiltration. As organisations lose more control over their infrastructure with trends like mobility and cloud, applications become one of the last control points for imposing the organisation's security policy.**

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**With cloud computing, shared data, and connectivity, it can be really difficult to gain a comprehensive and up to date overview.**

"We are doing what we know best, and where we can offer the most competitive price-to-quality ratio, thanks to our award-winning technology." Ilia confirms.

Kolochenko was nominated to the Forbes Technology Council last year, and has recently started on a Master's degree in Law. "Technical and human sciences will be intertwined in future," he believes. "I want to be informed as that happens." He also sees the challenge of bringing the legal system up to speed with developments in digital technology. "Today if a business gets hacked, they are on their own. The legal system cannot protect you," he states flatly.

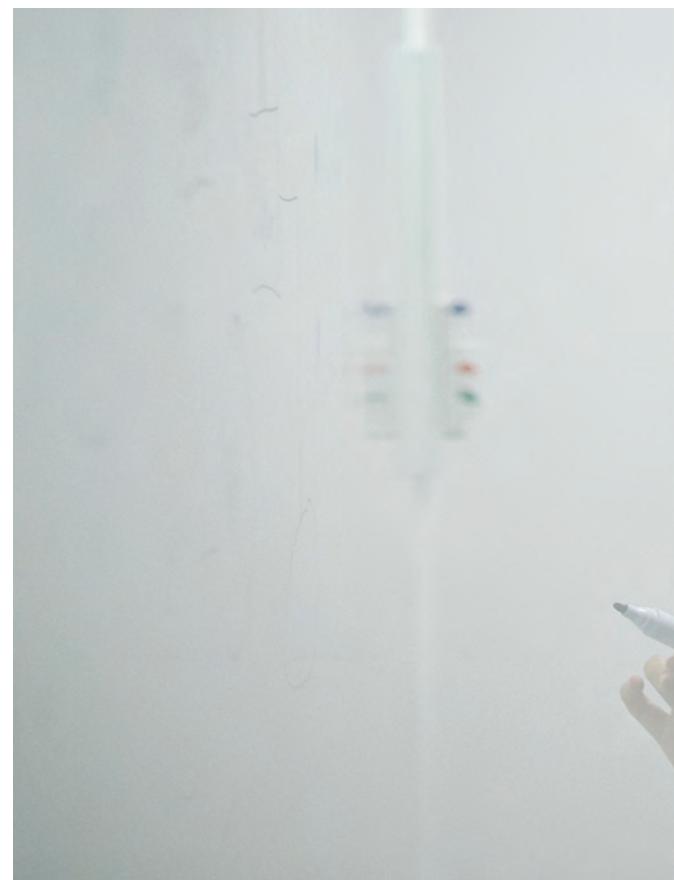
### Cyber surrender

One example of the legal community's belly-flop on hacking: When a machine with access to a company's mission-critical data is blocked, they are simply advised to pay a ransom fee to release the data. Investigation and prosecution are time consuming and complex, and it is much more practical to pay a small fee and keep the business running.

This practice has become so commonplace that data hijackers even operate multilingual call centres that advise on how to pay ransom, and even how to protect data from future attacks. "Now there is even ransomware as a service," Ilia says. "They sell the attack software and collect a flat fee, and the hacker simply plugs it in and goes to work."

Virtual capitulation is also becoming institutionalised: "Companies are budgeting with bitcoin to unblock devices, rather than using resources to fight hacking." While private citizens are more likely to balk on ransoms for monetary or ethical reasons, companies make better targets. "They need their data to keep functioning, and paying a small fee is not a problem. 50 dollars may be a lot for a private person, but it's cheap for a company. Also companies don't want to look vulnerable or unprofessional by admitting publicly that they are being hacked."

But don't hackers ever get caught? "Beginners and those who are indiscrete get caught. If you get greedy and demand too much ransom, a company might go after you. Or if all of a sudden a Lamborghini is parked in the driveway of your



new house, you are asking to get caught. But the real professionals can technically make hacking almost impossible to trace.”

And how to keep from getting hacked? “Just keep all your systems and all installed software up to date,” is Kolochenco’s practical advice. “Enough to minimise the majority of vulnerabilities.” Big companies will not change dramatically overnight, he points out. Bound as they are by legacy systems, contracts, and internal politics, they can only keep somewhat protected, and they will always have to live with weak points.

#### **Everything is hackable – but why would you?**

“We could also test cars or other hackable assets, but too much hype is generated around these risks in order to create business for security companies.” That being said, Kolochenco readily admits that the Internet of Things and sensor saturation could cause problems: “90 per cent of manufacturers do not care about security when they imbed sensors in their products. Often the systems cannot even be updated.” Still he believes the threat of virtually anything being hacked is exaggerated.

“Not everything needs to be connected. You don’t need to connect your smart toilet to the Internet.” For Kolochenco, it comes down to a simple rule of prevention: “Don’t stick your finger in the light socket, and you won’t get shocked. It may seem cool to connect to your car through the Internet, but then you are exposed, and you need to decide, is it worth it? Maybe you could just program your car to do what you want, and keep it offline.”

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**Technical and human sciences will be intertwined in future.**

Though he acknowledges that most people will allow themselves to be lured into excess connectivity, Ilia Kolochenco’s insight into the practical nature of humans keeps him from fearing the worst. “If you want to take over a car, it’s still easier just to break a window than to hack into the motherboard. If you want to wreck something, it is much easier to burn it than to hack it.”

A very down-to-earth reminder that even as we ascend into cyber space, we are still only human.



# Embracing individual disruption

As with many jobs on board a modern ship, the view from the engine room is changing as Shipping 4.0 becomes reality.

Digital services manager Palemia Field in ABB Marine & Ports has witnessed the transition. A former marine engineer with many years below deck on cruise ships and naval vessels, Field now heads up a team with responsibility for verification of automation, control, advisory and analytics systems.

“We put together a team that could look at networks holistically,” Field says. “Right away we discovered that advisory systems require an interface with automation and control systems.”

That interface is already displacing traditional roles and the need for expertise on a ship. Specialists are still needed on board, Field assures, but says they have learned that those with the deepest knowledge have more value in the office. “We have changed the way we support customers by shifting service personnel to Collaborative Operations Centres on land. Now we need to build up capacity to support our own engineers, by offering them centralised support.”

As to whether this development is proof of digital disruption on board, Field addresses the layers of disruptiveness: “Digital changes to operations are more disruptive at the individual level than at the industry level. Connectivity, big data and remote operations are primarily disrupting processes within companies.”

He cites the example of data scientists with no maritime experience being hired on in shipping companies to redesign the routines of seasoned marine engineers. Another is the sharing of

information that was once the exclusive domain of the captain. “We discuss the new order with captains to calm any fears they might have about losing control over the ship. The captain still has the ultimate authority, but transparency can be scary, when everybody can see everything that is done on board,” he acknowledges.

“We work with them on how they can benefit from changes. For example, on board crew and shore staff often disagree, and they always have done. Now transparency can help resolve those conflicts, because everyone has access to the same data. That in itself is a small revolution.”

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Digital changes to operations are more disruptive at the individual level than at the industry level.

Field adds that all levels of management can benefit from transparency: “Strategic, administrative and operative personnel all have an interest in the same data. It can help improve their planning efficiency, and their efficiency in practice.”

Beyond theory, Palemia Field has a specific goal he hopes digitalisation will help the industry reach: “Whatever we end up doing, I hope that someday we can remove human factors from marine incidents. New technology is enabling us to look at all the elements of a given situation and apply new solutions to old problems.”



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Palemia Field,  
Digital Services Manager,  
ABB Marine & Ports

For example, he believes that digital technology can help reduce fatigue among crew. "Computers are good at passive tasks, while humans are better at active tasks that require alert decision-making. Computers can relieve the burden of monotonous tasks, like routine controls or long watches on the bridge."

That being said, Field is by no means hinting at the autonomous ship. "The intelligent ship is not necessarily unmanned," he maintains. A more likely scenario has computers aiding humans in what humans do best: "They can help us create environments that are more appropriate for human operators, and they can help prepare us for consequences in a way that humans alone cannot do."



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# **CHAPTER 5**

## The future of ports

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**Container handling – a new order**

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**The secret to success at MIT Panama:  
Motivate and modernise**

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**Long Beach Container Terminal:  
Where there's a will, there's a way**

## Container handling – a new order

Not science fiction or fantasy, container-handling cranes are becoming increasingly intelligent, capable of making more decisions by themselves instead of following commands from above. It's time for the industry to challenge the current order.



**UNO BRYFORS**  
Senior Vice President,  
ABB Ports

"We started to look into how container handling in the terminals can be made more efficient and found that by adding real-time information to the equation, we are moving towards intelligent automation. This allows optimisation of container flows and reduces the risk of dependency on one centralised system," says ABB Ports Senior Vice President Uno Bryfors.

ABB Ports has been working with intelligent automation for some time now, allowing cranes to distribute work between themselves, and to proactively interact with vehicles to optimise terminal productivity. "We are moving forward on machine intelligence, and we will definitely see more happening in the near future," he explains.

### We are moving forward on machine intelligence.

Automation forms the basis for employing smarter machines, Bryfors notes, adding that port automation is on the rise, but with plenty of room to grow: "The deployment of crane automation, and gate and terminal process automation is now accelerating in all parts of the world. Today 6-7 per cent of the global container volume is handled by automatic stacking cranes, a share that will double when all ongoing projects are completed and in full production. Many ship-to-

shore cranes are delivered equipped with remote operation for automated, unmanned operation."

But the lifetime of the cranes has an impact on the speed of change: "With an expected lifetime of more than 30 years, it will take some time before the majority of the world's fleet of 5000-plus STS cranes is automated," he says.

Bryfors emphasises that the concept of intelligent automation is still new to the industry. Traditionally, the terminal operating system (TOS) has orchestrated all equipment and container moves, deciding which tasks to perform and how they should be carried out. "It is much better that TOS tells the machines what is to be done, and let them decide in which sequence the tasks should be performed."

In a terminal with dozens or even hundreds of automated cranes and vehicles, Bryfors points out that it is impossible to coordinate everything and to achieve the best possible productivity. "With so many units, we need distributed intelligence. This gives machines the ability to adjust their behaviour according to a given situation, and to get the work done in the optimal, most efficient way."

Bryfors clarifies that although machines are acting autonomously, they are not without supervision and control: "The role of humans



—  
Uno Bryfors in the  
Terminal Simulation  
Studio at ABB Ports'  
facilities in Västerås,  
Sweden

remains vital, although very different compared to conventional terminals.”

He also reports that most customers are increasingly open to automation and intelligent equipment. “The drive in the industry is for productivity. Bigger ships are putting more pressure on the terminals. They need to handle more containers per call, and the terminals prefer doing this without adding equipment.”

With an eye to building for the future, Bryfors says that the necessary components are available today: “Now we actually know where everything is in the process. We just have to use that information as efficiently as possible, and there is always room for improvement, even in the most modern terminals.”

#### **Remote remote**

The concept of multiple terminals being operated from one centralised control room is the natural next step in remote operations enabled by empowered machines, and Bryfors sees it as a goal within reach. “The distance from the control room to the equipment can be much greater today. This

allows the industry to think in a completely new way, and to bring the work to the people, instead of bringing people to the work.”

He points out that only a few major terminals remain in city centres or in close proximity to downtown, and most have been moved outside cities for practical reasons like space limitations or access to deep water. It can also be financially very attractive to free up existing port space close to city centres. When terminals relocate, workers are left with lengthy commutes to their jobs. Remote operation resolves that problem, in addition to allowing for more flexible staffing solutions.

“With remote operations it is easier to accommodate peaks and valleys in container traffic,” Bryfors says, noting that the same team can serve multiple terminals: “The jobs are pretty much the same across terminals, and resources can be shifted between terminals as needed in a matter of seconds.”

And ticking the box on one of the fundamental goals in ports development, remote operation

gets people out of the dangerous parts of terminals. "Safer, greener, and more productive are our main goals. Automation and remote operation are central in reaching all three of these goals."

Safety is also linked to occupational health. Remote operation allows the crane operators to be moved from crane cabins to an ergonomic and comfortable control room. For the operators this move is a significant improvement in their working environment, and enables real teamwork. It also allows the operators to continue in their careers to a higher age, and provides a great asset in recruiting the much needed next generation port professional: "The whole industry is struggling with a shortage of labour, and remote operator jobs have been proven to be more attractive than those on the cranes."

### The role of humans remains vital, although very different compared to conventional terminals.

Automation, remote operation and the concept of multiple terminals operated from one location not only open for new operating models for big greenfield terminals; existing terminals of various sizes upgrading their ability to serve bigger vessels, resulting in increasing yard activity and land side traffic, can also benefit from these solutions. "We now see several existing terminals automating parts of their operations, with a step by step approach. It is important to select the approach that fits the terminal's strategy, capacity and the remaining lifetime of the equipment", Bryfors says.

#### Getting greener

With improving battery and fast charging technologies, Bryfors feels confident that all-electric terminals are the future. "By 2030 all major ports in California must be emission free, and the first zero emission terminal is already in operation in Rotterdam. Looking 15 years ahead, I believe there will be no diesel powered equipment or vehicles in larger terminals."

#### Thinking inside the box

Not just concerned with moving containers, Uno Bryfors and his team have done some thinking about the boxes themselves, asking: Has everything that can be, been put into containers?

### The drive in the industry is for productivity.

"More of everything is going in containers, and that allows ships to be more flexible, and less specialised. But containers also represent a limitation, with basically only three sizes to choose from. What may be needed are more specialised containers, not just bigger." Fitting more freight into containers would allow the transportation industry to utilise existing infrastructure more efficiently, he argues.

Another shift in transportation might be back to speed. "The priority may shift from low cost to higher speed. With all the investments in accommodating larger ships and the time it takes to service them, costs may not have come down at all. Affordable higher speed transport may be the new differentiator, but it will require new ways of thinking and even more flexibility, for example in terminal operations."

But will ships keep getting bigger? Bryfors notes that the biggest ships on order are really no bigger than the biggest ones sailing today. "That is a pretty good indicator that the perceived limit is being reached." Bryfors observes that more big vessels will be delivered in the next 2-3 years for the Asia–Europe and North America–Asia routes, bringing the average ship size to 18 000TEU\* and over 13 000TEU, respectively. "Once completed, there will probably not be a need for more big ships for quite some time," he concludes.

More ships making more calls also give greater flexibility, a factor high on the priority list of cargo owners. "The number of port calls defines the number of opportunities to book transportation. With the bigger ships, if you miss one opportunity, the next one might not come along for days, or weeks."

\*1 TEU = 20 foot = 6 meter long container

### Virtual terminal reality

“The virtual terminal is here,” Uno Bryfors confirms. “We can now run a terminal in a very realistic way without the real equipment. This brings many benefits enabling efficient project execution and system integration, as well as operator training, without tying up hundreds of millions of dollars in assets.”

The simulated cranes and machines are interconnected, and these intelligent connections enable a terminal team to train on a terminal with empowered machines working together. All types of scenarios can be run without endangering humans, equipment, or cargo.

“We are not just training, but experimenting and testing. With simulated ships, ship calls with all their work orders, and the terminal, we can really see the interaction between the team and their terminal. Now we can learn about the real exceptions, the consequence of the consequence.”

### Expect the unexpected

Rounding off, Uno Bryfors has some thoughts about the place of ports in the entire logistics chain. “Environmental issues are important in pushing the development of container shipping and terminals, but also consolidation is driving change in the industry. We are seeing clear ties between terminals and shipping lines, and that could bring on many changes.”

With the industry converging around fewer players with more control, who will be driving future developments in the industry? “It’s hard to say exactly. It may be the shippers, the shipping lines, or the terminals. Amazon is one example of how a shipper could take control of its whole supply chain, and we see other developments impacting the industry too. The one thing we do know, is that the probability of things changing fast is much higher today than it was just a few years ago.”

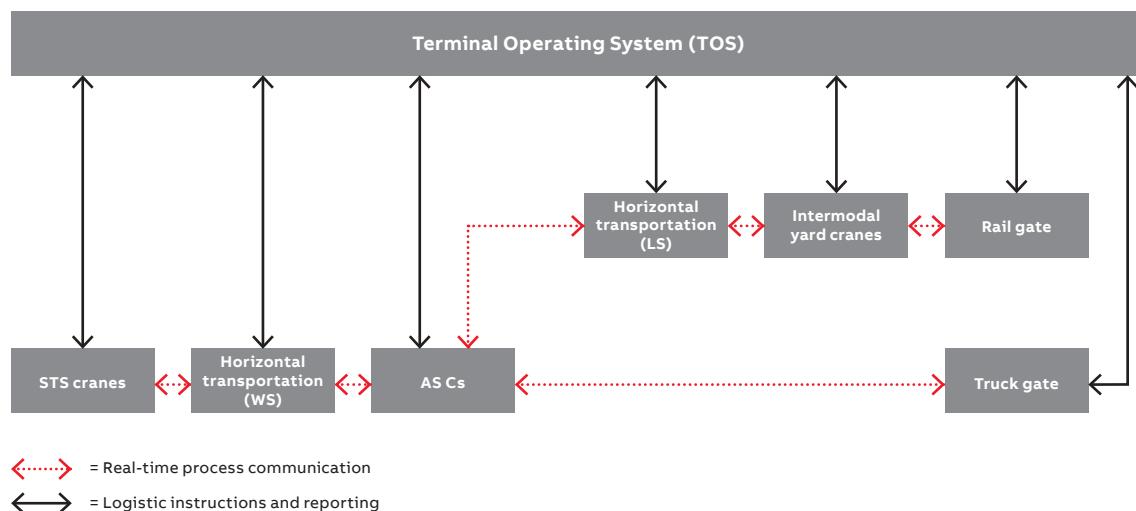
We are seeing clear ties between terminals and shipping lines, and that could bring on many changes.

#### Overall system level

- Manage
- Instruct container moves locations

#### Automated nodes of intelligent equipment

- Create and execute work orders
- Control motion
- Manage safety
- Optimise



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## THE SECRET TO SUCCESS AT MIT PANAMA

# Motivate and modernise

Even in the truly global ports industry, the story of MIT Panama, the Manzanillo International Terminal-Panama, S.A., located at the northern entrance of the Panama Canal, stands out as an example of how diversity, dedication and technology can combine across continents to achieve real progress.



KEN CHANG  
Director,  
MIT Panama

The story starts in Korea back in 1998, with Ken Chang, a Hyundai employee who saw an opportunity with US-based Stevedoring Services of America. SSA Marine had just acquired an 85 per cent stake in MIT and was looking for someone to oversee the work of modernising the terminal.

"The first thing for me was to try to understand Panamanian culture," Ken recalls, "and learn the language." Add to that the strong American influence in MIT's history, and Ken's challenge became even more complex.

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I thought it would be a stronger long-term solution to invest in developing local talent.

MIT was established on the site of what had been the largest US naval base outside American soil, so most of the staff were American engineers and technicians. "They were not especially eager to share their knowledge, so it was difficult to get them to train local labour," Ken says. MIT found themselves at a crossroads: retain American experience, or train the local workforce.

"I thought it would be a stronger long-term solution to invest in developing local talent," Ken relates. "Many had engineering degrees from Panamanian universities, but they did not have the mindset for adopting other ways of working, and they did not have the experience." He managed to convince SSA Marine management that going local would be the best bet in the long run, and began the daunting process of adapting local talent to the demands of a global industry.

"MIT was the first in SSA Marine to train the local workforce. We started hiring straight from the university, so we did not have people coming in with too much baggage from other cultures. In the beginning I trained them myself using an interpreter. Looking back, it took almost ten years to build up a pool of local talent," says Ken.

Already early on Ken knew that people thrive on challenge, so he put in a request for funding of projects that would serve to motivate trainees. "Learning by doing, and observing operations first-hand, was very motivational. I could see that they responded when I would use one of their suggestions." As their knowledge grew, so did interest in growing the business. "They became very keen to use and try out new technologies," Ken recalls.



—  
Ken Change visiting ABB  
Ports HQ in Västerås,  
Sweden

## Two technologies together:

**MIT's introduction of ASCs alongside RTGs is among the industry's first such cases. ABB Ports global head of sales Fredrik Johanson breaks down the chemistry:**

"The side-by-side operation of ASC and RTG cranes shows that it is possible to introduce automation in part of an existing terminal and achieve significant improvements, in productivity, the working environment, health and safety, and staff motivation through working in a multi-skilled team.

"This case can provide inspiration to those considering introducing automation in an existing manual terminal, but are concerned about how that can be done without disturbing the daily operation too much.

"The MIT case also demonstrates that automatic stacking cranes with remote supervision can successfully be installed and taken into operation in an existing mixed yard operation. This means that an existing RTG terminal for instance can consider adding ASCs to provide the additional yard capacity and productivity needed. Lastly, this case proves that automation and remote operation can be introduced step-by-step within one node, or node-by-node, throughout the process."

### **High and wide, side-by-side**

Once the local workforce was established and stable, efforts turned to modernising terminal operations. In 2015 the solution was identified in more efficient Automatic Stacking Cranes (ASC). “Container handling using Rubber Tired Gantry cranes, (RTG), uses a lot of land space and requires a wider path for operations, and space is at a premium at MIT Panama,” Ken says. “Stacking uses less land space, so we knew we had to find a solution that would allow us to introduce ASC, without having to replace the existing RTG cranes.

MIT allocated fifteen per cent of yard space to ASC operations, alongside the RTG cranes. The results of the ASC operations have met all expectations and MIT reports that stacking cranes represent only 8 per cent of their container handling equipment fleet, but perform 25 per cent of all the moves in the entire operation. The two different handling philosophies are now working together in harmony at MIT, but the combination is still somewhat unusual in the container terminal world. “We have made it work, and we will continue with a gradual conversion to ASCs as we go along, without having to make a wholesale conversion,” Ken says.

Adding Europe to the Asian and American elements of the story, cooperation with ABB Ports has been instrumental in the modernisation of MIT Panama, according to Ken: “ABB responded to our needs, and they listened to our ideas. We have used ABB as our sole supplier of drive systems for decades. This includes also refurbishment of older drive systems and equipment.” Therefore it was natural for MIT to turn to ABB Ports for the automation and remote supervision solution for their new stacking cranes.

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**ABB responded to our needs, and they listened to our ideas.**

As with any good relationship, both parties benefit: “MIT provides feedback to ABB that allows us not just to meet their needs, but to improve our products and services to the market,” says global head of sales, Fredrik Johanson of ABB Ports. “We are very happy with all aspects of cooperation between ABB and MIT.”

### **Moving on**

As regards plans for the future, Ken Chang is reflective, and decisive: “We will implement the Internet of Things (IoT) to a larger degree, and we are prepared with sensors on the modern stacking equipment. Eventually that will replace the manual signals that we use today.”

Another driver in MIT’s development is the recent expansion of the Panama Canal. MIT shares the northern entrance to the canal: “As you head in to the Panama Canal, we’re the first one on the left,” Ken smiles.

70 to 80 per cent of their volume is transhipment, moving cargo on from the big ships to feeder ships serving the Caribbean region. Though that is not likely to change, the increased capacity of ships passing through the canal should add to MIT’s total volumes: “The Plus Panamax ships are bigger, but the economic downturn has reduced traffic. When the economy picks up again, though, we are ready with new cranes and an expanded yard.”

### **Solid choices**

As with any professional choice he makes, Ken Chang has his reasons for choosing ABB as a preferred, if not exclusive, supplier: “We are confident in our relationship with ABB. In MIT we steer by three main Key Performance Indicators, or KPIs,” he says, and ABB helps us meet these goals.”

The first KPI is crane stability and availability, or downtime: “Downtime is when a crane is not available due to a fault occurring during operations. The industry norm for downtime is 1.5 per cent. MIT Panama established a target of .5 per cent, and we have achieved this target every year for the last 15 years.” This despite a near-impossible parameter of maximum five minutes from notification to response before an incident counts as down time.

One factor in achieving this goal is the good training provided by ABB, Ken points out. Another is the reliability of ABB products and systems. “These things have helped us achieve our downtime goal, even in this tough operating climate, with heat, humidity and salt from the ocean.”

We will implement the Internet of Things to a larger degree, and we are prepared with sensors on the modern stacking equipment.

Another KPI is cost related to MRO, or Maintenance, Repair, and Operations. "We rely on preventive and corrective maintenance. We may move on to predictive maintenance at some point, but right now the cost would outweigh the benefit." Ken's typically pragmatic solution? "We have a guy walking around the yard who keeps his eyes open and his ear to the ground. He sees things that need taking care of."

MIT Panama ASCs

Despite the importance of maintaining production and controlling costs, the safety KPI is the most important to Ken: "It took years for the Panamanians to recognise the importance of safety measures, even just the use of a harness and gloves." Ken tells of a Panamanian saying, that cats have seven lives; one for now, and six spares. "I started asking my workers, 'Are you a cat?' It took time with my bad Spanish for them to understand," he laughs, "but what I meant was, we have spare parts, but no spare lives."

Having put an ocean between himself and his former life, and invested half his working life in fine-tuning port operations on the isthmus joining two continents, Ken Chang knows both separation, and connection. "Good relationships are the most important. Our industry may be global, but everybody knows each other. It's a very competitive business, but we still have to be able to work together."



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## LONG BEACH CONTAINER TERMINAL

# Where there's a will, there's a way

When one envisions building the most technologically advanced, efficient, and cost effective terminal in the United States, the path to that goal may not necessarily be straightforward.

But at the end of the journey, when you are able to say you have achieved your goals, you most likely will feel it was all worth it. Long Beach Container Terminal (LBCT) is writing the future, together with ABB, by being the first fully automated container terminal in the United States.

Anthony Otto, President of LBCT, relates that he started on the project to develop and build the terminal about ten years ago. "When it all started, it took many different forms, and it did not look exactly like this," he says, pointing out that his terminal has been in commercial operation for about one and half years now. But the vision was always clear: "What we have achieved here is a paradigm shift in our industry, here in Southern California and in the United States," he says. The terminal is fully automated, and operated in a completely different way than the conventional terminals surrounding the new crown jewel of US container terminals.

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What we have achieved here is a paradigm shift in our industry, here in Southern California and in the United States.

When meeting Mr. Otto and his crew at the new terminal, it is easy to see that everyone working at LBCT is proud of their workplace and the

achievements they have accomplished. It seems that being part of a truly ground-breaking effort creates strong bonds between the people who share that experience. Perhaps they have formed the dream team that will ensure the success of the terminal for years to come?

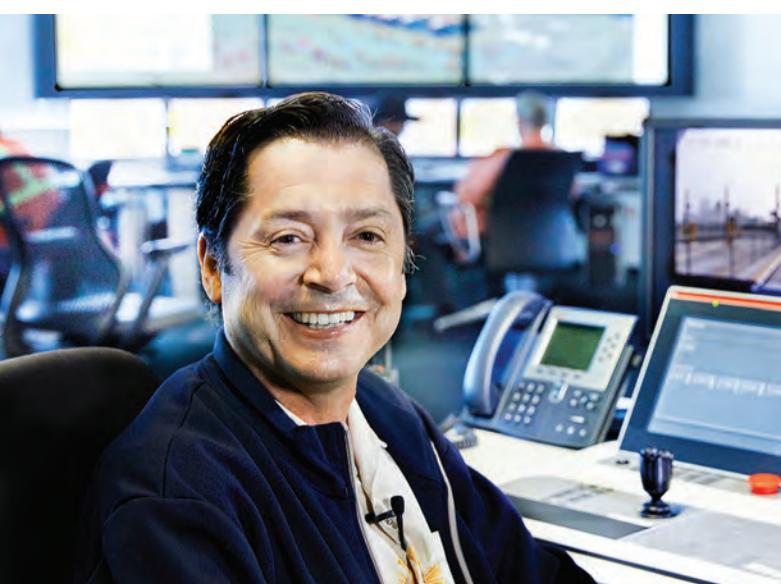
### At the forefront of technology

Otto says his team searched for the best technologies and travelled the world to see different solutions in operation. The ultimate goal was to find the best possible solution for their new terminal, and to be able to build a terminal at the absolute forefront of technology.

It soon became evident that automation was the way to go, and as a result, LBCT became the first fully automated terminal in the US, employing automated cranes and automatic horizontal transportation.

When it comes to crane automation, the choice of partner to undertake this major development was clear early on – the partner would be ABB. "ABB has the necessary experience, and they are the leading supplier of container terminal automation," Otto confirms.

As a result of that choice, all the cranes at the quay, the yard and the on-dock intermodal yard are equipped with ABB's automation solutions. The quay cranes also have a crane OCR system from ABB for automated container identification and detection of door direction.



Upper left:  
Jim Jacobs,  
General Manager of  
Maintenance and Repair,  
LBCT

Upper right:  
Anthony Otto,  
President, LBCT

Lower left:  
Eric Gonzalez,  
Crane Operator, LBCT

Lower right:  
Giuseppe Giannola,  
Maintenance Engineer,  
LBCT

The first phase of the terminal with 1MTEU capacity went live in April 2016. LBCT is serving megaships and calls that many times require around 10 000 moves to be performed by the STS cranes alone. When the last phase of the terminal is completed in 2021, the designed capacity will have reached fully 3,3MTEU, making LBCT the largest container terminal in the United States in terms of capacity.

#### **The first near-zero emission container terminal in the United States**

Bucking a trend of most new major container terminals, LBCT is located very close to the city of Long Beach. So how is this possible? "To be allowed to proceed with this project we went through a very long, difficult EIR, an Environmental Impact Study to make sure that the impact of this facility on the rest of the city, down-

town and the surrounding communities was kept to an absolute minimum," Otto explains.

The new terminal, including all cranes and horizontal transportation, is electrically driven. Add to that all vessels calling LBCT are required to utilise a shore power connection for ships during berthing, and Otto concludes: "We are happy now to say that we are the first near-zero-emission container terminal in the United States."

#### **In top shape at all times**

In an automated terminal, maintenance plays a key, even critical role, says Jim Jacobs, General Manager of Maintenance and Repair at LBCT. "In this environment any piece of equipment can be called on to service a customer anytime. For this reason, we rely on predictive maintenance rather than breakdown repairs. This requires mainten-

ance activities to be communicated closely with the operations team at all times,” he says. “In a conventional terminal you can let a few things go, but in an automated terminal you have to keep the equipment running in top shape to reduce, or even eliminate, the interaction between man and machine. In an automated terminal the operations group needs predictability and reliability.”

## — Automation has greatly changed maintenance duties.

This scenario of changing times in maintenance is confirmed by Maintenance Engineer Giuseppe Giannola who works with maintenance and repair of all the stacking and STS-cranes: “Automation has greatly changed maintenance duties. It includes new challenges and requires new skills as the duties are now more technical, computerised and software related. We also have much more coordination with other departments regarding access to the equipment. But the goal remains the same – keeping the cargo moving and minimising downtime.”

To support the maintenance of an automated terminal, ABB has delivered some new tools to LBCT. “One example is the overview table that shows all the lifting equipment in the terminal. That allows us to proactively spot problems as they arise, and centrally dispatch the maintenance,” Jim Jacobs says. “We can use the overview table to take care of many warnings, faults and problems that come up, and many of them can be solved efficiently from the control room, which helps keep things moving,” Giannola adds.

### **“This is real teamwork”**

In the heart of an automated container terminal, the control room, we meet a happy crew of crane operators. Here the team from ILWU Local 13 is remotely handling confirmations and exceptions for LBCT’s fleet of fully automated stacking cranes, a relatively new phenomenon in the US.

The stacking crane operators at LBCT are experienced crane drivers and have worked in traditional yards driving the cranes from a crane cabin, so they know what they are talking about. With 20 years of crane driving experience, Eric Gonza-

lez says his work at LBCT is completely different compared to his previous jobs. “I describe my duties as babysitting the cranes, because we are sitting up here in the control room overseeing the whole fleet of cranes out in the field.”

The operators appreciate the technical capabilities and responsiveness of the ABB systems, but they also emphasise the benefits of the new working environment, and how it allows them to become a real team.

It’s easy to understand that the new working environment is a big change. In conventional terminals, crane drivers work under harsh conditions, which in turn presents a challenge when recruiting future port professionals.

The crane operators at LBCT say that simple things really do matter; things that office workers take for granted. Like working in a clean environment, being able to take a short break to get a cup of coffee, or just getting up to move around. The flexible and ergonomic Remote Control Station also allows working sitting and standing up. “Now I can rest my back, and basically live a healthier life,” Gonzalez says.

But there is more to the control room at LBCT. More than being the “crane operators’ office”, it is the focal point in keeping the containers moving. At LBCT, the clerks and part of the maintenance crew are also stationed in the control room with the operators. In talking about the benefits of working in such environment, another very human aspect quickly pops up: communication.

Communication between people is not always easy, and using radios or sending your message via a third person does not make it easier. According to people working with operations and maintenance at LBCT, the shared control room makes communication much easier, more efficient and more direct, reducing the risk of misunderstandings.

When it comes to communication, it is not only the task at hand that needs to be addressed. Communication is also the key element in building relationship and teams. Having the possibility to work in a shared control room helps crane operators, maintenance engineers, clerks and super-

visors get to know each other. The person "at the other end" is no longer just a voice on the radio. They are a colleague you get to know, maybe even a little about their family or the names of their kids. Before, you might never even have met.

All this facilitates collaboration between people, and that has a positive impact on productivity. "This is real teamwork," says Giannola.

The future of LBCT has begun. The terminal is on course to combine two aging terminals into a new terminal that is safer, greener and more productive than its predecessors. There may be no better way to put it than Giuseppe Giannola does: "This is a great place to be."

ABB has made two videos about LBCT. To see them, please visit: [www.abb.com/ports](http://www.abb.com/ports) or [www.youtube.com/user/abbmarine/videos](http://www.youtube.com/user/abbmarine/videos)

—  
Long Beach Container  
Terminal

## Facts about the cranes at LBCT:

### STS cranes with world leading lifting power

- Lifting capacity up to 130 tonnes
- Automation enables efficient utilisation of various dual and single hoist configurations
- Lifting height up to 50,3 meters
- Main trolley speed 240 m/minute and hoist speed up to 180 m/minute
- Fully automated container handoff and detection of door direction with Crane OCR

### Fast and efficient automatic stacking cranes

- Stacking 6 high, 9 or 10 wide for optimised utilisation of yard space
- Gantry speed up to 240m/minute and hoist speed up to 120 m/minute
- High precision stacking
- Automatic landing and pick up of containers on AGVs, terminal chassis and road chassis

### On-dock intermodal yard cranes

- Automation functions similar to automatic stacking cranes
- Designed to operate over eight tracks
- In operation 24/7



# CHAPTER 6

## Technical insight

- 122–123** **MARANDA – Aranda goes hybrid**
- 124–129** **ABB Propulsion Control: Ice Mode**  
**Encounters in Kara Sea**  
**on board Christophe de Margerie**
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**development for Azipod® equipped**  
**with linear flow propulsor**
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- 140–143** **Intelligent Semi-submersible Heavy**  
**Transport Vessel**
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**(MPV) Integrated Automation System**

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## MARANDA – Aranda goes hybrid

In the EU-funded MARANDA project, an emission-free hydrogen fuelled PEMFC-based hybrid power train system is being developed for marine applications.

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The system will be validated on both bench tests and on board the research vessel Aranda, one of about 30 research vessels in Europe. Special emphasis has been placed on air filtration and development of hydrogen ejector solutions, for both efficiency and durability. In addition, full-scale freeze start testing of the system will be conducted.

When research vessels are performing measurements, the main engines are turned off to minimise noise, vibration and air pollution that could disturb measurements. The 165 kW (2 x 82.5 kW AC) fuel cell powertrain (hybridised with a battery) will provide power to the vessel's electrical equipment and dynamic positioning during measurements, free from vibration, noise and air pollution.

One of the major obstacles for wider implementation of fuel cells in the marine sector is the lack of hydrogen infrastructure. To alleviate this problem, a mobile hydrogen storage container, refillable in any 350 bar hydrogen refuelling station, will be developed for this project. This novel solution will increase hydrogen availability to the marine sector, and many others.

The project consortium consists of companies from the whole fuel cell value chain, from balance-of-plant components to system integrator and end user. ABB Marine & Ports has the role of designing and delivering the power electronics that convert fuel cell DC power to the vessel's main AC distribution plant. The fuel cell system will be tested in conditions similar to Arctic marine conditions before implementation on the target vessel.

The project will increase the market potential of hydrogen fuel cells in marine sector, which has long been lagging behind road transportation. General business cases for different actors in the marine and harbour or fuel cell business will be created, and the impact in the entire industry should be notable. MARANDA will run 48 months total, concluding at the end of February 2021.



Aranda – Finnish marine research ship



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**ABB PROPULSION CONTROL**

# **Ice Mode Encounters in Kara Sea onboard Christophe de Margerie**

ABB is happy to report that the Ice Mode function, which Generations covered in its 2016 Connectivity issue, has now been successfully trialled in ARC-7 ice conditions.

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The Christophe de Margerie (DSME H2418), the first of the series of Yamal ice-class LNG carriers with Azipod®-based electric propulsion, conducted ice trials in the winter of 2016/2017. Two of the authors of this article, Bo-Won Lee and Michal Robenek, were onboard in the ice trial support function, as the specialists for propulsion control and ACS 6000 drives respectively. During the trials, the Ice Mode function successfully handled the customer and owner requirements. The concept proposed by DSME and ABB was proven with flying colours, as the Ice Mode functionality added to the ABB Propulsion Control Units (PCU) used boil-off gas as the prime mover fuel for maximum ice-breaking effect.

## **The Vessel**

The Christophe de Margerie, in Figure 1, is the first of the Yamalmax class of LNG carriers designed and built to ship liquefied natural gas from the newly constructed port of Sabetta, built to service the Yamal gas fields of northern Russia. It is owned and operated by the Russian company Sovcomflot, and is the first in the line of 15 ships to be built according to the requirements of the Yamal project. The vessel, previously Daewoo Shipbuilding and Marine Engineering (DSME) hull number 2418, is registered under the IMO number 9737187. It is 299 m long, with the beam of 50 m, draft of 10.4 m, gross tonnage of 128 806 t and

summer deadweight tonnage of 96 779 t. Christophe de Margerie is capable of carrying 172 600 m<sup>3</sup> of liquefied natural gas across the High Arctic route to the markets of Korea, Japan, and China. More importantly for the Ice Mode function, the vessel is an ice-breaking design up to ARC-7 specifications, capable of breaking 2.1 m thick Arctic ice. The vessel breaks the ice while sailing stern-first (see Figure 7), using ABB Azipods® to create under-pressure below the ice-sheet, which thus loses support and breaks off into the low-pressure flume. Thereafter, broken off pieces of the ice sheet are further milled by the Azipods® and ultimately expelled to the sides of the ship, facilitated by the curves and reinforcement of the ice-breaking stern.

## **Propulsion Setup**

Steaming and ice-breaking are both the function of the ship's main electrical propulsion system, comprising three ice-breaking Azipod® VI thrusters rated at 15 MW for the total propulsion power of 45 MW. The thruster drives, three of ABB's top-segment ACS 6000 lineups, are supplied from two symmetric power supply and distribution sections, each characterised by a set of three ABB generators, two rated at 12.5 MVA, and one each of 9.4 MVA, according to the SLD in Figure 2.



Figure 1 (over): SCF – Sovcomflot IMO 9737187 Christophe de Margerie (previously DSME H2418), the world's first Yamalmax electrical propulsion LNG carrier with ARC-7 ice class

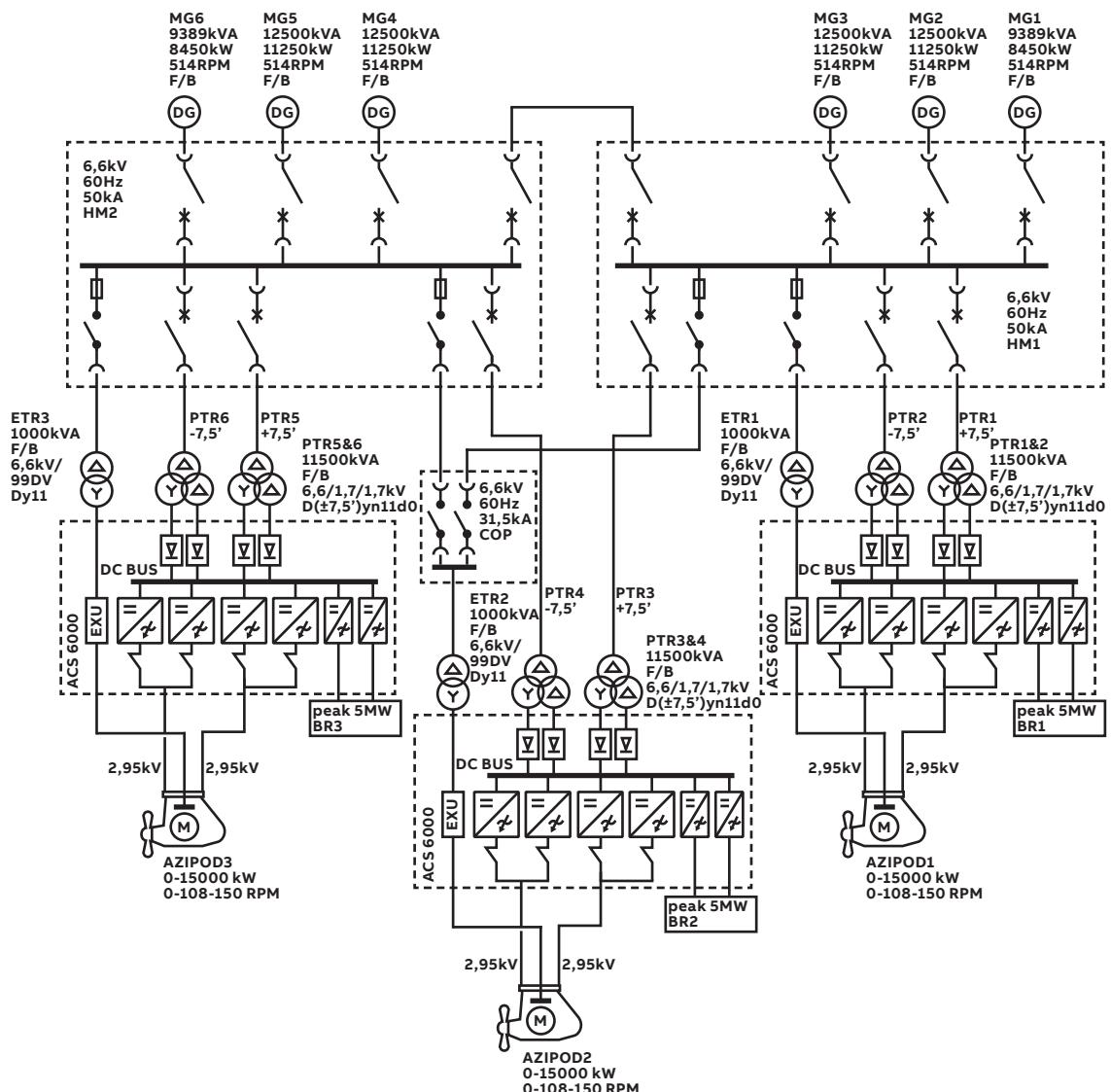


Figure 2: Single-line diagram of Yamalmax LNG carriers

Figure 3: The loading curves for the Azipods of Yamalmax LNG carriers

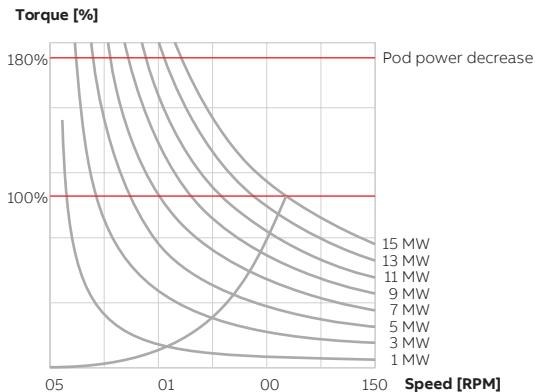


Figure 4: Stability of power principle, with torque necessary for equilibrium under 180 % nominal

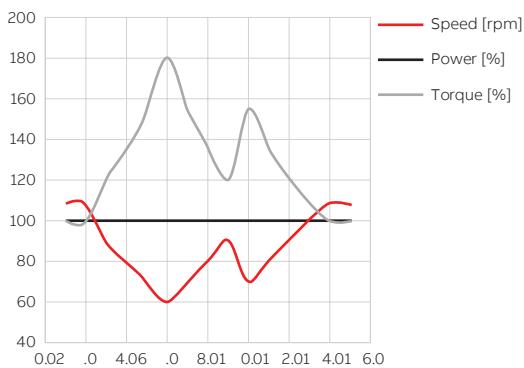
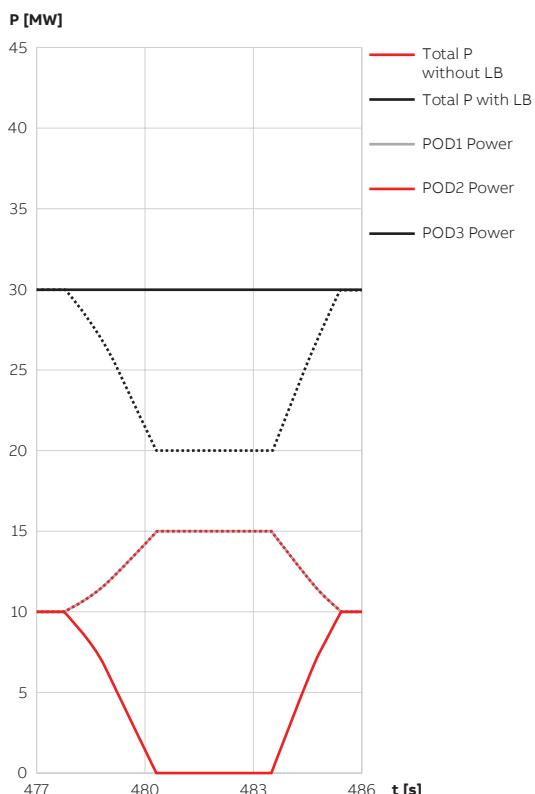


Figure 5: Principle of the Ice Mode function that boosts the load of active pods, taking over from a stalled one



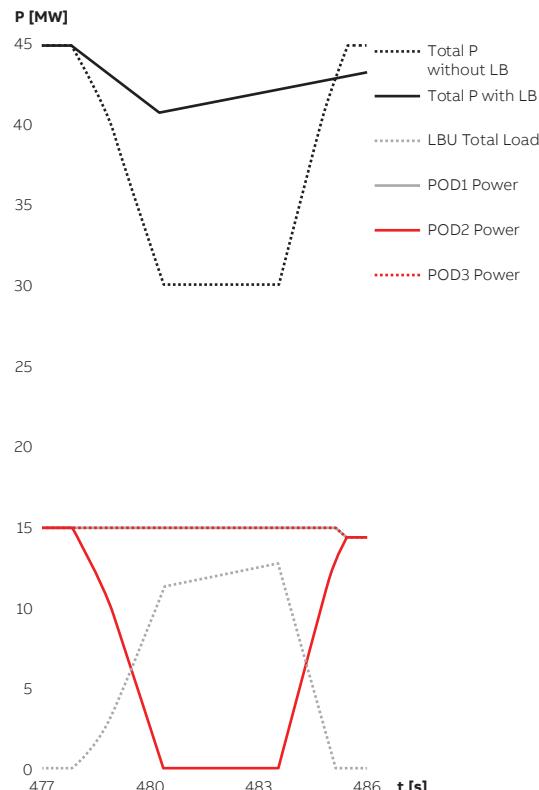
The two side pods are individually fed from the respective sections of the power system, whereas the middle pod is fed from a dual supply of both sections. This means that in the case of failure of one section, power (albeit decreased) is still available to the middle pod. Accordingly, in the failure scenario of either section, two pods are available, guaranteeing vessel manoeuvrability.

### Ice-Breaking Considerations

Especially important for ice-breaking (as well as crash stop) operations are the three installed breaking resistor units (BRUs) rated at 5 MW peak power, represented by BR1, 2, and 3 in Figure 2. Another important feature that facilitates ice-breaking in Christophe de Margerie and other forthcoming Yamalmax LNG carriers, is that the ACS 6000 drives for this project have been parameterised, tested, and commissioned with 180% over-torque capabilities, as noted in Figure 3. This is 30% more than the 150% over-torque capability usually provided by ABB for ice-class vessels.

The over-torque allows the Azipods to deliver sustained torque in conditions of a stable power command from the bridge, but with speed of revolution of the propellers widely varying and jittering due to mechanical milling and grinding of the ice sheet. In such unsteady conditions, the instantaneous torque command channel is continually updated on the ACS 6000 drive from the propulsion control units (PCUs). The PCUs are dedicated ABB controllers that implement and execute all the generic and specific propulsion control functions, including the Ice Mode function. The cyclical and instantaneous calculation is always proportional to the power commanded by the levers on the bridge, ice-breaking bridge, wings, or ECR –and inversely proportional to the instantaneous speed of revolution of the propeller. As the speed of revolution decreases due to friction with ice during milling and breaking, the torque necessary to break through the ice and maintain continuous rpm operation increases. In that way, the mechanical power provided by the propeller remains constant even in cases of dropping speed of revolution, as displayed in Figure 4.

In the cases where, at a required amount of power from the commanding levers, the speed of revolution of the propeller drops below a critical value



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Figure 6: Principle of the Ice Mode function that boosts load by activating the breaking resistors, and anticipates restoration of nominal conditions by throttling up the prime movers during stall-out

given as the respective power curves intersect with the 180% horizontal line on Figure 3, the regime of operation changes. The drive will cap the torque at 180% nominal. In such cases, precipitous and sudden dips of the load, in proportion to the variability of the speed of revolution, will be observed on the electrical network. Governors of the prime movers will seek to throttle down the gas-fired engines according to their rpm feedbacks. If the precipitousness of the rpm drop is sufficient that, in the proportional reaction of the governors, the throttling down will exceed, in its rate, the achievable elasticity of the throttle when fired by boil-off gas, the engine control unit will switch the fuel to the more elastic marine diesel. If even the marine diesel dynamics of the prime mover are not able to satisfy the dropping rate of throttling, the frequency of the network will grow unchecked and safeguards will ultimately react to black-out the offending section, or the entire network.

### The Ice Mode Function

Even in the cases where throttling down with diesel-fired prime movers would be sufficiently

fast to accommodate the rpm drop, this is an economically inefficient way of operating the Yamalmax LNG carriers. If possible, the ice-breaking transit should be made on boil-off gas fuelled prime movers, which are of thermodynamic necessity more sluggish in their throttle response. To ameliorate the gap between the possibly very dynamic propeller rpm response to ice-milling, and a sluggish throttle response of gas-fired engines, the Ice Mode function dynamically redistributes or boosts the electrical load to equilibrate the electrical network.

The Ice Mode function is based on cross-connectedness of the PCUs supervising and controlling the three propulsion sections in the bottom part of the SLD presented in Figure 2. In that way, the heavy loads respond as a system, offsetting in an optimal way three principle modes of equilibrating the network:

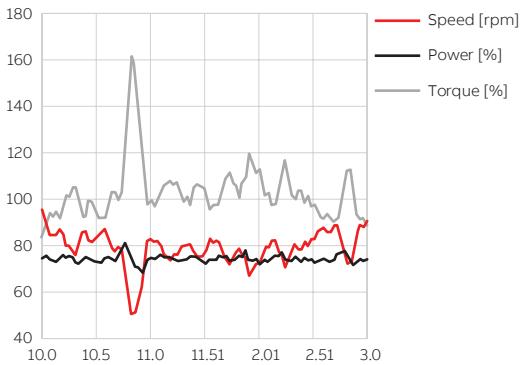
1. Maximum amount of generation excess is removed by throttling down the prime movers at the maximum rate allowed by the boil-off gas thermodynamic process.
2. The remaining excess is picked up by the spare capacity (the difference between the commanded power on the lever and the maximum power rating) of the Azipods® not experiencing a loss of power, at the maximum rate allowed by the ACS 6000 drive.
3. The remaining excess is picked up by switching in the breaking resistors BR1, 2, and 3, if they are available due to possible temperature-based interlock. This function of the Ice Mode is called the Load Bank function.

Additionally, the design of the Ice Mode Load Bank function takes explicit care of the disparity between responsiveness in throttle-down to throttle-up when operating internal combustion engines (regardless of fuel). Once the load on the ice-stalled pod crosses (and pans out at) zero, the Ice Mode proactively throttles up the prime movers, anticipating unlocking of the stalled pod and a resumption of operations according to the power lever settings. The Ice Mode throttles up the prime movers indirectly, by intentionally displacing the electrical network from its equilibrium, dictating a further ramped increase of load on either the breaking resistors, or the spare-capacity pods. This causes the governors of the

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Figure 7: Rough sailing conditions are expected for Christophe de Margerie and sister Yamalmax LNG carriers, even when not conducting ice-breaking operations



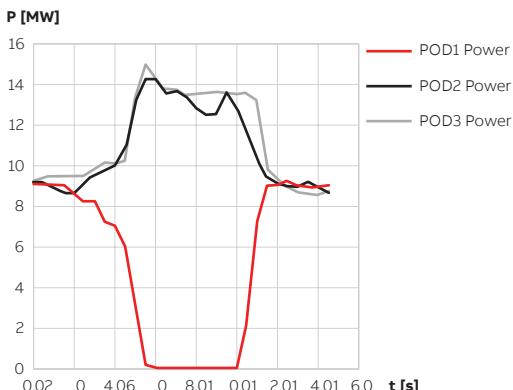
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Figure 8: Stability of power in the case of speed of revolution dips due to ice-milling, where torque necessary for equilibrium is under 180% nominal, onboard the Christophe de Margerie



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Figure 9: Ice-breaking conditions faced by Christophe de Margerie on its Kara Sea Ice Trials



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Figure 10: Power boosting function in practice onboard Christophe de Margerie during Ice Trials in the Kara Sea (cf. Figure 4)



prime movers to respond to the falling network frequency by ramping up the engines. The ramp-up regime stops when either the nominal amount of generation is achieved, even in the stalled pod configuration, or the pods re-start propeller rotation and conditions on the electrical network are restored to the original levers' settings.

The principle of load boost on pods other than the one stalling in ice is displayed in Figure 5. The principle of load boost by a breaking resistor, i.e. the Load Bank function, together with the proactive ramp up at power zero-crossing of the stalling pod, is displayed in Figure 6.

### The Ice Trials of Christophe de Margerie

Christophe de Margerie sailed out on its Ice Trial voyage on 2 February 2017, departing the Zeebrugge LNG port, after loading its first cargo following the vessel's delivery from DSME. The vessel sailed with ice trial participants on board, from the shipyard and several important suppliers, in a variety of engineering support functions. After a few days at sea, in progressively more difficult conditions, see Figure 7, the vessel could start facing the sea ice after passing the northern promontory of Severny island and transitioning from the Barents to the Kara Sea.

### Testing The System And Ice Mode Functions

With respect to the described over-torque capability of the installed ACS 6000 drives, there are several implementation obstacles to achieving the perfect equilibrium in the principle displayed in Figure 4. Such obstacles are e.g. processing delays of the speed feedback and calculation blocks for the new torque reference, communication delays between the PCU and the drive line-up, and a selection of measurement imperfections such as LSB jitter, or ADC imprecisions. However, even taking these into consideration, and due to ABB's propulsion control algorithms, a high quality stability of power expended (i.e. electrical load on the network) was still achieved during the Ice Trial, according to Figure 10.

With regard to the Ice Mode functions, these were severely tested by the ice-breaking conditions, as visible in Figure 9. We have selected a number of representative cases that display the principles designed for and depicted in Figures 5 and 6.

In the instance of the power boost function, a representative logged trend in Figure 10 shows the starboard Azipod® stalling in heavy ice even with full over-torque applied. As a result, the propulsion power rapidly decreases to near 0 MW from the lever rating of ca. 9 MW. The Ice Mode function implemented across the three PCUs responsible for the three pods immediately kicked in, assuring that the lost load was reclaimed by boosting the load on the central and port Azipod® equally. This resulted in ca. 4.5 MW boosted on each pod up from their lever settings of ca. 9 MW, meaning they were temporarily operating at near peak performance of 13.5 MW. Once the stalled propeller broke free of the heavy ice and the propulsion power started ramping back to the original power reference, the boosted pods proportionally released their boost down to their own references, equilibrating the network to its original conditions.

With respect to the breaking resistor boosting functions of the Ice Mode, the most severe stress-test came when the vessel penetrated a heavy ice ridge of ca. 500 m length, with 15 to 18 m ice sheet thickness. In these conditions, with all

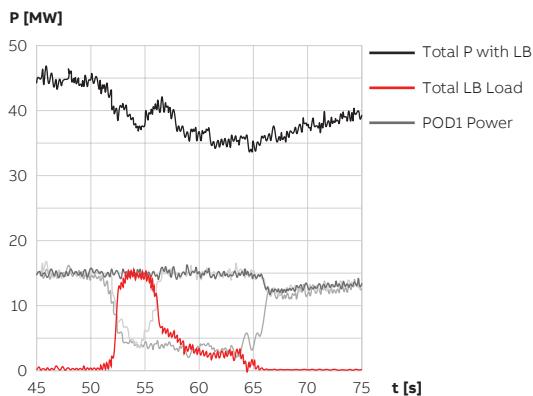
three Azipods® operating at peak performance of 15 MW in order to make any progress in milling ice, two pods simultaneously encountered heavy ice load, resulting in a total loss of 23 MW of propulsion power, as per Figure 11.

The Load Bank function coordinated all three networked PCUs, each in turn commanding the three breaking resistor banks BR1, 2, and 3, in a co-ordinated fashion, producing the aggregate dissipated power displayed in Figure 10. This response kept the total load variation (black line) appropriately low so that the ECUs of the dual-fuel engines could follow the variations while continuing to feed the engines boil-off gas, rather than switching over to marine diesel. No safeguards or interlock were activated, even during a cumulative loss of power of 23 MW for 3 seconds, continuing with the loss of 10 MW for the next 7 – 8 seconds after that, before returning to nominal operating conditions.

In conclusion, the authors, and the whole Technology and Engineering organisation at ABB Marine & Ports, were very proud to see an agile innovation provided to the customer within the scope of an ambitious delivery deadline, and tested for its mettle in such a harsh environment. Two of the authors, out of the group of four, who as a group conceptualised, designed, implemented, tested, commissioned, and trialled the Ice Mode function, were also on board and were able to testify to a smooth and failure-free operation of all the developed functions and installed hardware equipment. The ice trials were completed with ample spare time, after only six weeks. Michael Robenek and Bo-Won Lee, first and second from the right respectively, are understandably visibly relieved, satisfied, and proud in the group photo of ABB's complement onboard Christophe during the Ice Trials in Figure 12. ABB looks forward to the whole collection of 15 Yamalmax LNG carriers with ARC-7 ice-breaking capability, ultimately relying on high capacity ACS 6000 drives and the AC800 M PCU controllers running the Ice Mode, to provide uninterrupted, economical, and safe navigation on boil-off gas-fired engines the length of the Arctic route.

\*ABB Ice Mode – Smart, connected, safe solutions for Arctic LNG  
M. Barisic, B. Gundersen, M. Robenek, H. Knappskog  
ABB Generations 2016. p. 100-103

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Figure 11: The Load Bank function in a severe stress-test onboard Christophe de Margerie during Ice Trials in the Kara Sea (cf. Figure 5)



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Figure 12: ABB's Ice Trial personnel proudly completing the Christophe de Margerie 2017 Ice Trials with the first shipment of LNG cargo onboard



# Concept investigation and development for Azipod® equipped with linear flow propulsor

During 2016, ABB introduced a new member to the well-known Azipod® X-series. The main difference between the older XO and the new XL is the concept of how thrust is generated.

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The functional concept of the new XL is based on a pump-jet functionality. The following paper will describe how the concept was developed within ABB, and how the functionality was verified with the help of model tests and CFD (Computational Fluid Dynamics). Based on the results, the body form was further developed to give the optimum performance. At the same time the strength was investigated using FEM (Finite Element Method) calculations derived with the CFD results as an input to give the best possible model of the actual operational condition.

#### **Introduction**

Looking at the development with the existing pod propulsion concept, the conclusion was that there are only limited improvements that can be developed for the existing pod configuration. In response to this, ABB started a new research program in 2014 to investigate new propulsion concepts and see if there were some benefits that could be developed into new propulsion concepts. One of the concepts was the linear jet propulsion concept that will be further discussed in this paper.

#### **Background and concept**

The basic concept of linear flow propulsion is to have a duct that accelerates the flow to the rotor. The rotor on the other hand can be more loaded

in the top region, and additionally works in the accelerated axial inflow from the duct. After the rotor, the stator blades straighten the flow and make use of the rotational flow that would otherwise be lost to the flow.

The arrangement can be either with the stator blades in front or behind the rotor, depending on how the overall configuration is set up. For instance in naval applications, where the system has been researched and implemented since the 1960s, the concept is traditionally used as a pushing configuration (torpedo and submarine propulsion), which means that the stator blades are located in front of the rotor.

#### **Basic study**

The first assessments for the concept were done by the Krylov State Research Centre (Krylov) on behalf of ABB. The first estimation was for a 17.5 MW device envisaged to operate on a vessel with a design speed of 25 knots. The basic design was done for open water conditions, where the wake field was only considered as an axial component. However, the first estimation was to decide on either a pulling or a pushing version of the concept. The difference in structure was that with a pulling configuration the rotor would be located before the stators, whereas for the pushing they would be the other way around.

The first estimations were for a rotor alone with a nozzle. To this a set of stator blades were added in the calculations, where the aim was to have no swirl after the last component. These concepts were then calculated at different revolution rates and rotor diameters, where the variable factor was the pitch for the rotor (example shown in Figure 1). The outcome of the optimisation routine was that the pulling option showed a couple of percentage points better performance than the pushing option. Additionally, an investigation on the effect of the blade area ratio was investigated for the two concepts. This was based on the risk of cavitation inception. The basic concept was that both options should fulfil the required margin against cavitation inception. With the computational comparison, the conclusion was that the pushing type would also require a higher blade area ratio to match the same cavitation inception criteria.

The optimum nozzle dimensions were selected based on Krylov's experience with nozzle designs. They have developed a formulation based on model tests series where the nozzle dimensions are variables of overall diameter and the cross sectional diameters of the hub at different locations in the nozzle.

Based on the basic study, ABB opted for a pulling version of the concept with an optimised rotor and nozzle configuration, even if that would increase the challenges of handling overall forces and moments at the mounting block of the unit. The selection was made purely from a hydrodynamic aspect.

A 3D model of the pod body was delivered by ABB to Krylov, who performed the first CFD (Computational Fluid Dynamics) calculations in full scale for the concept to verify the estimated performance. Based on the calculations the pitch was slightly low, but was corrected before the model tests were conducted, also at the Krylov facility.

The conclusion of the first CFD calculations showed that the estimated efficiency in full scale would be approximately 0.72. Based on the model tests, the estimation at the time was that the efficiency in full scale was 0.71, or basically in line with the CFD calculation, given that at the time there was no scaling method for the concept. At the time, scaling was done according to Krylov's earlier experience with pod propulsion, i.e. the propulsion components (rotor, nozzle and stator blades) were assumed to have the same proportional drag in full scale as in model scale. However, the pod body was assumed to have 30 % less proportional drag in full scale. As regards the cavitation test, gap cavitation was only present up until the design advance value, after which some pressure cavitation was present.

### Optimisation and verification

Concluding from the base case, the following issues could be improved in the first optimisation round. The pod body was to be optimised for the new propulsion concept. In the first round the body was more or less a copy of the currently used body form for the Azipod® XO series. When the nozzle was introduced at the front of the pod, the effect on the steering forces was quite significant, hence the steering axis had to be shifted forward for the whole pod. (Due to the length of the nozzle the shaft line had to be lengthened). In addition, the indication from the first design study was that the gap between the pod strut and the nozzle should be larger. This contradicts the need to shift the steering axis forward, so the pod body for the upper part had to be an optimisation with these two boundaries in mind. To gain the optimum balance for the steering forces, a small fin was also introduced at the end of the torpedo, to give a balancing force at higher steering angles. Additionally, due to the longer shaft line the torpedo body could be slimmer compared to the current version. However, significant importance had to be assigned for the overall rotational radius of the pod not to grow too large.

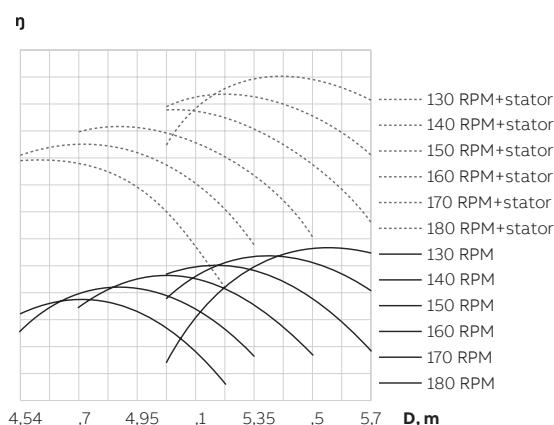


Figure 1: Example of diameter optimisation

Since the pod body was provided by ABB, it meant that the next step in the optimisation of the body was solely up to ABB. Hence the decision was made to switch the verification of the optimised pod to Marin instead of Krylov. The main reason for this was to get a third party involved, and to develop a scaling method for the new concept. In the meantime Krylov continued work on a numerical optimisation routine for the multiple component system, consisting of the passive and active parts attached to the pod housing.

To develop the new pod body, ABB used in-house CFD and FEM calculations to derive the optimised form that would later be used in the upcoming model test. The calculations were utilised by employing the results from the CFD calculations as input for the FEM calculations. The different operational scenarios included stationary forward operation as well as oblique operation at various vessel speeds. The modifications in the hull structure that were studied were the azimuth axis location, slanted strut design, fin location, correlation between stator and rotor blade number and nozzle-rotor location.

Such results, as shown in Figure 2, were used to validate the design from a strength point of view, in different operational conditions. Similarly, over

all force distributions, such as the steering force and total resultant force diagrams, were used to analyse the acting forces depending on operational conditions.

### Numerical optimisation routine for the propulsor

Simultaneous to the development work going on at ABB on the pod body, Krylov continued to develop their design process for the nozzle, rotor and stator combination. This has been described in more detail in Marinich, Yakolev, Ovchinnikov & Veinkonheimo 2017, but in short the process is as follows: The main routine is to use a BEM (Boundary Element Method) to calculate the flow around each component in the propulsor, i.e. nozzle, rotor and stator. However, the flow over the nozzle will depend on the loading on the rotor, which again will affect the flow over the rotor and stator blades, so the routine is a multi-iterative process to reach the converged solution for the operational point in question. With the calculation routine set up, the next step is how to proceed with the actual optimisation routine for the different components. Starting from the rotor, the goal is to achieve as much efficiency as possible, but without risking the strength or exceeding the cavitation criteria (where off-design condi-

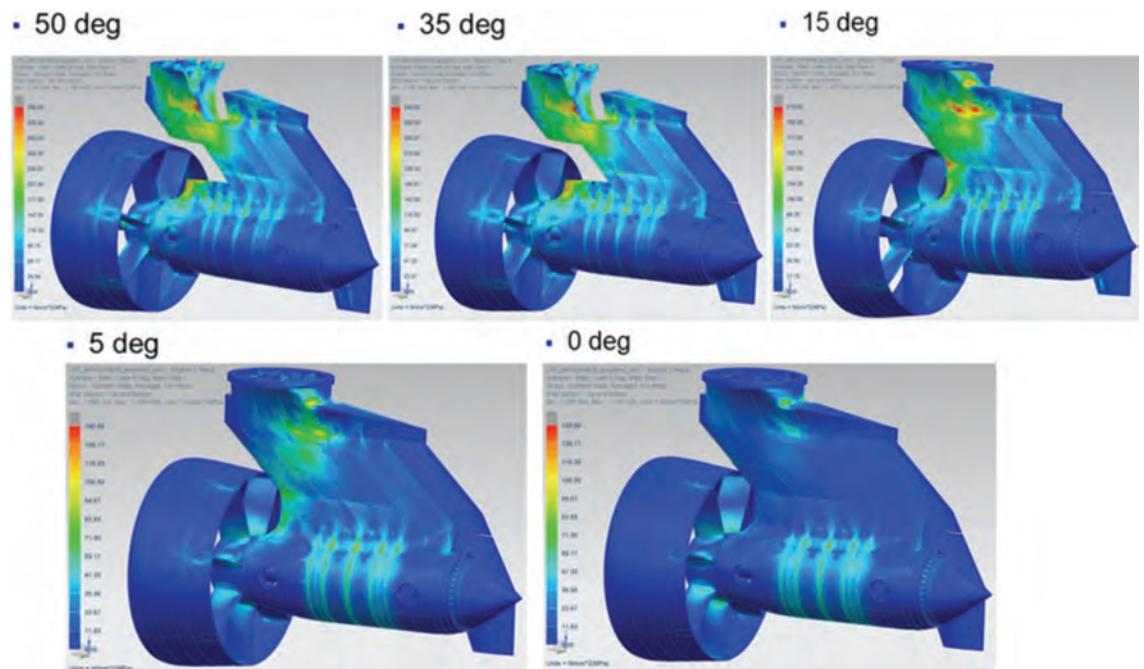


Figure 2: Results of oblique flow FEM calculations

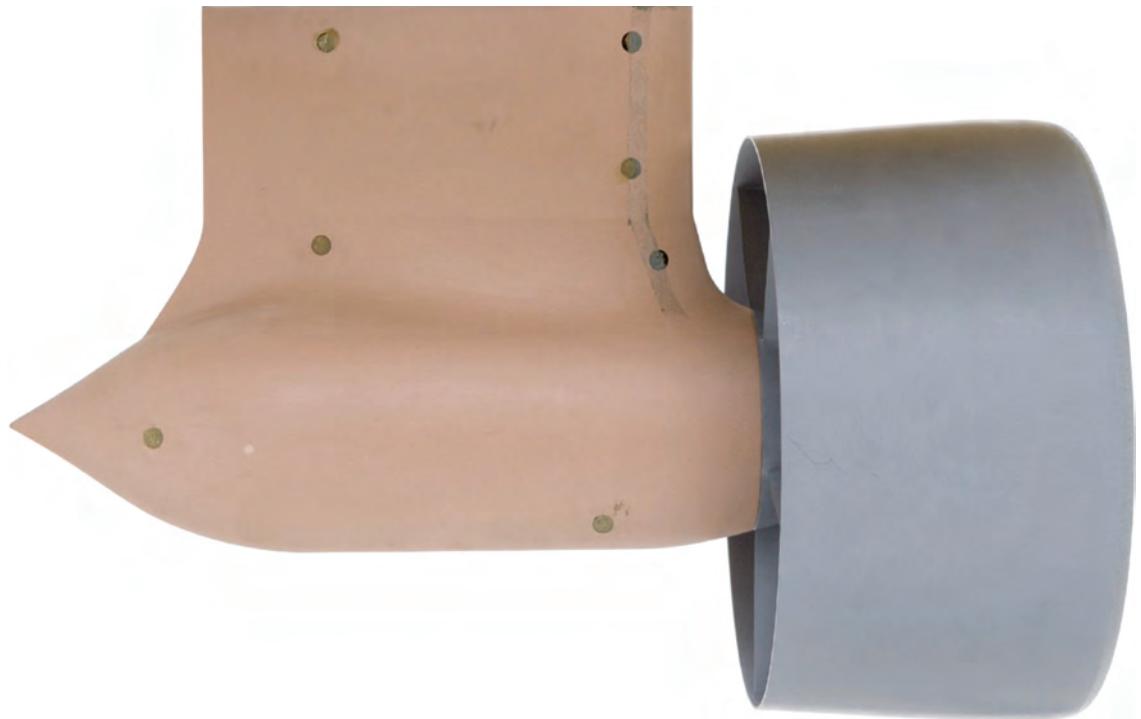


Figure: 3 Initially tested model propulsor

tions can be included) and still not exceeding the main boundary of the torque in that operational condition. The stator blades are optimised with a similar routine as for the rotor, with the difference that the main boundary is not the torque generated by the motor, but that the vorticity after the blades should be minimised. Additionally, the strength criteria are higher for the stator blades as they are the main supports for the nozzle construction. For the optimisation, the nozzle is separated into three different surfaces: the outer surface, the inner surface before the rotor, and the inner surface after the rotor. The aim in nozzle optimisation is to uphold the flow rate, see that the transition between the surfaces is smooth, and eliminate separation.

Following the optimisation routine a case study was done at Krylov. The propulsion configuration was analysed with CFD calculations, where special attention was given to the pressure distribution over the nozzle, pressure distribution on the blades during one rotation (no pressure spikes), average flow speeds before and after the stator blades, and additionally some off-design conditions to see that the system will work in these conditions as well. Based on the CFD for the basic

study, the achieved efficiency was 72%, after the optimisation routine the achieved efficiency in the CFD calculation was 75%, and in model scale test 69%. The difference between the CFD and model tests is due to the scale effect in the system.

### Scaling

As mentioned earlier, the verification tests for the new concept were done at Marin in the Netherlands. One significant issue realised early in the process, was that the current scaling method POD-U would probably not be sufficient for the new multi component concept. So in a collaboration between Marin and ABB, a new scaling methodology was developed which has been presented in Veikonenmo, Miettinen & Huisman 2017, but will be shortly described below: The assumption is that the model test values should be corrected for the Reynolds scale effect. The rotor is corrected for the thrust and torque according to the ITTC '78 correction method, but for the passively working components there is no clear methodology. The PODU-U method developed by Marin corrects the resistance of the pod housing based on the local Reynolds number, where form factors and velocity profiles are derived for the

“conventional” pod form. However, in this case we have components such as the nozzle and the stator blades for which there were no derived form factors or velocity profiles. So, in a collaboration where ABB did the CFD calculations, both in model and full scale, and Marin did the model tests, the same methodology as used in the POD-U method was further developed for scaling of multi component propulsors. Based on the CFD calculations, Marin devised form factors and velocity profiles for the stators, pod body, and nozzle. There was some inconsistency regarding the nozzle, so Marin used their experience to derive some suitable values. Additionally, the Katsui friction line was used both for model and full scale, but in full scale cases where the Katsui friction line was exceeded by the Prandtl-Schlichting's formula for roughened plates, the larger value was used.

The development showed that for a multi component propulsor, such a complex scaling method is needed, as the POD-U method did not sufficiently catch the relatively large scale effect compared to a conventional pod.

### Verification

In order to verify that the results achieved at Krylov and Marin would be the same, the exact same geometry was tested at both facilities. (Both facilities manufactured their own models but according to the same specification). At 15 Hz, the maximum efficiency in model scale varied by 3.5%, so there was clearly some discrepancy between the different basins. Thus it was necessary to do the verifications at two different, well renowned basins to verify the new concept. Similar differences between model basins have been noted earlier with “conventional” pod housing (internal, non-public report from 2006), which only underscores the importance from a pod manufacturer's point of view to develop a reliable scaling method for podded propulsion.

Adapting the scaling method described above to the model results measured at Marin and comparing them to the CFD results from Krylov, the difference in maximum efficiency was down to approximately 2%, which indicates that the prediction from two different model basins are within reasonable correlation of each other.

The current concept design was done solely for open water, i.e. no tangential or radial wake component had been taken into account in the design phase of the rotor-stator-nozzle configuration. However, based on the results from the open water test, the performance results were suitably in line with a project under construction with ABB Azipod® propulsion. In collaboration with the shipyard, ABB ordered a model test series from Marin consisting of self-propulsion and cavitation tests, to be compared to the performance of the current configuration. Based on the self-propulsion test results, the vessel speed gain was 0.33 knots at the design power rating, corresponding to the a  $h_0$  value for the propulsor of 0.73 under the vessel. Given that this is a non-optimised system for the current project, it serves only to indicate the minimum achievable benefits of such a system.

In the cavitation tests, some suction side cavitation was present, which was expected, as the rotor was not designed with the correct wake field. In a design project it is assumed that the rotor can be designed without sheet cavitation. More challenging will be to cope with the gap between the nozzle and the rotor. During the cavitation test, pressure pulses were also measured on the hull in the same locations as for the “conventional” pod propulsion. Based on measurement results, the propeller induced pressure pulses were approximately 50% of that measured with a “conventional” pod propeller. The same value also translated to 50% of the FZeg (criteria). Part of the difference comes from the fact that the rotor diameter was smaller than the propeller diameter, so the distance to the hull was slightly larger. Additionally, the nozzle also gives an advantage for the new arrangement, especially since there was some suction side cavitation present on the rotor, whereas there was close to no cavitation present on the propeller.

### Summary and conclusions

This paper has described in brief the development process that has been used to develop a new concept for pod propulsion. The development included numerical optimisation routines as well as new scaling methods for multi component propulsors, on top of the conventional development work.

Although considerable design work remains on cavitation inception, the hydrodynamic benefits with respect to efficiency and induced pressure pulses are clearly worth the effort.

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Figure 4: Azipod® XL



# Closing the loop from office to propeller with ABB Ability™

In most ship segments, fuel cost is one of the biggest cost elements in the ship operation. In addition to fuel costs, fuel consumption and the efficiency of power plant operation play a major role in the total emissions of the ship.

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Traditionally, power plant control systems are designed only for maintaining the balance between power consumption and production. In diesel-electric power plants this typically means that the Power Management System (PMS) starts engines if the average load of the engines is above a predefined load-dependent start limit for a defined period of time. Similarly the engines are stopped if the average load is below defined load-dependent stop limits for a defined period of time. Typically there are constraints related to the operational situation, which define the minimum power plant capability required in the operational situation at hand. The constraints are related to minimum number of running engines, minimum dynamic capability, etc.

When a traditional PMS operates the power plant, the typical strategy is to share the load evenly with all running generators so that the load relative to the maximum output of each generator is equal. While this might be the easiest method to share the load between generators, this is not optimal in terms of fuel consumption. Moreover, the power plant assets, such as diesel generators, change over time. The specific fuel oil consumption (SFOC) characteristic curve that describes the amount of fuel the diesel generator consumes to produce one unit of electrical energy with

respect to the relative load of the engine, changes over time due to wear and tear of the components. Based on data from tens of ships over several years, fuel consumption in terms of SFOC can increase up to 3-6 % between overhaul periods. In order to run the generators optimally at all times, an adaptive solution is needed.

Another major aspect in power plant operation is that traditional solutions do not take into account the forthcoming operation profile in determining which assets should be run to produce the required power. In ship operation, the operation profile is typically known in advance due to the fact that the ship has a mission and the operation is planned so that the mission is executed. In addition, weather forecasts are available to predict the forthcoming operating conditions.

This paper describes the vertical integration concept for power plant optimisation where operation planning is automatically connected to a predictive optimisation solution to plan how the power plant should be run. In addition to planning power plan operation, a low-level power plant optimisation has been implemented to run the power plant optimally in real-time to take into account the planned operation as well as the ongoing real demand. The models used for op-

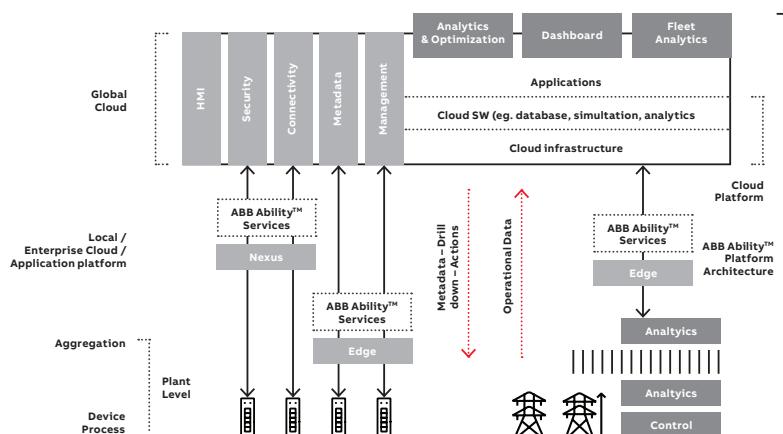


Figure 1: High-level architecture description of the ABB Ability™ platform

timisation are adapted using real data to ensure that the operation is optimal throughout the life cycle of the engines in order to enable continuous optimal operation.

ABB Ability™ Platform

The ABB Ability™ platform is ABB's integrated industrial internet platform. It is the technology platform used to build and connect ABB Ability™ solutions, such as ABB Ability™ Marine Advisory System OCTOPUS software for marine operations management and optimisation. It comprises several digital-enabling technologies that can reside at the device, edge and cloud levels. It operates ABB's own technology and industrial software while leveraging Microsoft's enterprise-grade Azure cloud infrastructure, cyber security and services.

One such technology currently integrated in the Ability™ Platform is the Advanced Process Control & Analytics (APCA) suite, offering Analytics & Optimisation (A&O) services for monitoring, predictive diagnostics and closed-loop control. The APCA suite communicates its deployed advanced controllers and soft-sensors (i.e. analytics) with the ABB Ability Edge via OPC UA, an IoT enabled protocol, and can operate at the Edge, in a Distributed Control System, or at the ABB Ability™ Cloud.

In the ABB Ability™ Edge and Nexus, users can, among other options, filter, aggregate, analyse, process and store the data for redundancy and transmission between ABB Ability™ Cloud and the plant as illustrated in Figure 1.

Furthermore, in the ABB Ability™ platform, control and commissioning engineers can develop straightforward interfaces for tuning and configuring the parameters of deployed controllers as well as dashboards for data visualisation of key process variables.

## **ABB Ability™ OCTOPUS vertical integration concept**

In typical ship operation, there are several types of planning and decision-making, typically performed by various people. There are several ways to define the levels of operation. In this paper, the decision-making and planning levels divide the operation into vertical levels, which are defined by the time constants of the operational dynamics typical to that level.

The highest level contains planning and management activities mostly taking place on shore, but also onboard the vessel, depending on the ship segment. The typical time constants in operation planning vary from hours up to months. Today, operation at this level is manual. The level below the planning and management is onboard operation. In this context the onboard operation consists of activities where a human is typically involved in decision-making or even in continuous control. The typical time constants in onboard operation vary from seconds to hours. The operation in this layer can be manual or automatic, depending on the case. The onboard operation layer commands the automation and control systems layer, which consists of several subsystems. The operation in this layer is fully automatic, except for backup functionalities that can be controlled manually. The typical time constants in this layer range from 1ms up to 1s. The lowest level of hierarchy consists of devices. The devices are individual devices or subsystems which are controlled by embedded control systems which concern only one system, such as propulsion motor and frequency converter, diesel generator, etc. Typical time constants in this layer range from microseconds to milliseconds. The operation in the device level is fully automatic, except for backup manual control functionalities.

In traditional operation of a ship, the information available in higher levels of hierarchies is not typically automatically utilised in the lower levels

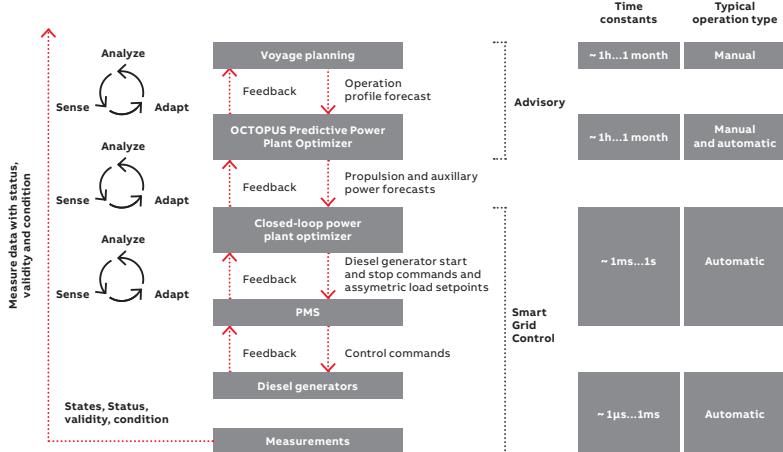


Figure 2: System hierarchies in voyage planning and optimal power plant operation

to enable optimised system level control in the lower level. Similarly the information available in the lower levels is not typically automatically utilised in the higher levels to enable better planning and decision-making. This leads to suboptimal system level behaviour.

The vertical integration concept enabled by ABB Ability™ applied to optimal power plant operation closes the loop from data to analytics and optimal control of the plant. In the highest level the operator onboard or onshore plans the voyage so that the mission of the ship can be executed as efficiently as possible given the operational constraints such as maximum speed and Required Time of Arrival (RTA). Voyage planning relies on knowledge of the ship model, predictions of forthcoming weather etc. Once the voyage plan has been done, the power demand during the voyage can be predicted in advance using the ship model, optimised speed profile and weather forecasts. In addition, the auxiliary power demand can be predicted based on ambient conditions, time of day, etc. By using the predictions of the forthcoming power demand, power plant operation can be planned in advance. This includes planning the charging and use of energy storage systems, figuring significantly in the operational efficiency in several operational situations.

The voyage plan and optimised operational plan for the power plant resources provide valuable information for the crew onboard when managing the daily operations. In addition, the optimised operation plan of the power plant can be fed to

the lower level optimisation that runs in a second scale with prediction horizon of some minutes. The closed-loop optimisation integrated to the Power Management System (PMS) utilises the results of the higher level optimisation and the actual measured status and power demand of the power plant as well as accurate short term predictions in order to operate the power producers, such as diesel generators in optimal asymmetric setpoints and to start and stop the correct generators.

### **ABB Ability™ OCTOPUS Predictive power plant optimisation**

The predictive power plant optimisation takes as input the predicted power demand over the whole voyage or voyage leg of the vessel, and minimises total fuel expenditure by determining the optimal load for each diesel generator for the duration of the voyage. The prediction horizon thus is expected to span tens of hours, and the sample time for optimisation is defined as one hour. The long-term optimisation utilises the model predictive control (MPC) paradigm to determine the optimal load distribution in the power plant over the voyage. In MPC, a process model is used to predict the plant state over a number of time samples (prediction horizon). An optimal control sequence for bringing the plant to a desired state is then determined for a shorter time span (optimisation horizon). This process is repeated at every sample time.

The prediction for the total power demand over the prediction horizon is delivered by OCTOPUS. Based on, or refined with operating data, various power demand models are included in OCTOPUS, which are able to deliver fairly accurate predictions. For example, the total propulsion power can be predicted based on the voyage plan, prevailing or forecasted weather conditions, and the time-variant vessel characteristics such as loading condition or the level of biofouling present on the hull. Similarly, the power demand of air conditioning on a cruise vessel can be predicted based on the number of passengers and the weather conditions.

OCTOPUS also monitors the specific fuel oil consumption (SFOC) of each diesel generator over the practical load range. Due to wear of the diesel engine, the resulting maintenance actions, and variations in fuel type or quality, the SFOC curve

can vary considerably over time. The impact on the optimal load distribution in the power plant is significant. Naturally in the absence of SFOC, monitoring the SFOC curve specified by the diesel engine manufacturer may be used as input to the power plant optimisation, but this should not be the default case.

The fuel consumption of the power plant is modelled as a nonlinear function of the diesel generator loads and online statuses. The optimisation takes into account the monitored SFOC curves of each diesel generator (DG), as well as any user defined constraints. Such constraints may be limits on the load of individual DGs, a requirement that some DGs are assigned equal load, or the exclusion of one or more DGs from optimisation altogether. In the last case, the power produced by the DGs excluded from optimisation is taken account as a feedforward variable when determining the optimal load for the other power producers.

The outputs from the optimisation are the loads of each diesel generator over the whole optimisation horizon, as well as the online statuses of the DGs. There are costs defined for manipulating these variables, which the optimisation takes into account. In particular, a suitably high cost may be assigned for switching a diesel generator on or off during the optimisation horizon. Frequent switching of the online status of a DG can thus be avoided.

### Closing the loop with intelligent Power Management System

Power Management System (PMS) provides functions to remotely control power generation, and system topology. PMS also handles the state monitoring, and collecting information from vari-

ous control locations. An illustration of the ABB Marine PMS user interface is shown in Figure 3.

In order to operate the power plant optimally, the PMS has been modified to provide an additional interface for closing the loop from analytics to optimal control. The PMS takes care of standardising the interface between power management and an optimiser layer, so that the interface to the power plant hardware can be modified according to the actual specification and the optimiser interface can be left without modifications.

The interface between PMS and optimiser is simplified in order to provide required feedback and command signals for the optimiser, but so that PMS still retains overall responsibility over the power plant control, and can take over the control from optimiser if needed. This is important to make sure that the operational hierarchy and safety is ensured.

The closed-loop power plant optimiser running on top of PMS is able to request available engines for control, and choose which generator to use as a swing engine, to account for load shifts. Controls per engine are limited to starting, stopping, and a reference for desired working point. The power management system then provides, per engine, the signals for indicating the availability for optimising, current working point, maximum capability, and a running indication.

The optimiser utilises adaptive SFOC curves equally as in the OCTOPUS Predictive Power Plant Optimiser. The estimated SFOC will be used for sharing the load between the currently operating diesel generators to minimise actual fuel consumption. The minimisation is carried out using optimisation employing a short time prediction of the required power. The prediction horizon covers the start-up time for a diesel generator. The optimiser also has the ability to start a new diesel generator when needed and to stop a diesel generator when beneficial. With this function, the least fuel consuming combination of diesel generators will always be used. It is important to note that this solution may suggest a non-equal sharing of the load between the different diesel generators. The closed-loop power plant optimiser function runs in System 800xA as native code and is therefore fully integrated to the PMS.

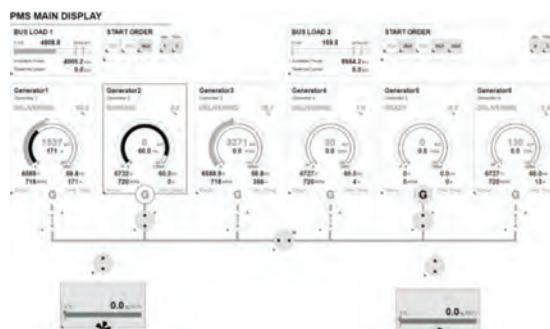


Figure 3: A user interface of the ABB Marine PMS

# Digital and intelligent Semi-submersible Heavy Transport Vessel

As the major ocean transport tool of large intact cargo, the semi-submersible heavy transport vessel (SSHTV) has become more and more valued with the rapid advance of ocean engineering, polar exploration and global trade.

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Simultaneously, higher safety, reliability, efficiency and performance requirements for SSHTV are needed in order to guarantee owner and operator profit. The Digital SSHTV concept presented here is based on development and maturity of intelligent sensor technology, information technology, data technology and IoT technology, all aimed at satisfying these demanding requirements. The concept combines onboard equipment and energy management, vessel and fleet operation, and onshore planning and service based on a uniform platform. It embodies efficient the integration of people, things and service, in keeping with current development trends. It also supports China Classification Society's rules for intelligent ships, effective March 1st 2016.

## Preface

Semi-submersible heavy transport vessels (SSHTV) are specialised in the transportation of large-size cargo, which is overlong, overweight and intact.

Compared to other large cargo transport tools, SSHTV has advantages such as high transport speed, long duration sailing, loading/unloading by roll-on/roll-off, and supporting semi-submersion, dynamic positioning and double-vessel combination operation.

Due to such operational features as:

- Large hull size and power requirement
- Multiple working requirement
- Preferred unlimited navigation area
- Difficult and dangerous working process
- Heavy, big and expensive cargo

SSHTV owners and operators have some key concerns, such as:

- Saving on fuel, manual labour and maintenance costs
- Environment friendly, e.g. lower emissions, low noise, etc.
- Good performance on sailing, manoeuvrability and positioning
- Flexible and friendly operation to adapt to schedules and multiple working requirements
- Safe, reliable, long life and comfortable
- Information timely accessibility to both ashore and aboard
- Continual improvement of operation performance and working efficiency

ABB Marine is the largest and most experienced power and electric propulsion system supplier in the SSHTV global market. ABB Marine China has gained around a 65 per cent global market share of SSHTV since 2008. As an important component of ABB Ability, which represents ABB's complete portfolio of digital solutions, the digital SSHTV



Dockwise Vanguard

(D-SSHTV) is ABB Marine China's new solution, based on ABB's IoTSP (Internet of Things, Services, and People) proposition, to satisfy owner and operator requirements, and also to maintain the lead in SSHTV application and advancement.

#### D-SSHTV

##### Definition of the digital ship

In concept of the digital SSHTV, the digital ship is defined as to the use of sensors, communication, the Internet of Things, edge computing, cloud

computing, and other technical means to automatically collect and process information on the ship itself, from the marine environment, and on logistics, ports and other marine data. Based on computer technology, automatic control technology and large data processing and analysis technology, the system is able to realise intelligent operation in ship navigation, management, maintenance, cargo transport and other aspects, making the ship more secure, more environmentally friendly, more economical and more reliable.

The concept has six aspects independent of concrete equipment and location:

- Autonomous information sensing and acquisition
- Autonomous data processing and storage
- Autonomous data mining, calculation, analysis, knowledge extraction and decision and advisory, based on real-time and historical data
- Autonomous control and management execution
- Autonomous self-diagnosis and improvement
- Autonomous interconnection, communication and cooperation

Application depth and degree of integration of the six aspects determine a vessel's level of intelligence.

#### **D-SSHTV goals**

To help customers enhance the value of both economy and society, based on market development, customer position, and working autonomously, cooperatively and flexibly to integrate multi-level information processing and communication, fleet, vessel, equipment, energy management, strategic and advisory information.

#### **Solution**

Intellectualised and digital objects of SSHTV can be divided into eight classes:

- Navigation
- Equipment
- Energy
- Motion & hull
- Cargo
- Communication
- Operation
- Service

Automatic cooperative work between all intelligent objects is the primary concept of smart SSHTV.

Each dimension of SSHTV intelligence is rooted in imitating interaction between human intelligence and objects. Comprehensive D-SSHTV will integrate onshore planning and analytics and on board autonomous control and management through a unified communication platform. This includes planning and management from owner and operator, advanced analytics and monitoring from ABB, automatic navigation, equipment and energy control, and status management from the vessel.

Increasingly, ABB offers many qualified products and solutions, with a uniform name of ABB Ability, satisfying the core requirements of complete intelligence, some of which have been deployed widely. ABB Ability™ Marine Advisory System – OCTOPUS, for example, has been installed and applied on more than 80 per cent of SSHTV globally, and has had success in helping vessels to transport large and costly cargoes to their destination safely, economically and quickly.

#### **Case Illustration**

ABB is a leader in marine power and propulsion equipment and solution supply. Therefore, intelligence in engine room machines plays a significant role in their D-SSHTV solution.

#### **Engine/machine room**

After decades of continuous research, development, application and improvement, ABB offers a complete engine room solution portfolio. Some advanced solutions significantly enhance SSHTV digital implementation.

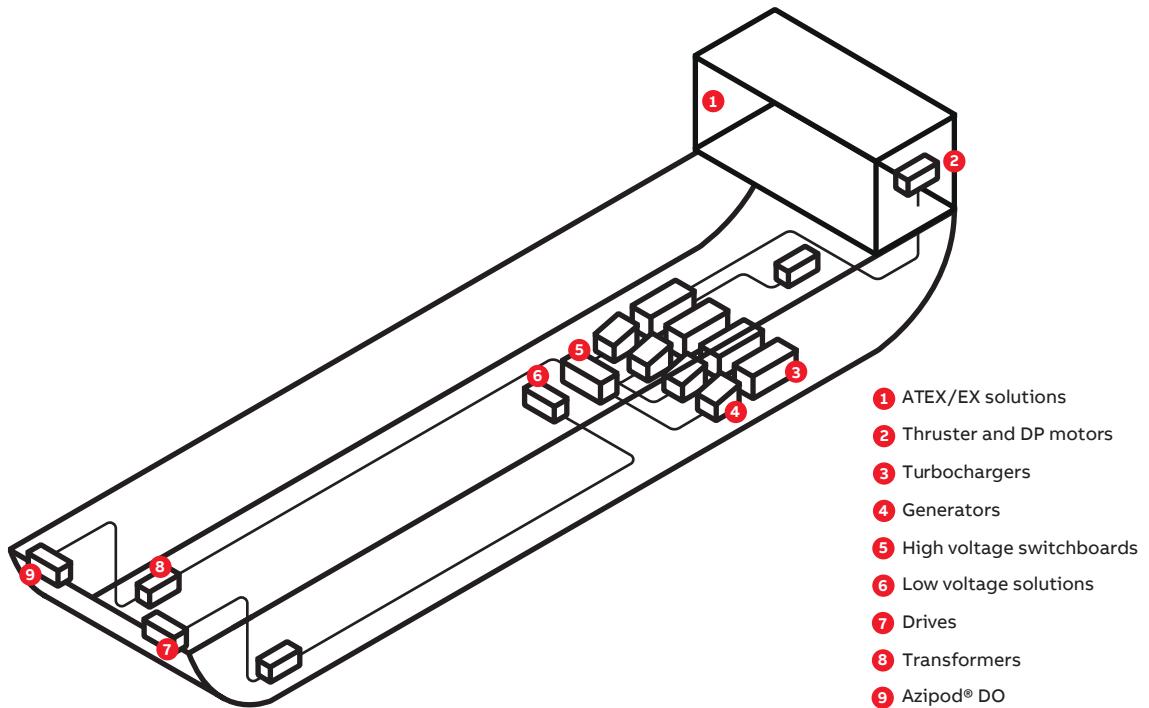
Working from forecasts on the intelligence megatrend, ABB began several years ago to focus on increasing the intelligence of the main engine room equipment. Most ABB main equipment can be merged into digital and intelligent solutions, as both functionality and data are sourced through integrated monitoring sensors and communication.

For example, compared with a traditional switchboard, the digital switchboard (D-Switchboard), in addition to fulfilling normal power distribution function, is able to acquire, collect, display and send multi-dimension data by installing additional real time sensors and function units inside the switchboard. Depending on these input data, RDS can also conduct health condition assessments to implement status monitoring, fault diagnoses and health assessment and prognostics to the switchboard.

#### **Digital Engine room operation analysis**

In SSHTV shipping operations, after loading, the vessel management centre (VMC) will break down the shipping plan, and according to a self-correcting schedule, route and optimisation targets, allocate tasks to all engine room equipment controllers. Autonomous propulsion controllers will

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SSHTV 3D view



follow the command and requirement to operate propulsion equipment to provide sufficient push force and side force, so that the vessel may safely sail to its destination with optimal course, speed and fuel consumption, within the specified time.

Meanwhile power and energy controllers will follow the command and requirements to optimally configure supply and effectively control generation equipment in order to guarantee energy supply.

Throughout the entire shipping process, various intelligent sensors covering electric status, temperature, vibration, stress, voice, light, etc., both integrated in equipment and independently installed, will continuously monitor the status of main engine room machines. The real time monitoring data will be sent to the Remote Diagnostics Centre, RDS, using certain rules to support fault forecast and diagnosis, status analysis and assessment, settlement advisory and the Conditioned Based Maintenance, or CBM plan. Looking closer at CBM, if a potential generator bearing fault fails to activate a traditional fault response, but is detected by RDS because the bearing's temperature and vibration are beyond

normal range, RDS will present possible causes and come up with a handling solution based on the status level, such as communicating with Power Management System (PMS) to advise a generator changeover and preventive maintenance to the faulty generator. Fault escalation and performance decline can be avoided, and effects and maintenance costs can be minimised.

In the near future, ABB's maintenance robots and automatic spare parts warehouses might make engine room component auto-replacement a reality.

### Summary

Requirements for SSHTV continue to increase and diversify. D-SSHTV is a promising and growing concept to compliment owners' and operators' eagerness and ambition. It uses a friendly, efficient, developing and autonomous method to handle SSHTV issues, including safety, cost, efficiency, functionality, environmental care, availability and optimisation. Foreseeably, with progress in related technologies, product portfolio extension and the maturity of the intelligence environment, D-SSHTV will continue to grow in strength and scope.

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H389

## Ice going Multipurpose Vessel (MPV) Integrated Automation System

The H389 Ice going multipurpose (MPV) is a DYNPOS-3 vessel built at Keppel Singmarine shipyard in Singapore. This vessel is equipped with the ABB Medium Voltage Power and Propulsion System.

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ABB supplied the integrated automation system (IAS) and power management system based on the ABB Ability System 800xA. In order to comply with AUT1 notation, ABB also supplied the dead-man and extension alarm systems.

To comply with DYNPOS-3, ABB provided redundant star configuration of the integrated automation system. The IAS is equipped with redundant servers, PLCs, networks, communication interfaces and power supplies. The vessel is also equipped with remote redundancy functionality from the AC800M hardware. This functionality enables remote IOs to be connected to redundant PLCs located in different physical locations, so that the loss of one PLC due to failure, fire or flood has no effect on the RIO.

The ABB power management and integrated automation system is based on high performance HMI developed by ABB Marine. ABB high performance HMI provides:

- Fast access to key information
- Quick and easy navigation of the mimics without losing the overview
- Improved operator situational awareness and enhanced response
- Clear dynamic indications
- Harmonic and hierarchical layout
- Day, high contrast, and night colour palettes



The power management system and integrated automation system supplied by ABB is based on ABB MAPL (Marine Automaton Platform Library). The power management system (PMS) is the foundation of the vessel's combined power and control system, used for fast responses on critical actions. The PMS is integrated into the 6.6 kV switchboards. Installation of power management inside the switchboards is very advantageous as it reduces footprint and PMS commissioning time. Integrating the PMS with the switchboard with IEC61850 enabled relays reduces amount of cabling inside switchboard. IEC61850 enables fast communication between the switchboards and the PMS.

Some of functionality of the PMS provided on the vessel:

- Automatic load dependent start/stop
- Isochronous/droop load sharing
- Symmetric and asymmetric load sharing
- Automatic load shedding

- Mode selection
- Dynamic load reduction
- Heavy consumers

The integrated automaton system supplied by ABB provides seamless integration of process control and power control. Integrated automation is based on ABB's MAPL. It is used to efficiently manage control, monitoring and alarms of the entire ship's marine systems, including bilge, ballast, seawater and freshwater cooling systems, anti-heeling systems, main engines, propulsion systems, and more.

The IAS is also interfaced to many third-party systems like the main engines, emergency engines, fire detection system, anti-heeling system, bridge alarm monitoring system, ship emergency switchboards, fire door monitoring system, thrusters, remote control valve and tank gauging system, using various industrial protocols like Modbus RTU, Modbus TCP/IP and profibus.

The H389 Ice going multipurpose vessel



## SMARTER CONNECTIONS

# Towards environmental compliance with the next generation of onboard decision support

ABB's decision support software provides a common platform integrating ship data within a tool providing real-time decision support.

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By utilising a single interface, the technology supports ship officers and engineers in making proactive safety and efficiency decisions, resulting in immediate benefits. On shore, details about the impact of external factors, such as weather against the loading computer parameters and propulsion data, allow staff to assess the safety and full cost of future charters, as well as providing suitable route options and delivery dates. Historic voyage data can also contribute to raising efficiency across a whole fleet through intelligent analytics.

On the same platform users can access a range of information including data about vessel trim, bunker transfer, fuel consumption, power plant optimisation, electricity use, speed advice, propulsion power analysis and hull cleanliness.

**The ABB MRV option**

ABB's latest generation software tool is a full suite of advisory vessel management software that is currently installed on over 450 ships. It is the maritime industry's most extensive suite of onboard digital decision-making tools, using the data generated by sensors and other inputs to feed analysis and enhance planning, routing and the decision-making to optimise vessel performance. Inputs include external information, such as weather or cargo load parameters, whose impact can be combined with propulsion and other sys-

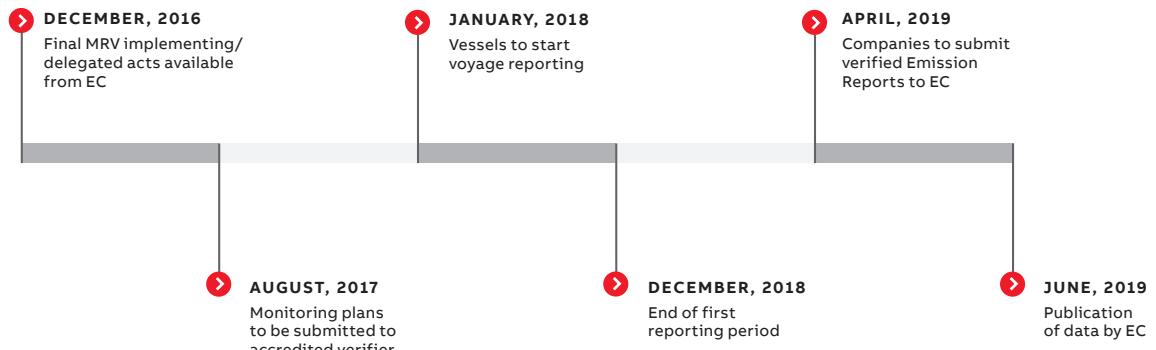
tems information to yield optimal advice.

By collecting data in real time, including variations in speed, draft, water depth, wind and waves, the complete package harmonises an unmatched range of datasets to support optimised decision-making for greatest net vessel efficiency.

By August 31<sup>st</sup>, 2017, shipowners must be approved by an accredited verifier as having plans in place to monitor and report their carbon emissions. From the European perspective, the MRV (Monitoring, Reporting and Verification) is the regulatory response to an industry whose current contribution to GHGs is not otherwise mediated through an Emissions Trading Scheme (ETS) or the so-called Effort Sharing Decision on CO2.

In April 2017, ABB received certification from EU-accredited verifier Verifavia covering its MRV module. This new software module within ABB's digital suite has been developed to help owners meet MRV requirements under EU regulation 2015/757. ABB's MRV software relieves shipowners of the burden of preparing fuel monitoring, reporting and verification plans, offering an integrated software solution that enables input of fleet wide 'per-voyage' fuel consumption and CO2 emissions collection. The system incorporates a tool to deliver an annual emission report, as required within the MRV regulation.

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MRV timeline



ABB's MRV technology has been structured as 'user-proof', with windows and prompts designed in a logical way to avoid reporting errors. It transforms the monitoring/reporting task into a straightforward data inputting procedure lasting minutes at the beginning of the voyage, with a similarly simple checking out routine at its conclusion.

#### **Open-ended system**

In 2017, shipping remains in a negative phase; analytics, and by extension management software, have been identified as keys tools in realising cost savings. Whether by obligation or not, a newly formalised or modernised fuel consumption monitoring and reporting procedure should be seen by owners as an opportunity to keep track of one of their key costs. Put another way, despite the looming MRV deadline, rather than feeling under pressure to choose off-the-shelf software quickly to comply, solutions should be considered for their ability to perform as a building block for greater ship efficiency.

ABB's MRV software is notable both for its standalone functionality that has been certified to ensure compliance, but also for its potential to be integrated into the wider vessel management software from ABB.

Every shipowner must meet the same conditions to comply with MRV, but it is also fair to point out that each will set out from a different starting point. ABB's digital application is completely scalable, meaning that owners can make an initial installation to cover fuel monitoring without compromising potential to add modules that cover other functionality.

Selecting ABB's MRV application means that a company is immediately compliant. Furthermore, with no obligation, the customer's path to a full vessel management package that can optimise trim, bunker transfer, fuel consumption, power plant, electricity use, routing and speed advice, propulsion power analysis, and hull cleanliness remains open.

ABB suggests that, in being tailored to individual vessels and taking account of conditions such as the wind, currents and swell and their effects on a ship's behavior, one 'good' routing decision taken using ABB's digital application could pay for itself in fuel savings.

#### **Other outputs**

Crucially, users can select the scale they want, based on different parts of the full functionality palette. Looking beyond the MRV software for example, Torvald Klaveness recently installed a SEEMP-compliant digital management solution to measure and display fuel consumption and torque. These Key Performance Indicators are shown in real time to the operating crew and are available for analysis onshore using ABB's fleet portal. In addition, the fleet management tool uses historical data to create benchmarks for future performance, working in combination with a new Torvald Klaveness special operations center using ABB's digital application to monitor ship performance.

Looked at more generically, ABB's Energy Management System is a decision-support tool to minimise the overall energy costs for individual vessels and whole fleets. It compares and analyzes historical and operational data, then

calculates and advises on improvements using easy-to-understand displays.

Ultimately, ABB's digital application can combine wave measurements, weather forecasts, and navigation data like speed, course, RPM and the voyage plan, with ship characteristics, loading conditions, and motion sensor measurements. This facilitates continuous monitoring as well as forecasting of the ship responses and performance. As a result, the system makes the main tasks of the officer on watch easier, supporting safe and economic navigation, damage avoidance and route planning. ABB's digital application also acts as a hub for vessel data that can improve efficiency across a whole fleet.

#### **Software outreach**

Overall, ABB's experience is that when an owner makes an initial commitment to its digital application for specific reasons, far-reaching adoption of the software follows. When that happens, owners reap the full benefits, as their ships skirt adverse conditions and arrive on-time at optimum cost, with their cargoes delivered safely and in good condition.

In fact, the modular nature of the software suite has proved to be one of its most compelling appeals.

Part of the suite is a state-of-the-art modular ship motion monitoring and decision support system, with around 80-90% of the heavylift ships in the world now including ABB's maritime software onboard. The software responds to the hydrodynamic properties of the vessel, its loading parameters and the ship's onboard weather forecasting to create a polar chart that maps the safest and most efficient voyage route, allowing ship's officers to update course or speed decisions continuously during the passage.

When shipowners choose ABB's digital application, they can also choose the modules most relevant to their operations. For example, an owner of an LNG carrier would plan routes to avoid in-tank sloshing, basing its decisions on the limits set by motion measurements and LNG storage tank sloshing modelling provided by cryogenic specialist Gaztransport & Technigaz (GTT).

Similarly, the system functionality designed to optimise trim is of particular use in ferry operations, while a cruise ship owner might want to monitor vessel motions using the parameters that best ensure passenger comfort.

Meanwhile, an offshore vessel owner might want to make precise predictions for dynamic positioning, with vessel motion parameters set to make the most of a safe time-window for weather-sensitive operations, in this case based on data drawn from thrusters plus the environmental and weather forecasting conditions that are integral to ABB's digital application.

Initial interest from Maersk, meanwhile, focused on the use of ABB's digital application as a support tool to avoid the type of weather that risked containers falling off ships. Today, 140 Maersk containerships use motion-monitoring, forecasting and decision-support software with SPOS Seakeeping plug-ins from weather forecasting specialist MeteoGroup to optimise routing.

#### **A holistic approach to optimisation of ship operations**

ABB believes that the MRV option offers a gateway, through which an off-the-shelf compliance tool with ABB's fleet portal reporting can be the first step towards optimised vessel efficiency.

As one of the most active technology companies supporting sensor-based ship and marine equipment management, ABB sees advisory software as vital in the industry's journey towards remote diagnostics, maintenance planning and performance monitoring. The complete suite provides seamless exchange of data, full integration of sensors, automation, ship software and cloud solutions, demonstrating ABB's philosophy of 'bridge to propeller' thinking. It also sees shipping's future as lying in greater connectivity and more automated processes supported by shore-based engineering and maintenance staff able to respond to data gathered from vessels and optimise fleet efficiency. But ABB never forgets that owners need to see these efficiencies at the level of the single vessel, as well as fleet-wide. Maritime software is a critical component in ABB's strategy to combine platforms into a single interface, leverage the Internet of Things, Services

and People (IoTSP), and support the real-time decision-making by engineers and ships officers that enable safer and more efficient ships. For owners, bringing external factors such as weather into the decision-making process that considers vessel loading computer parameters and propulsion data allows shore staff to assess the safety and full cost of future charters, as well routing options and delivery dates. Historic voyage data can also feed the analytics software that raises efficiency across a whole fleet, or at the individual ship level.

Increasingly, better connectivity between ship and shore means that monitoring and maintenance, and even operational decision-making can be coordinated in real-time. ABB has invested heavily in shoreside expertise, analytics firepower and engineering availability to provide 24/7 support from Remote Operations Centers that support troubleshooting, maintenance planning, benchmarking, and interventions based on predictive diagnostics.

At group level, ABB frames its solutions to digitalise the maritime industry within ABB Ability™,

supporting fleet-wide intelligence gathering to reduce costs and an owner's environmental footprint. As a technology developer, ABB is also continuously improving its offer, as witnessed by the newly-launched Torductor torque measurement system, which uses contactless sensors facing the propeller shaft to send information to the digital onboard application.

But the group also never forgets that the journey towards all of these things can start with a single ship. Tallink Megastar, for example, is one of the most advanced ferries in the world, operating on the Helsinki – Tallinn route. The 212.2 m long ship carries about 2,800 passengers and is the shipping company's first ship operating on liquefied natural gas (LNG).

ABB has supplied the power production, electric propulsion and energy management system on board, and offers support to the vessel from its Helsinki Remote Operations center. Tallink Megastar also benefits from vessel management software from ABB, which is being used to monitor the use of energy in the entire ship in real time, focusing specifically on fuel consumption.



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**UNIQUE ABILITY**

# ABB Ability™ System 800xA

ABB's Ability™ System 800xA integrates all onboard systems into one platform, empowering both crews and land-based organisations to operate vessels and fleets with enhanced intelligence, safety, efficiency and effectiveness.

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ABB Ability™ platform, developed in conjunction with Microsoft and launched in 2017, enables customers to securely integrate and aggregate data, applying big data and predictive analytics, and generating insights to help drive performance and productivity improvements. It builds on the company's deep domain expertise with network connectivity and the latest digital technologies and innovations to unite all digital solutions – solving real business problems, while creating tangible business opportunities. Within this portfolio sits the market leading ABB Ability™ System 800xA.

## The system

ABB Ability™ System 800xA is an extended automation system capable of sensing, analysing and enabling users to drive greater efficiency. It gives vessel crews access to a fully integrated ship where all systems and equipment work seamlessly together. A single-screen user interface delivers easy and intuitive access to all the information needed to operate vessels more effectively and safely.

All automation modules are united with a similar look and feel, providing completely integrated automated control from the bridge right through to the propeller. The versatility and scalability of System 800xA for vessel management, propulsion control, power distribution management and cargo control make it possible to meet the unique needs of individual ship types.

## Fleet benefits

Fleet managers have to deal with similar issues across many individual ships, which can make it challenging to see the bigger picture. However, if all the vessels can be connected, with intelligence from each ship delivering value for all, fleet wide efficiency, environmental performance, fuel costs, safety and effectiveness can be optimised. Ability™ System 800xA enables this, uniting not just systems but also ship- and crew-based teams, so each can benefit from the other's expertise.

ABB Ability™ solutions collect data from each ship's propulsion systems in real time, including variations in speed, draft, water depth, wind and waves. Then through the Industrial Internet of Things it analyses the data, drawing on ABB's expert knowledge of the marine industry, to provide recommendations that can be applied throughout the fleet.

Results can be jointly viewed and implemented quickly by the company, with information applied in real time, as opposed to traditional post-voyage analysis. Fleet managers can access data about fuel consumption, speed advice, propulsion power analysis and hull cleanliness, while recommendations can be made for current and future journeys. It is a unique fleet management, control and optimisation platform.

### Unlocking potential

From immediate, real-time control to long-term optimal lifecycle management, Ability™ System 800xA provides the platform both crews and on-shore teams need to make the best decisions for their operations and businesses.

Enhanced energy efficiency is enabled through closely integrated systems and data capture and sharing. Simulation allows for optimised system design from the outset, while integration with advisory systems delivers optimal voyage execution and reporting processes.

Energy can be saved through intelligent loading of the power plant, while reduced cabling, thanks to fieldbus solutions, leads to the highest possible redundancy.

The uniform look and feel of all systems leads to a more intuitive user experience.

Project execution is also transformed with a common project management platform for power and control systems, less communication points and interfaces, faster commissioning time due to pre-testing, and complete control of documentation and interfaces. Integration of power systems can be handled by ABB in-house.

Ability™ System 800xA unlocks enhanced life cycle management through asset monitoring and modernisations, optimised maintenance and common spare parts, and ABB's established global marine service network, with a single service contact for all customers.

### Integrating the industry

Together with the rest of ABB's Digital Solutions portfolio, Ability™ System 800xA forms a key part of what is the most comprehensive solution available within the maritime industry. The complete ABB suite provides seamless exchange of data, full integration of sensors, automation, ship software and cloud solutions.

The total offering consists of several important elements, providing decision support software for safety and comfort and energy efficient operations, and remote diagnostics technology that preventatively and continuously monitors critical equipment on board a ship.

The overall solution helps to optimise day-to-day shipping industry operations, whether it is increasing the efficiency, safety or workability of a ship, or helping shipowners to comply with increasing demands from environmental regulations, including the IMO Ship Energy Efficiency Management Plan (SEEMP) and future European Union Monitoring, Reporting and Verification (MRV) rules.

ABB's AbilityTM platform is supported by Collaborative Operation Centers that enable next generation vessel and customer onshore operations. They deliver advanced analytics, portals, and value from digital twin technology, driving forwards the digitalisation of ship operations.

### On board:

The system provides a comprehensive range of automation modules to simplify and enhance vessel operations. These encompass the following areas:

#### Power Management:

- Diesel Generator Monitoring System
- Power Management System
- Power & Energy Management System

#### Vessel Management:

- Alarm, Monitoring & Control
- Propulsion Control
- Remote Control System
- Intelligent Manoeuvring Interface

#### Process Control:

- LNG Cargo & Gas Management System
- Cargo Control System
- HVAC Control
- Drilling Drives Control System
- Propulsion/Thruster Drives Control System

#### Safety Systems:

- Fire & Gas System
- Emergency Shut Down System

#### Dynamic Positioning:

- DP integration

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## ELECTRICAL AND AUTOMATION SYSTEMS TESTBED

# Integrated Marine Systems Lab

Traditionally, electrical and automation systems on board a ship are designed and verified separately by different vendors for independent and reliable operation.

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The systems are then connected together to operate as a single system on board a ship. This usually leads to a situation where these products or subsystems perform well independently, but when evaluated as a single complete system (with many interfaces between subsystems), the overall performance leaves room for a fair amount of improvement. Often, the first opportunity to fully test and evaluate a complete system is only after installation and commissioning on board a ship, during harbour trials and ultimately during sea trials. Should failures or quality issues occur during these late phases of ship building, they can have serious consequences and interruptions to prescheduled processes of ship builders. In the worst cases, this can result in significant delays in deliveries, thus causing major monetary losses to the ship builders.

To improve this traditional way of engineering automation systems on board a ship, ABB has previously opened a new high technology facility called the Integrated Marine Systems (IMS) laboratory. A part of this laboratory is shown in Figure 1, where an ABB remote control system (RCS), Vessel simulator, Remote Control Unit (RCU) and Azipod® Interface Unit (AIU) cabinets can be seen. In its entirety, the lab contains the key components of ABB's marine technologies including automation, RCS, propulsion, integrated operations

and waste heat recovery systems. The laboratory is designed to efficiently meet the needs of the customer and enables close working between ABB and customers already in the earlier phases of system design.

To go one step further and include the transient and dynamic characteristics of the electrical power systems into the IMS test environment, ABB has now expanded the laboratory with low level power electronics controllers and protection devices (i.e. protection relays) together with real-time simulation devices. In this new setup, all electrical and automation subsystems of a ship are integrated into a complete system that exists in a controlled environment in an ABB laboratory. Such an environment allows testing of full systems even more effectively, and ensures that the delivery processes, quality of the deliveries, and safety of the system are maximised.

This article describes how ABB's integrated system testing methods can improve the overall system efficiency and quality of ABB Marine solutions. The IMS electrical system platform is further described and its benefits are shown. Also, a short introduction to real-time hardware in the loop simulation technique, which is used in the IMS electrical system platform, will be given.



Figure 1: A section of the Integrated Marine Systems Laboratory. The lab consists of the pillars of ABB's marine technologies including automation, remote control systems, propulsion, integrated operations and waste heat recovery systems.

### Benefits of full system testing with IMS Testbed

Rapidly evolving technologies and increasing amount of intelligence on ships demand new methods to effectively verify the operation of complete systems. Testing of complete marine electrical and automation systems is often very expensive due to their size and complexity, and therefore the possibility to do so before the actual commissioning is extremely limited. This often leads to a situation where the interfaces between different subsystems are properly tested for the first time only after the equipment is already installed on board vessels. Therefore, it is often the case that bugs and incompatibilities are discovered at this point, leaving little time for trouble shooting without causing serious damages to other processes related to delivery. Since the IMS test laboratory already contains the same

critical equipment and connections as in the actual vessel, long before delivery on board, testing and improving of these systems is possible with little effect on other delivery processes. This ensures the optimum quality of ABB deliveries and that the installed systems are safe and fully operational.

By having all critical interfaces of the low level protection and control devices connected to the upper level power management system (PMS) and the propulsion control unit (PCU) in a laboratory, the complete system can be fully tested and evaluated together with the customer already during the earlier sales and engineering phases. This enables the customer to better take part in the system design, further reducing the learning curves of both the customer and ABB. By work-

ing together with the customer on the IMS test platform, ABB and the customer can together iteratively identify customer needs and the optimum solutions that exceed requirements for these needs. This way, with ABB's help, the customer can truly understand the problems at hand, and with the customer's help, ABB can provide the best solutions.

In addition to testing delivery projects, the IMS test platform will be consistently used for developing new technologies. Novel technologies, e.g. variable speed engine operation, energy storage and fuel cells on board an all electric ship are both developed and fully verified on the test platform, which further increases quality by enabling more standardised product interfaces. This makes ship building processes even faster than before and shortens the time-to-market of both ABB products and customer's final system.

#### **Real-Time Hardware in the Loop simulation in IMS Platform**

The IMS electrical system test platform is a test-bed based on Hardware-in-loop (HIL) simulation technology. HIL simulation is a real-time simula-

tion technique which can be used to develop and test complex power systems. In this technique, a real-time HIL simulator is used to build a virtual model of the power state in which real power electronic controllers and electronic protection devices can be connected for interaction. The virtual power state consists of power producing and consuming components (e.g. engines, generators, motors, converters, etc.) since the electrical and mechanical dynamics of these components can be fairly accurately modelled. On the other hand, the real equipment connected to the simulator are logic-containing controllers (e.g. protective relays and power electronic controllers). Analysing both hardware and software aspects in different situations (e.g. grid faults) is highly interesting for optimal system development regarding performance, reliability, safety and efficiency. This equipment is connected to the simulator through hardwired I/O and fieldbus communication (e.g. Modbus TCP or IEC61850 GOOSE and MMS) as they would be in a real system on board a ship. Together, the simulator and the real equipment form a simulation loop that can be used to test the operation of a complex system in both normal and fault situations.

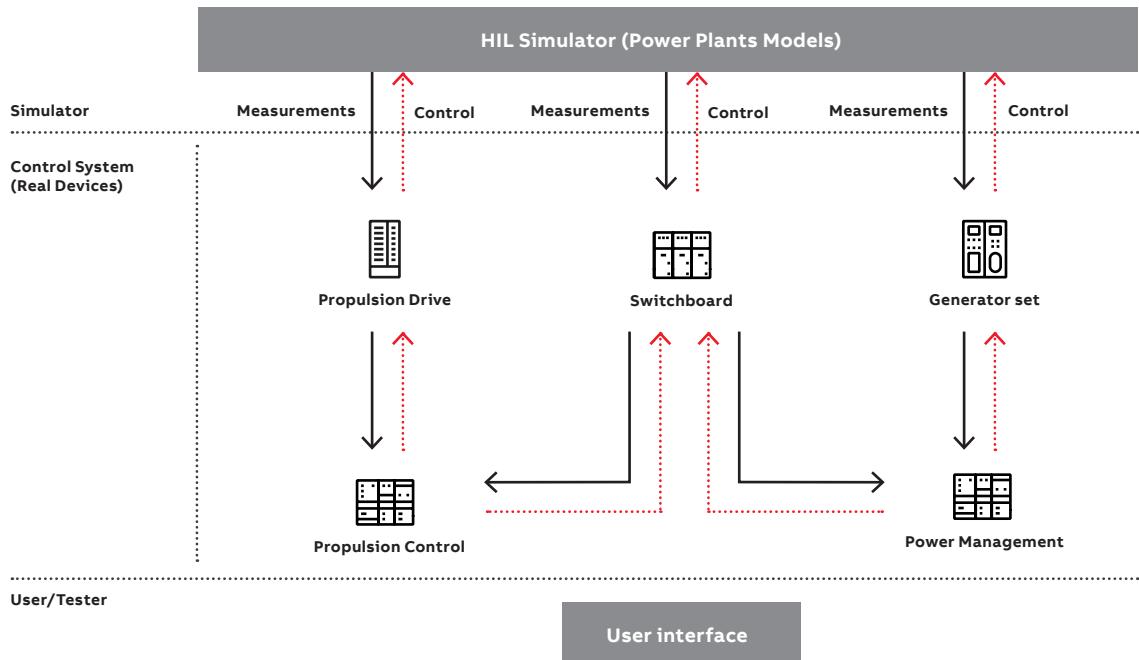


Figure 2: Hardware-in-loop testing illustration with ABB equipment as used in conventional AC Grid solutions

The data obtained from the test platform is regularly compared to that obtained from real ships. This makes it possible to ensure that the results obtained from the test platform are valid and comparable to the ones obtained from the systems on board a ship. This provides ABB and their customers an efficient and valuable testing environment from which they can have access to the hardware features that would not otherwise be available in a completely software based simulation model.

### **IMS Electrical Systems Test Platform**

The IMS electrical systems testbed contains all critical components of ABB Marine power plant deliveries. The objective of the testbed is to provide the means to test and verify all control and protection functions of different intelligent devices in ABB Marine deliveries. Compared to conventional, purely simulation based testing methods, this testbed provides the user access to both software and hardware features of the system performance.

The laboratory contains equipment as required in both conventional AC system and Onboard DC Grid deliveries. The equipment consists of ABB's newest generation protection relays (Relion615, Relion620 and Relion630), AC800M control units, ACS880 control units, UNIREC control units, Unitrol1020 automatic voltage regulators and HIL simulation equipment. The general idea of HIL testing with ABB equipment, as used in AC systems, is illustrated in Figure 2. By combining this equipment in different configurations, different delivery systems can be tested.

A general configuration of an ABB Marine AC distribution system in IMS electrical system testbed is illustrated in Figure 2. In this configuration, starting from the top, is a real PMS which controls the virtual diesel engines in the simulation model. The PMS communicates with the main switchboard components (protective relays) using IEC61850 GOOSE protocol. Real Unitrol1020 AVRs are used to regulate the voltage of the virtual generators. The main switchboard is completely modelled using a combination of real and virtual relays. Up to seven real protective relays can be simultaneously connected to the test platform, enough to test most different system config-

urations. The addition of virtual relays is often interesting, e.g. in fault situations, to see how the rest of the system reacts to the fault. Continuing further, the testbed contains real ACS880 drive controllers that control the virtual frequency converters and propulsion motors. The real PCU gives references to the drive controllers. Both the PCU and the PMS are directly connected to the rest of the IMS lab equipment, e.g. RCS and automation, as they would be in a real ship.

To give a concrete example on how the testbed works, consider a situation where a critical fault happens on one side of the grid which forces the whole grid section out of operation. Once the protection relays detect the fault, they will attempt to isolate the fault by opening the surrounding breakers. Through IEC61850 GOOSE, they inform PMS and PCU to reduce both power production and consumption respectively. Once the affected grid section is de-energised, it will not go back to operation until the fault is cleared and the protection relays are informed of the clearance. Once this is done, the generators can be re-started and the previously faulty grid section can be synchronised and connected back to the rest of the healthy grid. The second propulsion motor can also be turned on again and the whole system is again fully operational. In this scenario, the functionality of the PMS, PCU, and protection are fully tested and validated using the same controller and communication protocol as in the real vessel, giving the customer higher degree of confidence in the system.

Using the same setup, the ABB team also has the opportunity to test a variety of scenarios and sea conditions, allowing verification of the seamless operation of ABB Marine systems long before building the real system on board a ship. Some of the test scenarios include grid faults and fault recovery sequences, testing of communication network performance and stability on high traffic, optimal tuning of grid components and designing and testing of novel technologies. By performing all these various tests in the earlier phases of system design, ABB can ensure the optimum quality of system deliveries by improving the reliability, safety and efficiency of the systems.

## DIGITAL PRODUCT PG

# ABB Ability™ Marine Remote Diagnostic System Release 5.2

Software and hardware technology upgrade, new functionality, simplified commissioning, scalable infrastructure for IT service centres.

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New RDS UI

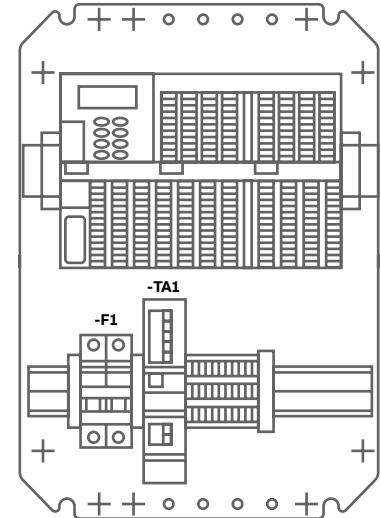
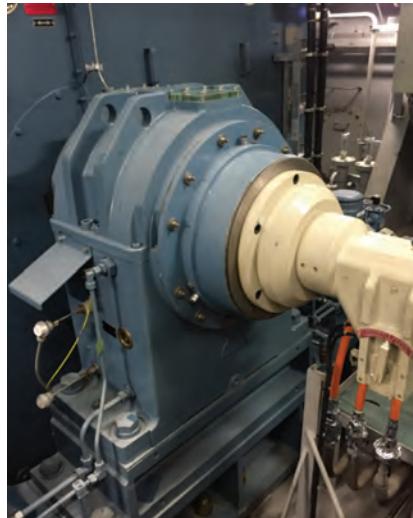
After fundamental improvements and changes in the back-end and server side functionality, in 2016 the RDS system has been subject to major modifications related to its presentation layer. In order to fulfill requirements of 'common ABB Marine Onboard User Interface' look and feel, a totally new design of the RDS main view was introduced. ABB Marine graphical designers worked closely with system users to create a visual design that will inherit the best functionalities from the previous RDS release and deploy them according to the new philosophy of user-machine interaction that is to be common for all types of onboard systems delivered from ABB (e.g. automation, voyage optimisation and diagnostics). The iterative process of discussions, specification and

incremental implementation allowed building the new RDS UI with focus on user satisfaction and ergonomics. On the technology side, communication between data server and presentation layer has been improved drastically by introducing fast and ultra-light messaging protocol. Graphical elements are based on world's best UI frameworks such as Telerik and SCICHART. Main features of new RDS User Interface are as follows:

- Consistent presentation of information from the level of equipment status and analytics results through detailed alarm and event description, to the level of time series trends and high frequency sampled signal transients and loggers
- Two different ways of aggregating information, e.g. by asset types (drives, motors, generators) and system types (e.g. portside drive train, power system, etc.)
- Status Panel with three levels of drill-down navigation allows user to quickly assess the condition of monitored equipment in real time
- Alarm Panel and Trend Panel with detailed alarm list and advanced plotting controls facilities fast fault tracing – a core feature for internal, ABB users of the system
- Embedded roles-based mechanism governs presentation of certain information only to privileged users
- No software engineering required to redesign the content of Status, Alarm and Trend panels



Condition monitoring



- Optimised for wide screen displays
- Information presented onboard in the Status Panel is replicated on the RDS section of ABB Fleet Portal to provide consistent notification to both offshore and onshore customer teams.
- The status panel is only visible onboard for customers with Service Level 3 – RDS Prediction

#### Condition monitoring of rotating equipment

The Diagnostics for Machine (D4Machines) package has been greatly improved with two main areas of development:

1. Introduction of a new data acquisition hardware solution for online condition monitoring of critical rotating machinery.
2. Piloting a new concept of Modular Tool – multi-sensor data acquisition tool for condition monitoring of LV rotating equipment

Ad (1) The online solution for condition monitoring of critical machinery received a new hardware platform for signals acquisition. Proven and widely tested in various industries and application, the ABB AC500 based, highly specialised data acquisition components have been chosen and integrated with the RDS system. With its pilot deployment onboard PGS Ramform Hyperion, the new concept proved to be fully operational. Similar to previous release of D4Machines concept, measurements from AC500 CMS system are triggered by RDS under precisely defined operating conditions to normalise the calculation results. Some of the raw readings

and end results are automatically sent to our Service Center databases to feed periodic reports. The main highlights of the new release are as follows:

- AC500 Condition Monitoring Package consisting of PM592 CPU and FM502 input module form new RDS data acquisition unit
- The system facilitates signals collection from up to 16 I/O channels acquired simultaneously with maximum 50 kHz sampling frequency
- Input channels re-configured ‘on-the-fly’ by RDS systems typically read signals from accelerometers (IEPE) and +/- 10V voltage signal out from current clamps and voltage probes
- Extendable with standard, 16-channel AI module for additional hard-wired input signals such as temperatures
- Installed inside the RDS marine cabinet forms a portfolio of four different options fitted for normal and extreme condition of installation, depending on the vibration level of the machine and the installation location of the cabinet

Ad (2) Year 2016 brought significant effort in further product development and market introduction of ModularTool – a cost effective hand-held solution for RDS condition monitoring of LV rotating equipment. Conceptualised and researched in previous years, the tool was successfully integrated with the RDS system in 2016. All analytics provided with the tool are deployed in the onboard RDS system and launched automatically each time it is connected to RDS PC.

Acoustic, vibration, magnetic and tachometer recordings acquired by the tool are processed with the number of specialised algorithms to give high level indication about the condition of the motor bearings, rotor and mechanical installation. Pilot installation of prototype device was done in January 2017 onboard the PGS Ramform Hyperion and received very good feedback from end customer.

#### RDS Cyber security enhancements

- Fully compliant with ABB cyber security requirements
- Encrypted traffic from ship to shore using ABB's technology Remote Access Platform (RAP)
- DSAC and hardening for onboard RDS infrastructure
- Firewalled from ship network - the vessel's network is secured from outside (Internet) by a firewall which is by default configured only to allow for traffic required for ABB Remote Access Platform and set up to pass only dedicated predefined data connections and block all other traffic

#### Enhanced portfolio of monitored assets and analytics

- Connector to ACS880 drives
- Turbochargers monitoring and analytics
- Infrared temperature monitoring and diagnostics for MV power systems
- Integration with ABB 800xA and Asset Optimiser
- Prediction algorithms for MV drive water cooling system

#### Improved IT serviceability

For internal users and RDS IT maintenance teams in particular. RDS version 5.2 comes with new

functionalities that simplify and accelerate the process of RDS software upgrade and reconfiguration. With several years of experience on remote troubleshooting and maintenance of RDS, what proved to be particularly troublesome for our IT team were 2 types of operations:

1. Update of software typically requiring transfer of the entire RDS installer, reaching more than 100MB in size
2. Reconfiguration of RDS using configuration screens

Both above activities, perhaps trivial tasks when working on a local desktop computer, become a challenge if the remote connection to onboard RDS stations is using a very weak satellite connection with very limited broadband capacity. In those cases, a single click of mouse to change the configuration may take dozens of seconds and the transfer of installation files, if possible at all, may take several days.

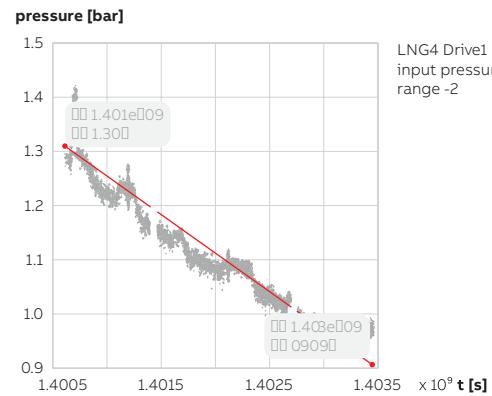
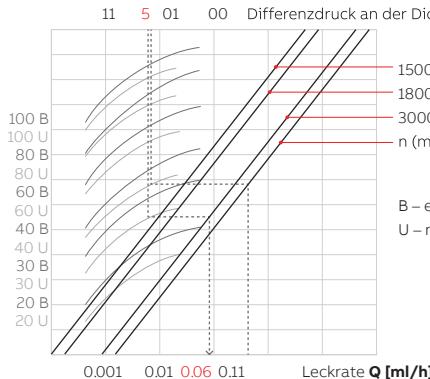
The first problem was solved by changing the release and build philosophy of RDS. From version 5.2, each and every maintenance or production release of the software comes with the pair of full .msi installer .msp patch files. As a result, in order to upgrade the software version between minor versions, transfer of a maximum 2MB file onto the site is needed, or 50 times less than previously required.

#### New diagnostics functionalities in RDS 5.2

Continuous innovation on existing solutions and newer products delivered to customers requires RDS to constantly adapt to market needs and

<b>TunnelThruster01_Inverter:MarineACS800 'InverterTemperatureStatus' Condition Details</b>	
Condition Details	Asset Monitor Status
<b>Condition: InverterTemperatureStatus</b>	
<b>Condition: SubCondition:</b>	⚠ [good] <b>InverterTemperatureStatus:</b> Warning
<b>TimeStamp:</b>	Wednesday, June 21, 2017 15:32:42
<b>Severity:</b>	450
<b>Description:</b>	IGBT overtemperature
<b>Possible Cause:</b>	Drive IGBT temperature is excessive
<b>Suggested Action:</b>	Check ambient conditions. Check air flow and fan operation. Check heatsink fins for dust pick-up. Check motor power against unit power.
<b>Corrective Action Taken:</b>	

Left: Natural leakage mapping  
Right: Pump input pressure drop



provide state-of-the-art monitoring solutions that match equipment installed onboard the most sophisticated vessels. Additional drives have been incorporated into the already existing D4Propulsion diagnostics package, including ACS1000, ACS800, ACS880 and DCS800 used in DC grid projects. In order to provide better condition monitoring of circuit breakers and contactors, a new client library based on IEC61850 MMS protocol is being developed to interface RELION protection relays installed in MV switchboards, which will significantly increase the volume of signals being recorded, and will enable further advanced analytics. For example, monitoring the total number of opening/closing cycles, load of operations, short circuits and faults, etc., will help to determine the life expectancy of a circuit breaker.

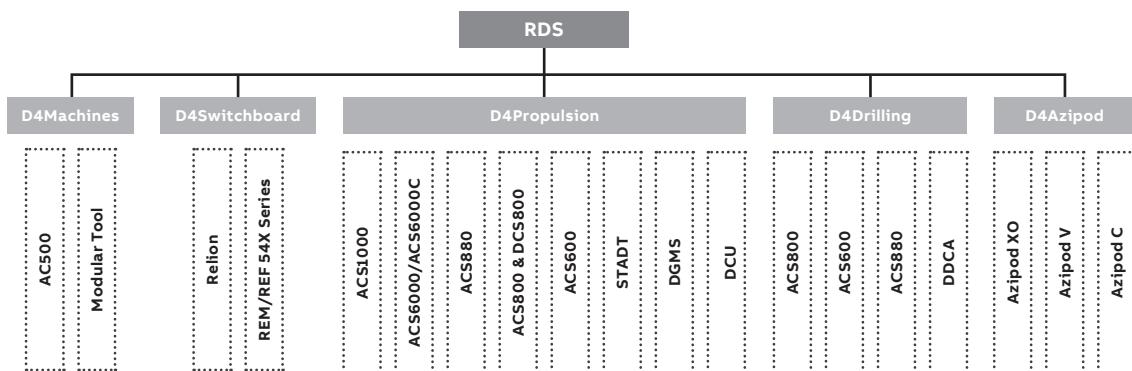
Thanks to the modular approach of standardised modules connected to different equipment, RDS is able to expand its diagnostics portfolio

and regularly adapt to brand-new equipment. With currently >45 different diagnostics solutions installed in about 600 automation PCs, ABB is able to remotely monitor approximately 100 vessels with service contracts.

#### Hardware and platform upgrade

The increasing amount of assets being monitored, and higher-end diagnostics solutions with onboard edge analytics, require more resources from the automation PCs and panel PCs running RDS software. Within 2017, all computers will be delivered with an increased 8GB RAM memory (previously 4GB RAM) with 64-bit Windows 10 operating system. These upgrades not only contribute for better performance and user experience, but also extend the serviceability of the equipment and eliminate hardware constraints that could limit future software development activities.

RDS modular concept of diagnostic solutions



# Onboard DC Grid – a system platform at the heart of Shipping 4.0

In March 2013, ABB delivered our first Onboard DC Grid system on the MPSV Dina Star, making Myklebusthaug Management the first in the world with an IMO vessel powered by a modern primary DC power system.

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The main focus at the time was variable speed generators, space savings and dynamic performance. Much has happened since; the role of DC in the marine industry is maturing and it is clear that Shipping 4.0 – electric, digital, and connected – spells a bright future for DC-based electric propulsion.

The world is changing and the shipping industry with it. For some, this new reality has already made its presence known, for others it is looming on the horizon. Regardless, the future holds a new mix of low- to zero-carbon energy sources and a new level of digitalisation.

## What is special about DC?

A DC-based power system enables simple, flexible and functional integration of energy sources such as variable speed gensets and shaft generators, batteries and fuel cells.

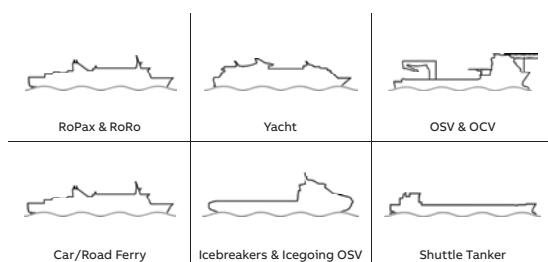
Also, a DC and power-electronics based power system provides a unique platform for digital

solutions onboard a vessel. Equipped with sensors and communication infrastructure, data is transmitted between systems in an instance. This gives access to information that enable the bridge to monitor and optimise their performance. And, better connectivity between ship and shore mean that performance management is taken to the next level.

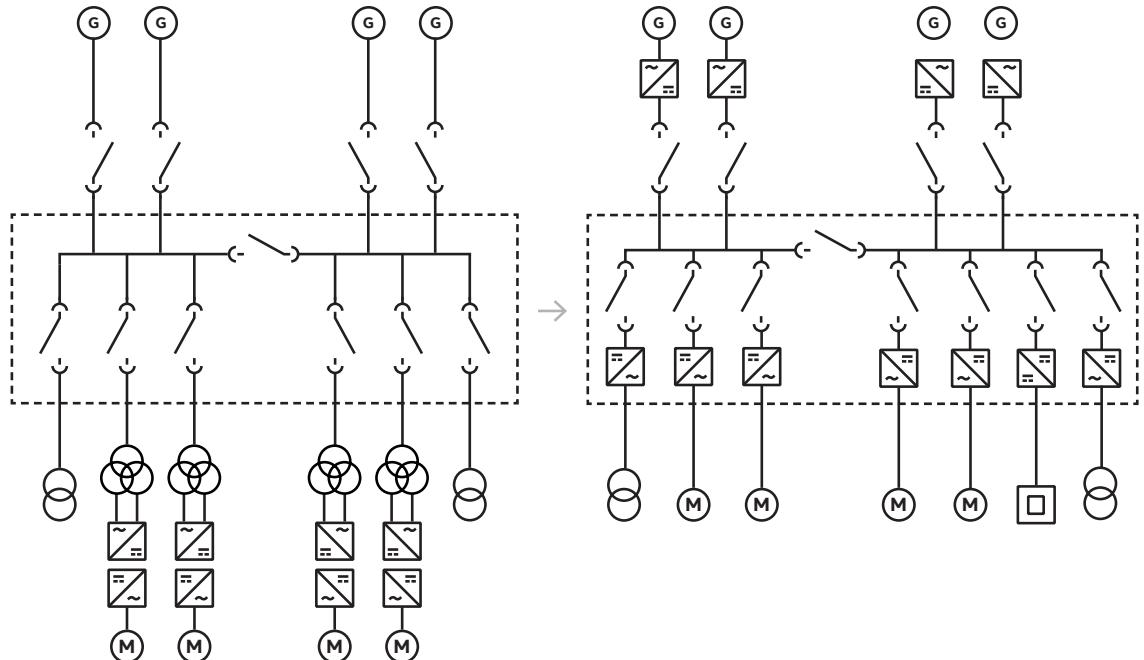
Onboard DC Grid is gaining traction in a wide range of vessel types, and the reason for this varies. Ferries choose it because it is the most cost efficient and functional platform for integrating energy storage, making hybrid and fully electric operation a reality. This is true even to the extent that the two retrofit ferry projects Aurora and Tycho Brahe chose to update their AC power plant into a predominantly DC power plant to get maximum benefits out of their new plant.

Offshore support vessels choose it primarily for the heightened fault tolerance, variable speed generators and ease of energy storage integration, whilst a couple of icebreakers needed a way of fitting an otherwise too large electric power plant within the confines of their hulls.

Shuttle-tankers will choose it for simple and functional integration of variable speed shaft generators and, right around the corner, expedition



The basic transformation from an AC based power distribution to a DC based power distribution



cruises for its suitability to integrate batteries and fuel cells for extended zero-emissions operation in sensitive areas. The larger of these vessels will also enjoy the possibility of distributing main power at 1000Vdc instead of 690 or 660Vac, representing savings of up 40% or more on cabling.

#### Onboard DC Grid – a system platform

Onboard DC Grid is a system platform tailored to the needs of the next generation of vessels. It serves applications from low to mid-power range by offering a competitive, flexible and state-of-the-art system platform. It is especially well suited to the integration of variable speed generators, energy storage and new energy sources such as fuel cells in a safe, fault tolerant way. It is highly configurable, enabling a close fit for the simplest to the most demanding application.

It is a modular power system platform comprising modules for sources and loads built using industry leading power and automation products. This approach reduces customer risk by enabling a high quality and efficient engineering process and post-delivery support whilst not forsaking necessary flexibility needed for a tailored application fit.

Some of the main benefits include:

- Footprint reduction of up to 30%

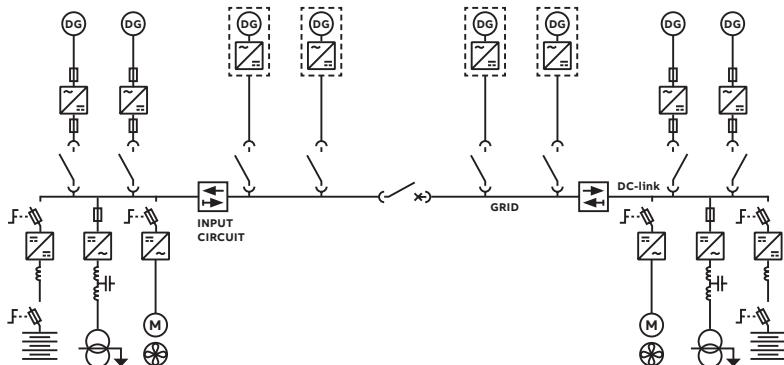
- Variable speed generators for improved SFOC engine characteristic coupled with reduced emissions and maintenance and improved SCR performance
- Most efficient integration of energy storage/fuel cells/shaft generators from perspective of cost, functionality and weight and footprint
- Best in class fault-tolerance is intrinsic to the design
- Highly controllable power plant suited for advanced operation and optimisation by overriding controls (Advisory)
- Unique DC distribution capability
- Unique remote diagnostic and service functionality

#### Protection Philosophy

Onboard DC Grid employs a patented protection scheme that uses a combination of fuses, isolators and breakers and converter control to effectively protect the system.

The protection system provides safe and reliable operation of the vessel and high safety for personnel and equipment. This approach relies on input circuits to segregate the system into two types of protection zones:

- Grid (blue): this is the power distribution zone.
- DC-link (red): this is equivalent to the traditional dc-link of a multi-drive.



The input circuit forms the boundary between the link and grid zones and allows free flow of current in both directions during normal operation. In case of faults on the grid side of an input circuit, the input circuit will block near instantaneously, blocking fault current contribution in this direction. Fault currents in the opposite direction are not blocked.

The DC-link zone is characterised by the fact that most converters connected to it have integrated capacitor banks that support the DC link voltage. The capacitive nature of the DC link means that fault currents in this zone have very short time constants and consequently reach high levels very quickly after a fault. This also means that any faults in the zone must be handled extremely quickly to avoid adverse effects on its converters. This environment is ideally suited to solid-state breakers and high speed fuses which clear faults in the range of a few microseconds to a few milliseconds. The input circuit ensures that faults outside the link-zone do not immediately cause the converters to trip on under voltage.

The Grid zone is characterised by fault currents with longer time constants. This means that it is possible to use a slower-acting protection approach such as a fold-back scheme or air circuit breakers in this zone. All entry points into the Grid are guarded by devices that can control fault current (e.g. the input circuits).

As a function of its low fault current level and fold-back or air circuit breaker protection, the grid zone is very well suited to distributing power throughout the vessel. This is an alternative to 690 or 660Vac distribution resulting in >40%

reduction in needed conductor cross section and the possibility to use lower cost single-core cables as opposed to multi-core double-screened cables.

### Vessel Control System

**Onboard DC Grid** uses ABB's 800xA automation platform to implement system control functions, including PEMS and VMS. The system integration and control is done in such a way that it plays to the strengths of the various energy sources in the system, and keeps tight control on consumers.

ABB has adopted a new approach to power and energy management in the form of the **Power and Energy Management System – PEMS**. PEMS manages both the balance of power (traditional PMS responsibility) and energy in the power system. The latter becomes important when adding sources like batteries or super capacitors with very finite amounts of energy available. The balance of power also takes on new dimensions in a DC Grid system when sources like variable speed generators, shaft generators and batteries operate in parallel.

So, what does it mean to “play to the strengths” of a system’s energy sources? For a simple hybrid system this means that ES (Energy Storage) will primarily perform an energy buffering function whilst engines provide the steady-state power. Some of the functionality to achieve this is implemented at lower levels, closer to the converters and ES – typically functions requiring fast response such as standard load sharing and overload protections. This is done autonomously by the different energy sources. Other functions have been implemented at a higher level such as the traditional PMS domain – typically functions that require a level of coordination between sources. Optimal functionality and performance is achieved through tight horizontal integration between power sources and consumers, as well as tight vertical integration between fast embedded control of converters and generators and the system level application.

**Onboard DC Grid** has a harmonised control and communication infrastructure that allows for a transparent and lightning-fast flow of information between system components. This ensures a holistic approach to the task of coaxing the best performance,

be it for safety or efficiency, out of a power system. The high level of integration also means that high quality information is available to an operator or remote support service engineer should he need it. For vessels with automatic charging from shore, the PEMS coordinates the process of connecting, charging and disconnecting from charging station.

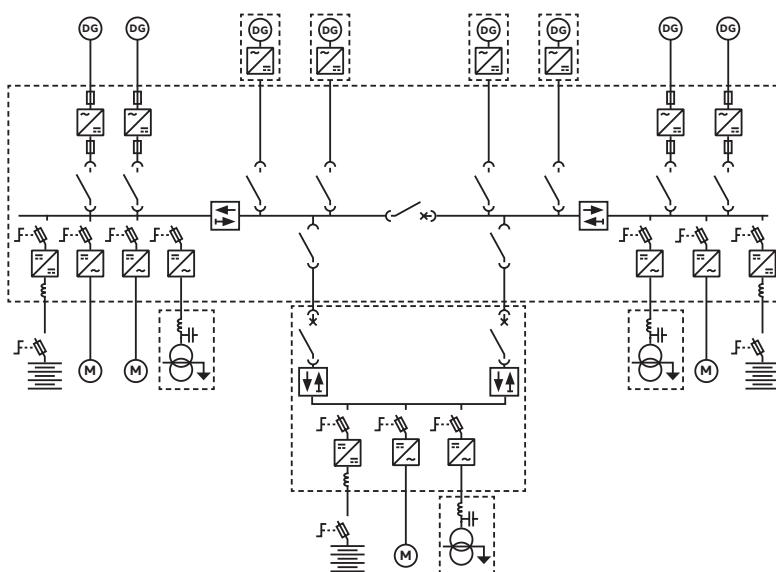
The PEMS is structured so that each energy source forms an autonomous subsystem. This increases the fault tolerance of the system controls by reducing interdependence between energy sources. Sub-system functionality is realised as far as practicable on a sub-system level, only involving the wider system when it becomes necessary. This also means that operation of the vessel remains intuitive and simple even when done so from local control since the majority of sub-system functionality remains intact.

### System Benefits – Why Onboard DC Grid

This shift from AC to DC in the form of DC Grid is primarily driven by three main features:

1. Variable Speed Engines
2. The integration of Energy Storage
3. Ease of integrating other types of energy sources such as shaft generators and, in the near future, fuel cells

However the benefits with DC Grid is not limited to these points. The following sections will describe some of main benefits in more detail.



### Variable Speed Engines

Unlike AC based distribution systems where connected generators need to match system voltage and frequency, the DC Grid system only requires the generators to match system voltage. This means that the generator and engine speed can be dynamically optimised to the system load situation. When the engine load decreases, the engine speed is also reduced.

The most immediate benefit of this change is reduced fuel consumption, visualised in the graph above. There are also additional benefits to variable speed operation, summarised below:

- Reduce Specific fuel consumption by up ~20% and ~40% for medium and high speed engines respectively for partial load operation
- Cleaner combustion process with less build-up of soot when operating at partial loads
- Reduced GHG emissions due to lower fuel consumption and reduced particle emissions due to cleaner combustion
- Increased temperature of exhaust gases at lower loads means that SCR's can be fully operational at all load levels, reducing both NOx emissions and urea consumption
- Potential reduction of audible noise level by more than 5dB
- Reduced maintenance costs due to up to 30% reduced wear and tear on the engine

### Energy Storage

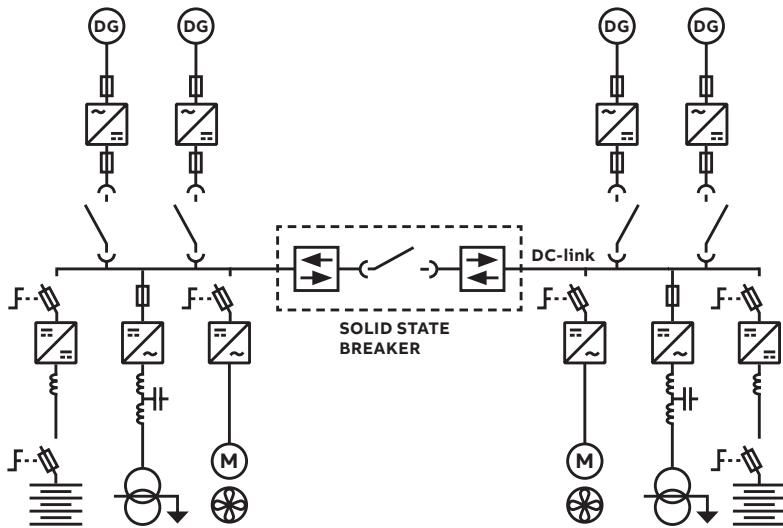
Energy Storage (ES) and associated technologies have received a dramatic increase in attention in recent years, not least in the maritime industry. Whilst this can be attributed to a number of different factors, what is certain is that ES has the potential to improve safety, efficiency and performance of future vessels.

### Integrating Energy Storage into a Power System

The availability of ES is only one part of improved safety, efficiency and performance. First, the energy must be made available to consumers.

Since most Energy Storage media are DC based, the integration into a DC distribution system becomes simpler and becomes more functional for less added cost than doing the same into an AC based distribution system.

DC solutions require less equipment in general and the converter (if used) also becomes signific-



A simpler variant of the system – here two input circuits are functionally bundled with an isolator or breaker to make a bi-directional solid-state breaker.

antly more compact than its AC counterpart. For basic functions where no selectivity or starting scenarios are considered, the AC converter solution is almost twice the length of the DC equivalent. If selectivity, overvoltage and starting scenarios are also considered, then this ratio becomes closer to four.

The option of connecting the ES directly to the DC link can offer a slight reduction in length and improved efficiency compared to the converter option. However, this is at the expense of controllability of the current in and out of the ES and system voltage level.

From a control perspective, this option means that ES power flow is determined by the sum of the actions of all other sources and consumers in the system. This means that this method of connection is only suited to a limited number of applications, typically systems of low complexity where batteries represent a dominant power source.

From a system voltage perspective this option means that the system voltage is defined by the ES and its state of charge. This can vary significantly and may therefore require the rest of the system to be over-dimensioned.

For these reasons, direct online solution is often chosen when efficiency is more important than controllability. An example of this is are ferries that operate in zero-emissions mode where large

portions of the consumed energy pass through the battery on the way to the propeller. The converted based solution is preferred in applications where controllability and fault tolerance are of higher importance than the efficiency of the ES system. A good example of this is a DP vessel where the battery is used to support the power system by means of functions like peak shaving, enhanced dynamic support and spinning reserve. In these cases ES efficiency does not have a significant impact on power system overall efficiency because the battery is primarily used as an energy buffer and relatively little energy is passed through it during normal operation.

### Energy Storage & Variable Speed Engines

The combination of ES and variable speed engines offers some additional synergies.

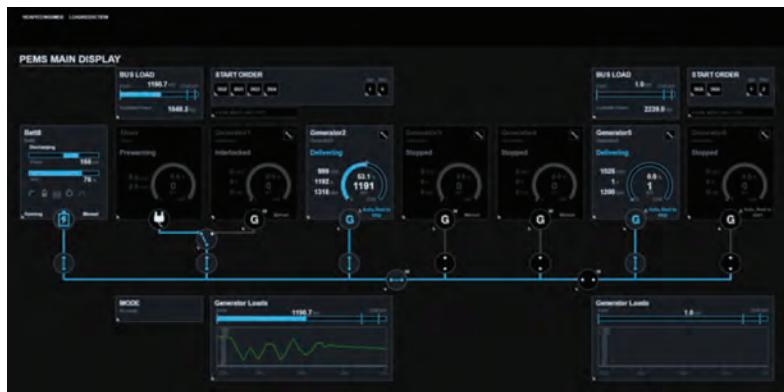
In a system with variable speed engines where energy storage is not included, the engine needs to be operated in such a way that it always has enough reserves to be able to absorb load steps. The need to always have some power margins in reserve means that some optimisation potential is left untouched.

When a system is equipped with ES and the Enhanced Dynamic Support function is activated, the ES can take on the role of absorbing quick load changes and the engine optimisation has one constraint less to consider, and can now optimise its operation even further.

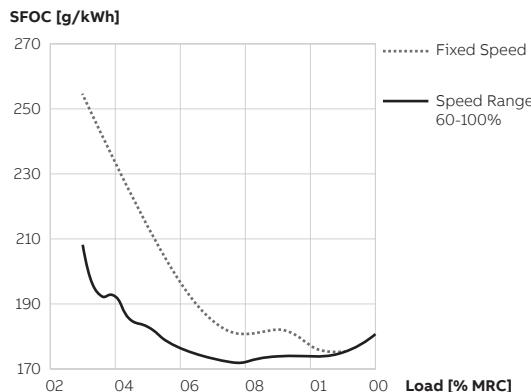
Going from fixed speed to variable speed operation, the speed vs. load path is moved from the vertical 1800rpm axis (red line, see left) to the propeller curve (blue line). When energy storage is added, this path can be moved even further to the left, sometimes all the way to the MCR curve (green line). The effect this has on the specific fuel oil consumption (SFOC) is shown in the graph below left. The figure shows the SFOC for the traditional AC System (blue), DC grid with variable speed (green) and DC grid with variable speed and energy storage (orange).

### Safety

DC is inherently simpler than AC. When building up a system platform this means that it is easier to predict fault scenarios and devise effective protection against them. For Onboard DC Grid this has resulted in:



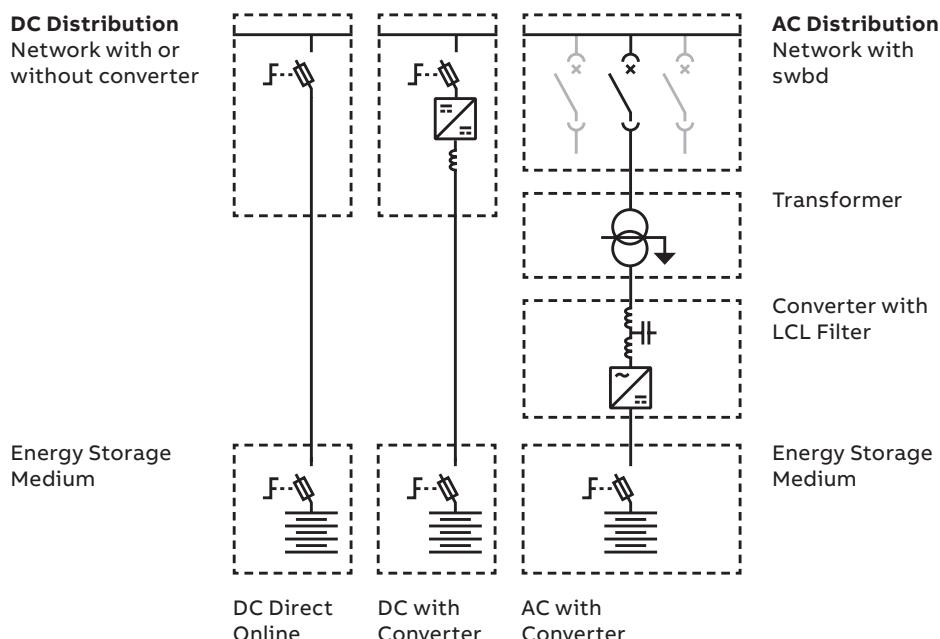
— PEMS main display

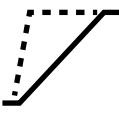


— Reduced fuel consumption with variable speed

- Closed bus operation in DP2 without additional equipment because common mode faults like governor and AVR failures are handled more effectively.
- Generators that can be online in close to 10 seconds (for high-speed engines) because they don't need to wait for synchronisation.
- Engines that are virtually impossible to overload even when operated at lower speeds. This is because each generator has built-in overload protection that limits output power. The end result is that the engine does not stall and remains online.
- Clearing of major short-circuit currents in a "soft" way so that the system recovers quickly and predictably. This is a function of both system capacitance and converter control. The system is therefore not plagued by ugly transients as is often the case in AC systems when large fault currents are interrupted by protective devices.

A safe and fault tolerant system is a benefit in itself, but there is another often forgotten benefit of this. Operators quickly understand that in the rare event that failures do occur, the system will recover quickly and reliably. Such confidence in the system has proven to result in significantly more economical operation of the vessel because the system is not split and additional generators are not brought online until necessary.



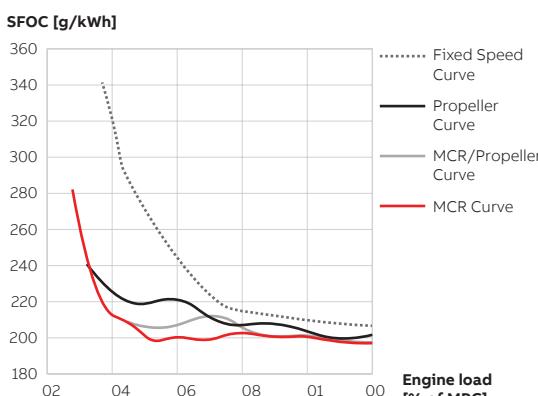
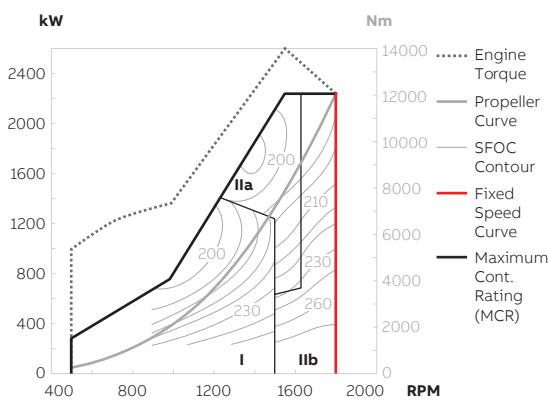
Symbol	Name	Description	Purpose
	<b>Spinning Reserve</b>	<p>Unit is connected and running but not charging or discharging energy into the system. On loss of generating capacity it steps in to take the load for a predefined period of time.</p> <p>If other functions are activated simultaneously, this function ensures that sufficient energy is left in battery.</p>	<ul style="list-style-type: none"> <li>• Backup for running gensets</li> <li>• Fewer engines needed online</li> <li>• Improved fuel efficiency through higher partial load</li> <li>• Reduced engine running hours</li> </ul>
	<b>Enhanced Ride Through</b>	Same as spinning reserve, but on a local level in a sub-system like a thruster or drilling drive.	<ul style="list-style-type: none"> <li>• ES storage solutions can give UPS like functionality for all or portions of power system</li> <li>• New ways of achieving higher ERN numbers</li> <li>• Higher power system availability</li> </ul>
	<b>Peak Shaving</b>	Unit absorbs load variations in the network so that engines only see the average system power.	<ul style="list-style-type: none"> <li>• Level the power seen by engines</li> <li>• Offset the need to start new engine</li> <li>• Improved fuel efficiency</li> <li>• Reduced engine running hours</li> </ul>
	<b>Enhanced Dynamic Performance</b>	Unit absorbs sudden load changes and then ramps the change over on running engines. If peak shaving is used, then this function is automatically included.	<ul style="list-style-type: none"> <li>• Instant power in support of running gensets</li> <li>• Enable use of «slower» engines; <ul style="list-style-type: none"> <li>– LNG/Dual Fuel engines</li> <li>– Fuel Cells</li> </ul> </li> </ul>
	<b>Strategic Loading</b>	Unit charges and discharges to optimise the operational point of running engines, ensuring that energy is produced at the lowest cost, taking the efficiency of the ES system into account.	<ul style="list-style-type: none"> <li>• Charging and discharging ES media in such a way that it optimises the operating point of the gensets.</li> <li>• Power is produced at peak efficiency</li> </ul>
	<b>Zero Emissions Operation</b>	Unit powers the system so that engines can be turned off.	<ul style="list-style-type: none"> <li>• Zero emissions in harbour</li> <li>• Quiet engine room</li> </ul>

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Energy Storage  
Functions: ES can be used in a wide range of ways onboard a vessel and most of these can be broken down into the few basic functions (or combinations thereof) described in the table to the left.

### Other Benefits

In addition to the benefits described above, there are numerous other benefits with DC distribution. Some of these are summarised below:

- **Power transmission:** Distributing on 1000Vdc instead of 690Vac reduces cable need by as much as ~40% and permits use of lower-cost cables.
- **Voltage distortion:** (THD) common in AC systems with frequency converters is no longer an issue.
- **Shore connection:** If shore connection is done on the DC side, vessels can more easily use shore connections in different ports because network frequency is no longer an issue. Also, starting currents from motors and transformers are not drawn from the shore connection, thus allowing more operational flexibility in ports with low-power feeders. If ES is available onboard, then this can be operated in parallel to take peak loads, improving operational flexibility in port even further.



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The effect for an example high speed machine

- **Shaft Generators:** Variable speed shaft generators can be integrated in the same simple way as variable speed generators. Similarly, a PTI/PTO solution can be solved in a very streamlined fashion, analogous with ES.
- **Fuel Cells:** Fuel cells are already making an entry into the marine industry, and the fuel-cell business case may make them a viable power source within a few years. Fuel cell integration into an Onboard DC Grid system is solved in a very streamlined fashion, analogous with ES and shaft-generators.
- **Centralised Drive Lineup:** Collecting all the drives in a central lineup means that the need for ambient conditions (temp and humidity) and cleanliness is reduced in e.g. thruster rooms. This is particularly useful during construction and commissioning.
- **Centralised vs Distributed:** Whilst most systems will be highly centralised, the DC Grid platform also supports fully distributed systems using cables or bus-ducks.
- **Space and Weight Reduction:** The number of components in the system has been reduced, resulting in a reduced footprint of up to 30% as compared with an AC system.
- **Electrical Efficiency:** In the process of going from AC to DC distribution, the electrical system efficiency has improved by 0.5-1 percentage points.
- **Variable Speed Motors:** Fans and pumps represent a large portion of the auxiliary loads onboard modern vessels. Most of these can be operated at significantly improved efficiency by fitting variable speed drives. This enables regulation of flow by means of adjusting fan or pump speed instead of e.g. throttling. The DC Grid platform is uniquely suited to tapping into this potential in a cost-efficient manner.

### Where does that leave us?

Shipping 4.0 spells a bright future for electric propulsion, and the Onboard DC Grid system platform will be at the heart of this transformation. It is uniquely prepared to optimise current energy sources, integrate new energy sources and tap into the very significant potentials afforded by digitalisation. It appears that the future of shipping may very well be electric!

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