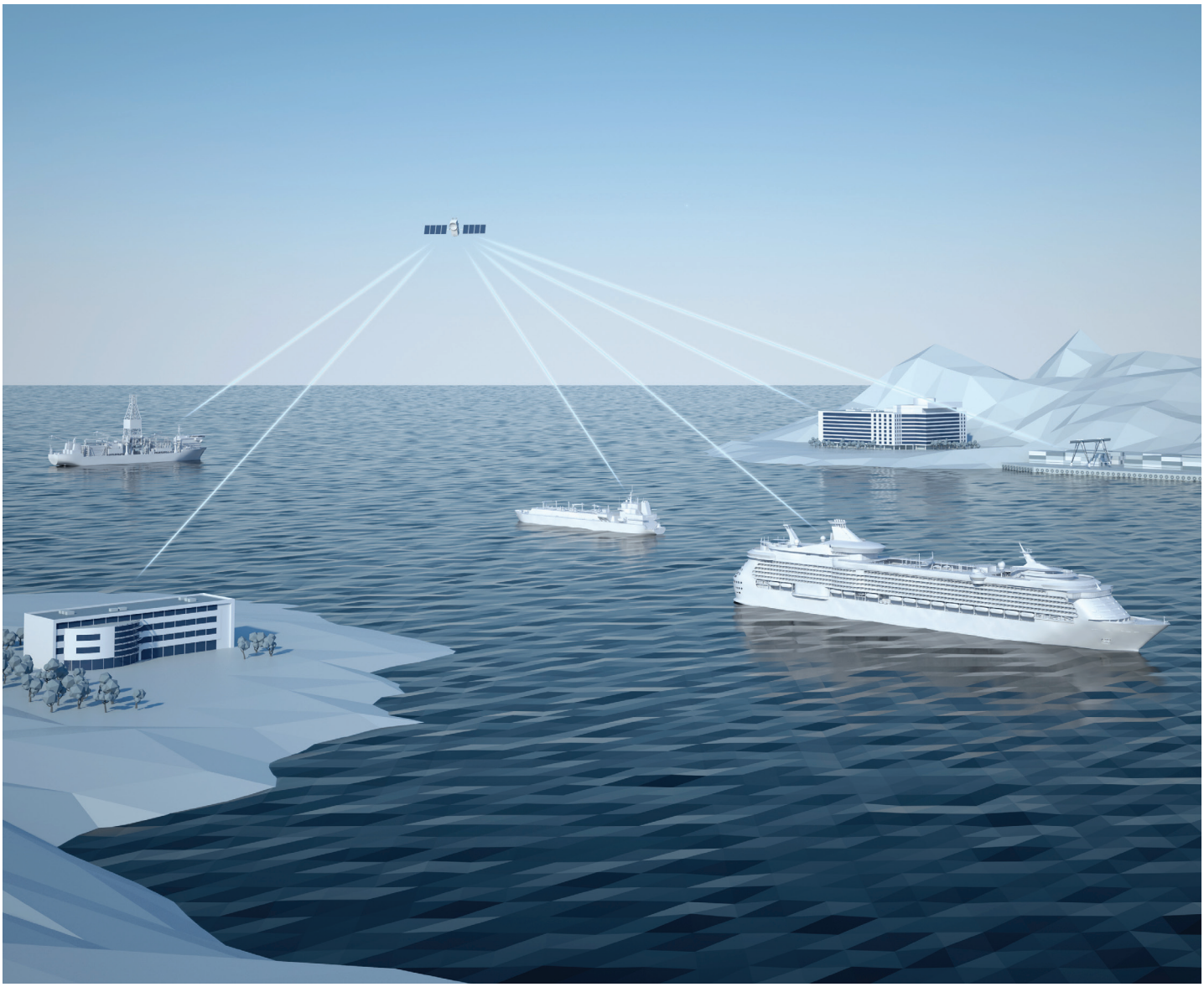

CONNECTIVITY

generations
A publication of ABB Marine and Ports

Power and productivity
for a better world™

This issue of Generations marks a step up to a new, larger format, and features a multi-faceted look into connectivity and how it is changing virtually everything about the way we work, and play. In the sky and under the sea, and everywhere in between, connecting things, services and people is keeping the world busy. And once connections are made, what seemed impossible only a few years ago becomes routine overnight. Read on for business and technical perspectives on how connectivity is transforming companies, operations, thinking – and lives.

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Business Insight

Perspectives on connectivity

The first examples of connectivity may have been the networks formed by early human relationships: selecting partners, developing tribal identity, organising hunting parties – all devised to help humans survive, and eventually, to thrive.

"In helping us to help each other, connectivity achieves its ultimate meaning, and purpose."

In a sense, modern connectivity serves the same purpose: allowing humans to connect with each other, and to connect all the things in their world, always with the ultimate purpose of improving quality of life.

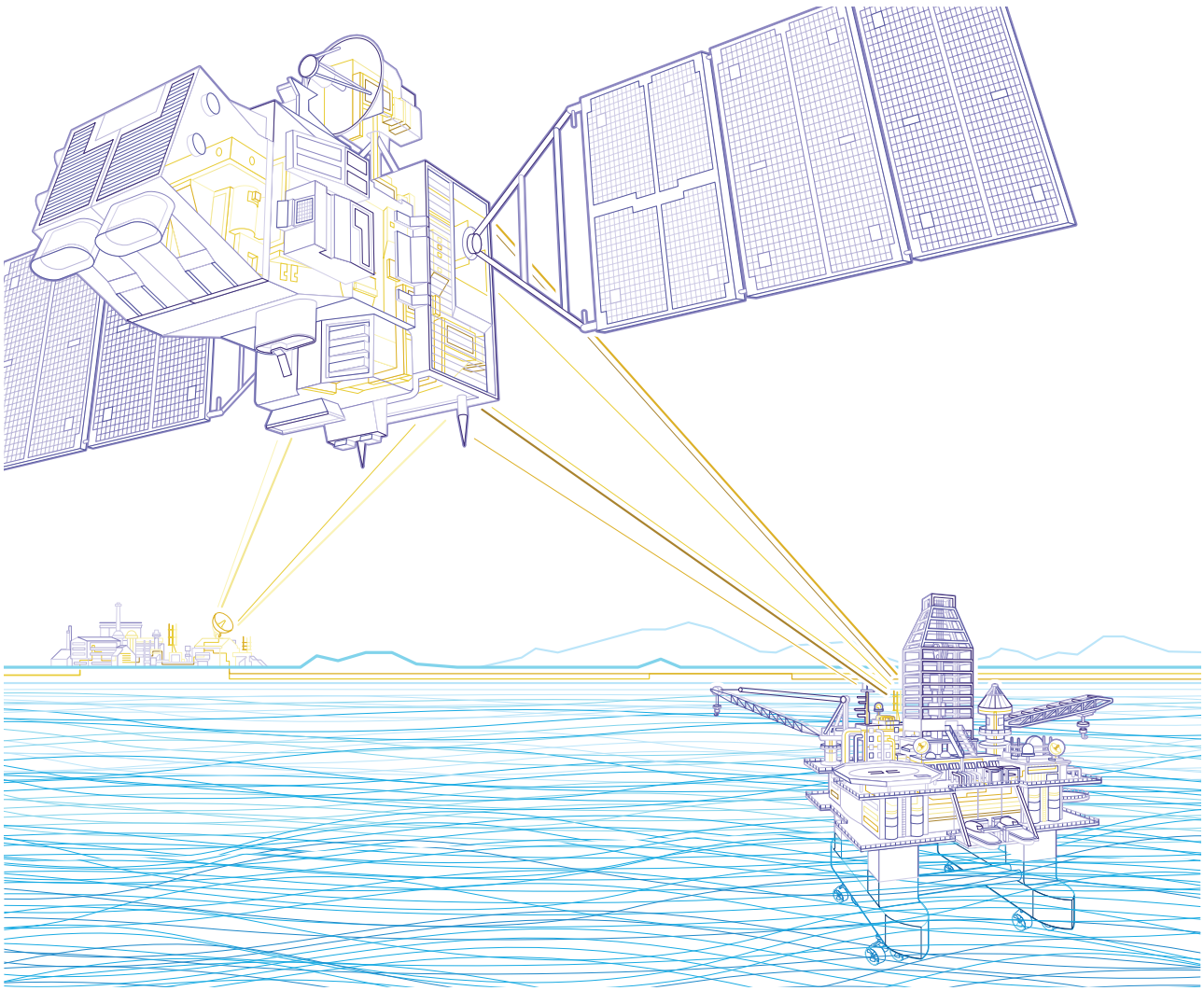
The principal feature of today's wave of connectivity is that, in a relatively short time, it will affect virtually everything, and everybody. The way we do almost everything has already been changed: shopping, banking, building and transporting, communicating and recreating, even sleeping.

And nowhere has the effect of connectivity been more dramatic or more pervasive than in the business world. Companies change not only their images but their fundamental philosophies and business models seemingly overnight. As you can read in this issue of Generations, this trend applies not just to small, nimble start-ups, but to world leaders like IBM, Ericsson, and Deloitte, who have had to embrace the digital revolution at a pace that would have been inconceivable only a few years back.

The Big Buzz

In the wake of this digital tsunami, certain buzzwords have emerged and ensconced themselves in our vocabulary, and our consciousness: Cloud Computing, Big Data, and the Internet of Things have become the templates on which virtually all new business developments are built. At the same time, competitors have had to cultivate their own unique identities in order to carve out a niche in the cloud.

For example, the Internet of Things has quickly become many things: ABB uses the Internet of Things, Services



and People (IoTSP), IBM talks about the Internet of Everything, Inmarsat likes the Internet of Everywhere, and the Industrial Internet of Things has evolved more or less organically.

From buzz to bucks

But in order to make money on the buzz, value must be created, and therein lies the core challenge of the latest industrial revolution: How to deliver digital services that make life better for your customers, and that they are willing to pay for. This is the rock solid, meat and bones reality that the winners in the digital economy have embraced.

Tools and knowledge must be developed to take advantage of the opportunities that new technology presents. Sensors and satellites, information and analysis, sharing and security, all must be moulded from virtual possibilities into concrete advantages for suppliers and their customers. That is what we are witnessing in the best examples of companies successfully leveraging connectivity today, and those likely to do so in the future.

However intriguing digital technology and new business models may be, the real value of connectivity is found in its impact on human relationships. In helping us to help each other, connectivity achieves its ultimate meaning, and purpose. The examples cover nearly all aspects of human life. We are honoured to share some of the most remarkable of these in the following pages.

The Generations editorial committee

Expanding connectivity has opened up new worlds of business opportunity in virtually all industries. But the northern shipping route is one place in the world where staying in touch could mean the difference between success and failure for an entire mission.

When staying connected becomes critical

Gregor Bogle

Teekay will be shipping gas from the Yamal LNG project, above the Arctic Circle in western Siberia, and over the northern route to Asian markets. “The importance of connectivity in this project is almost to the point of criticality,” says Gregor Bogle, manager of electrical, instrumentation and automation for Teekay Gas, operating out of Glasgow. “If you lose power in the Pacific, you might drift around for a day or two before help arrives. Up there you can freeze solid before help comes, and then it’s too late.”

“That’s why we have to have support 24/7,” he states. Noting that ships will be navigating the roughly 2500 nautical mile Northern Sea Route with virtually no communications infrastructure along the passage, Bogle underscores the challenge of maintaining a robust connection to land support.

Satellite coverage can be spotty in the high north, so Teekay is investigating technologies such as data connection using old-fashioned High Frequency radio that can send signals virtually around the globe, or to another ship with capacity to relay the signal. ‘Snapshots’ of 1 – 2 megabytes will be transmitted regularly, and vendors will collect all the data they can, whenever they can, so as to have it when the need arises.

If all this seems a bit like patchwork, it still gives the ships the connectivity they need to stay safe. “We plan for the worst and hope for the best, but we will always have at least some degree of connectivity,” Bogle stresses.

Far, and yet so near

“These ships are designed to sail solo through the Northeast Passage. Not

Yamal LNG shipping routes

only do they have to be prepared to meet all operational challenges, we have to help them avoid problems before they occur." In that context, Remote Diagnostic Systems (RDS) are essential tools for identifying potential systems issues.

"RDS allows us to provide advance support to our people on the vessels. On board, you know something is wrong when the alarm goes off. The crew don't have the time to methodically graph and predict everything. With advanced warning, they can do preventative, condition-based maintenance, and we can help them fix things at sea, too."

Teekay's Yamal LNG ships will employ power and propulsion systems from ABB. Gregor Bogle has visited ABB Marine's Integrated Operations Center at Billingstad, outside Oslo, where they monitor and diagnose systems in real time, and found it highly reassuring. "We like to know they have people on watch. It's that warm, fuzzy feeling, knowing they will be there."

ABB can connect to a ship, generate predictive reports, and identify trends that might go unobserved on board, while the crew tend to the day-to-day running of the vessel. And Teekay can monitor all its ABB DFDE (Dual-Fuel Diesel Electric) vessels using their myABB portal. The system allows them to see the location of ships and check alarm systems, and access all RDS data.

How much is too much?

For all its remarkable advantages, Gregor Bogle does believe that connectivity can be taken too far. Big Data enables the analysis of more data than

"If you lose power in the Pacific, you might drift around for a day or two before help arrives. In the Arctic you can freeze solid before help comes, and then it's too late."

most enterprises need, or are able to handle. Because Internet on ships is still slow, operators will collect large amounts whenever they are able, but Bogle maintains they should analyse performance based on need, not just data availability. In this he is simply acknowledging that there are limitations to what a company really needs to do, if not on what they can do.

"And you have to be clear on just what you want to expose," he warns. "Sharing data increases security concerns, and companies have to control their vulnerability."

Though most vendors are aware of the risk problem, owners have to take into account the potential threat of harmful action if they expose everything. The most common solution to this is to control the ship's connection to the suppliers, using one secure connection for the ship, another for crew, and a separate one for suppliers.

"If remote support is available," Bogle asks, "would you want your supplier to take control of the system and fix problem? It sounds tempting, but then you open a Pandora's box by relinquishing control. I trust my suppliers to do no harm, but if something goes wrong when they are in control of the system, how am I to know that they are not at fault? Of course I will want to know what happened while I was out."

He adds that class societies are also sceptical of relinquishing control of a ship, simply due to the ambiguous nature of responsibility when the system is open. "When you're dealing with perceived threat, suspicion is the threshold, not technology," Bogle concludes.

"These tankers are probably the biggest ice going ships in the world."

Never before in the north

"Teekay has shipped LNG all over the world, but we have never done it in ice, so this is new to us," Bogle says. Another first is Teekay's use of ABB's Azipod propulsion system, instrumental in enabling the stern-going function that gives the tankers ice breaking capacity in more than six feet of ice.

"These tankers are probably the biggest ice going ships in the world," Bogle reflects. Teekay and partner China LNG will take delivery of six of the vessels for Yamal, operating on 25-year charter contracts. The vessels are ice classed to RMRS class Arc7, designed by Yamal consortium and built at DMSE in Korea. Yamal will employ four shipowners, and Gregor Bogle represents Teekay in the technical working group with the other owners. Teekay have their own Yamal operations group, and a team on site at the yard in Korea.

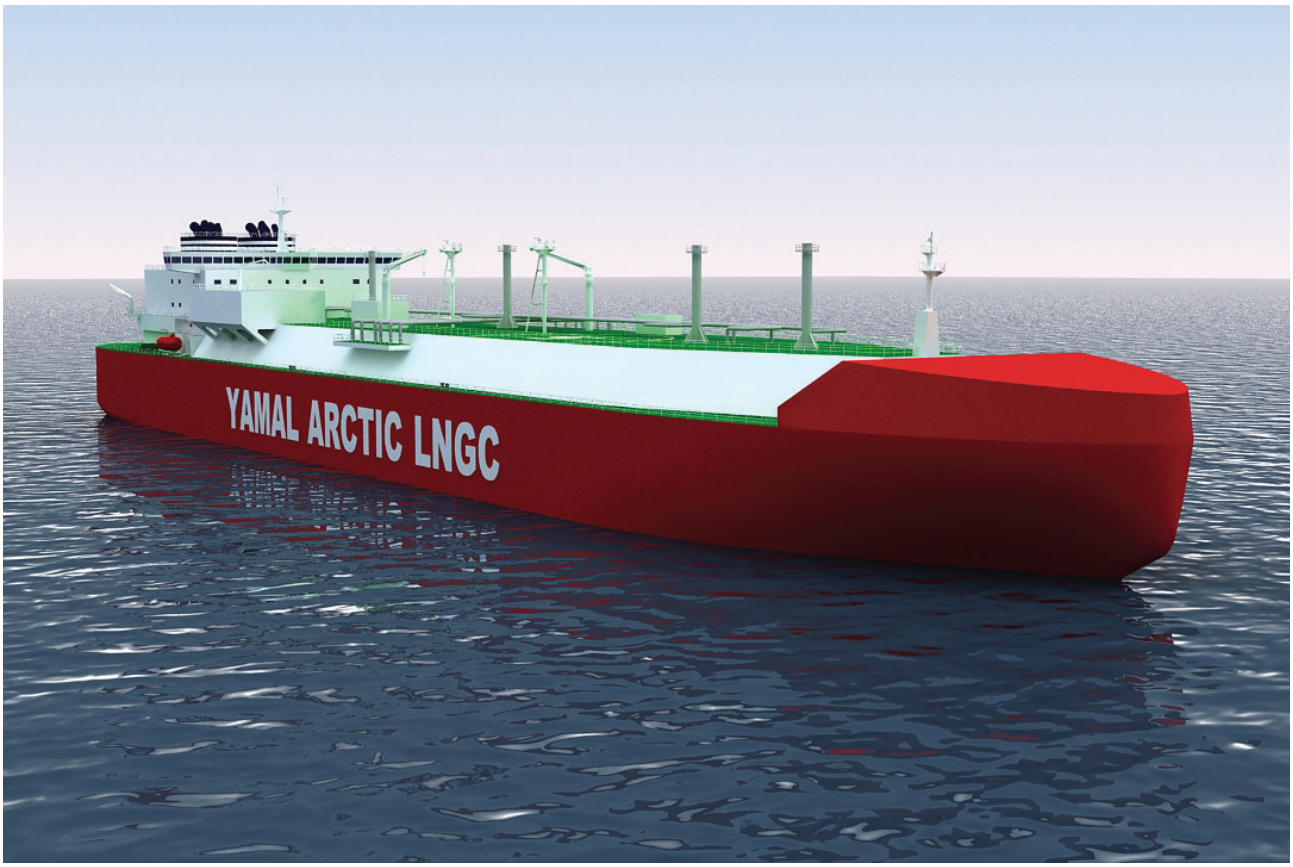
Yamal is the largest LNG project Teekay has served to date, and Bogle calls the facility itself "a logistical marvel". With no manufacturing on the site, every component is constructed at lower latitudes, transported and assembled in sub-zero conditions.

Yamal LNG owners Russian Novatec, French Total, the Chinese National Petroleum Company (CNPC) will invest USD 27 billion to extract the 900 billion cubic metres of gas reserves, with peak production scheduled to reach 16.5 million metric tonnes per year.

No substitute for experience

So with all the expense, complications, and risk to crew involved in sending ships through the Northern Sea Route, were autonomous vessels ever considered?

"It may sound like a good idea on paper, but there are just too many variables," Gregor maintains. "Not just in the north, but in general. With the complexity of systems and tasks,



The Yamal LNG carriers will be some of the most robust on the water

things are going to go wrong. What happens when a computer-operated ship is on a collision course with a human pilot? How can a computer know what the human will do? And who does a computer protect, itself or you?"

Having served many years at sea, Gregor can assure that no such dilemmas arise with a human crew. "Technology changes on ships, but not the mindset, and not the responsibilities. It's a condensed society on board, and you are all responsible for each other. You are the police, the fire department, the ambulance and the hospital. You are family and friends, and you can't just walk away. In the end it all comes back to the people."

And he is clear on the value of integrating shore support into the tight shipboard society. "When we share our on board experience with the support centre, it helps the specialists on land relate to the all-round nature of life on a ship."

Gregor Bogle sums up the significance of human experience in an increasingly digital world: "For example, a service centre is going to have a much easier time communicating to an engineer on board if they have people who have been on a ship," he observes. "At the end of the day, the success of all systems comes back to personal connections."

Dealing in efficiency

As the largest single investor in marine transportation in Europe, what does the shipping arm of the European Investment Bank want for its money?

"Efficiency," says the EIB's Head of Shipping Mark Clintworth. "Improved efficiency makes shipping cleaner and more competitive, and that helps clean up the environment. These are our goals."

Focusing primarily on ports and infrastructure until about a decade ago, the bank decided it was time to get involved in "cleaning up shipping," as Clintworth puts it. "We started looking more at shipping in 2006," he tells. "Not just ships, but all aspects of the maritime industry, including R&D, technology, the environment, employment, everywhere we see potential for improving shipping to the benefit of society."

"Improved efficiency makes shipping cleaner and more competitive."

Something old, something new

That starts with newbuilding of modern, more efficient vessels, but it doesn't stop there. "We support the building of new ships, but right now the market isn't absorbing too many new vessels, so we are looking to support modernisation of the existing fleet through retrofitting, especially in the short sea segment."

But like newbuilding, retrofitting too is being hit by the low price of oil and the general dearth of capital in maritime markets. "Our job then is to identify what is required for owners to meet new and pending regulations, and then use our own investments in these areas to try and pull commercial banking back into the market," Clintworth explains.

"Working with shipowners, we are attempting to de-risk activities and trying to get more movement in the industry, particularly in retrofitting." EIB shipping offers two major products: green shipping guarantees, and green shipping program loans. All told they will attempt to entice investments of around EUR 1.5 billion into the market by 2018.

The European Investment Bank in Luxembourg

"These are not subsidies," Clintworth clarifies. "Subsidies and grants are tools of the European Commission." Rather, the EIB tries to offer more attractive loan conditions, mixing loss guarantees with lending liquidity.

Multiple targets

There are several areas EIB shipping targets for improving efficiency. One is the digital wave currently sweeping the marine transport industry. "Digitalisation of the sector can only result in further efficiency gains, which in turn will contribute to significantly improving environmental and safety aspects," Clintworth says.

Some of the EIB projects related to the digital economy include development of mobile networks, improving transmission networks with an emphasis on satellite communication, ICT applications and services for industry, and R&D aimed at improving broadband infrastructure.

Inland waterway transport is another prime focus area. The Rhine-Danube, North Sea-Baltic, and Scandinavian-Mediterranean corridors are of chief interest, all part of the EIB strategic transport policy. "There is room for cleaning up, but also for growth. We are trying to get customers to invest, but quite honestly, there is relatively limited response." For that reason the EIB has chosen to run pilot projects on the national level, starting with the Dutch government.

Clintworth refers to TEN-T 2016 days held in Rotterdam, featuring an Investors Conference on how to boost funding and financing in transport infrastructure. "Access to capital is a hindrance here as well. The EIB can only go to 50% of CAPEX, so commercial finance has to step in to provide full funding of projects."

ABB's Ulrike Haugen in conversation with Mark Clintworth

Water is good for you

Getting more efficient ships on the water is one thing, but getting goods off trucks and onto more environmentally friendly ships often proves to be another. How does the EIB go about making that happen? “Again, it all hinges on efficiency. We encourage tighter regulation for road transport in order to level the playing field. At the same time we invest in ports and intermodal transport, including rail. The EIB can only follow EU policy, and that means creating greater efficiency however we can.”

Many see increased efficiency and modernisation as synonymous with job cuts, but Clintworth does not share that view. “Efficiency itself can create jobs, and often better jobs. Employment is essential,” he says, “but it has to be balanced with progress.”

He adds that ships are popular regulatory targets, with CO2, SOx, NOx, particulates and ballast water regulations all gaining steadily more traction. The resulting cleanup could serve to strengthen water borne transportation in the long run, “But only if capital is available,” Clintworth reminds. “The Commission develops policies, the Parliament votes on them, and then it’s up to us to develop the tools to implement the policies. We have a mandate, but we are beholden to the same economic cycles that define the shipping industry.”

Half empty, or half full?

“In the medium to long term, I am an optimist,” Clintworth says. “We seem to have reached the bottom of the present cycle. Regulations and an aging fleet should correct overcapacity and strengthen the equipment supply industry. Oil is on its way back up, and this should stimulate increased investments in efficiency and abatement technology. Meanwhile we will continue to attempt to help de-risk investments in the segment.”

While the European cruise shipyards are fully booked into 2020, EIB shipping is trying to target smaller yards in Europe for short sea work, specifically for retrofits. Both cleaner operations and cleaner fuels are in focus. “For example we are interested in stimulating the use of LNG as a fuel,” he says, “but LNG as a good medium term alternative, not as a long term solution.”

On perhaps a more long term note, he reports that customers have approached EIB shipping for assistance in financing battery and hybrid power. Here Clintworth points out such EU programs as InnovFin, specifically targeted at financing of innovative solutions. “Many of those who want to do change are smaller, but small is good if it brings change.” For them, InnovFin offers guarantees and loans targeted at enterprises of all sizes, from the smallest to the largest.

Mark Clintworth is currently completing his PhD in ship finance and risk, to further hone his skills in management and absorption of risk in the industry, and learn more about how shipping can better manage itself. The EIB’s role in this, he says, will continue to be reducing barriers to investment.

Summing up, Clintworth believes the European shipping community can be compared to a family, a complex and diverse unit, always with differences, but still sticking together. Together with institutions and commercial banks and lenders, EIB shipping strives toward a common mechanism, using an array of fiscal tools to keep people connected in the EU, and the EU connected with the rest of the world.

“Digitalisation of the sector can only result in further efficiency gains.”

"You better start swimmin' or you'll sink like a stone," sang Bob Dylan more than 50 years ago. If anything, the times are changing even faster today, and only the fastest swimmers will survive.

The times, they are a-changin'

Jan Höller

At Ericsson corporate headquarters in Stockholm, the receptionist is using not one, but three, Samsung mobile phones. Just a few years ago, they would of course have been Sony Ericsson units. What happened?

"Oh, we don't do those anymore," says Jan Höller, research fellow for the Internet of Things (IoT) at Ericsson.

That was fast.

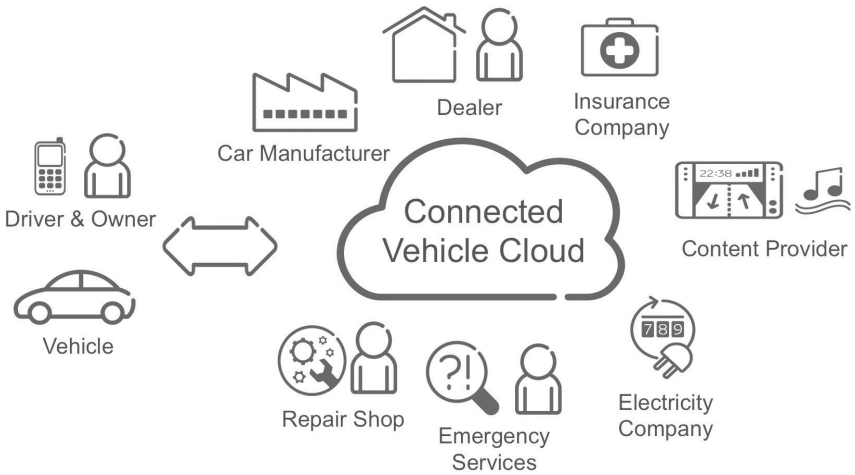
So what does Ericsson do now? It's still mobile telephony, just not with the phones themselves. "We have over one billion mobile end users that we manage on behalf of our customers, the mobile operators," Höller says, ticking off operational centers around the world, in the Americas, Europe, and Asia. Even though mobile communications products and services constitute the bulk of Ericsson's business, their focus is shifting, to the networked society.

"I have been working with IoT for 12 years, he continues. "First we started connecting people with each other. Then we said, 'Lets see if we can connect other things.' Now our goal is making machines first class citizens on the internet, on a par with human users."

In Höller's world, connectivity is more an enabler, an important infrastructure service like running water and electricity "Cheap chips are making connectivity and computing more accessible," he explains. "We are shifting from inanimate physical infrastructures to a world with connected embedded sensing and intelligence in everything. This creates a wealth of data, and it is this wealth that is fueling the digital transformation that we are seeing today."

Exposing data

So how to know who needs what data? "The strategy must be to expose



Connected Vehicle Cloud as a digital marketplace of data and information

as much data as possible, and to make that data understandable by computers, what we call 'semantic interoperability'. We open up this wealth of data to expanded use and see what people and organisations want to do with it, of course making sure that privacy is protected and access to data is authorized and secure."

When Jan first started to pitch this concept to his people at Ericsson, he liked the term 'data broker' for the interface between raw, harvested data and its consumers. "We were collecting data from different sensors and feeding it to a 'broker' in order to expand exposure to the market. Now we liken it more to a factory, producing all kinds of items for the consumer to choose from, both simple data and rich insights."

With the advent of 5G, wireless infrastructure is more suitable for industrial use. Infrastructure is increasingly distributed as well. "Not all data processing needs to be centralized. Some can be handled in a distributed environment," Jan says. "The idea is to bring analytics to the data, not just feed data to analytics in the big centres."

Driving forces

Though the maritime and aviation industries are also making progress in the field, he offers the automobile industry's use of distributed data collection as an example. Ericsson is currently involved in a brokering-type project with Volvo. "We have developed the connected vehicle cloud, or CVC. This can broker in-vehicle infotainment, engine data, and more. Each car is connected to the entire infrastructure, via the Cloud, which also gives them global connectivity."

Car manufacturers have been harvesting data from their automobiles for years, improving knowledge of vehicle performance. Car owners in turn benefited from improved service and design. But with greater diversity and accessibility, the number of uses for this data is growing. For example, Höller relates that insurance companies now track data from cars, in order to tailor their offerings to the individual driver's habits – good and bad.

The utilities industry is another that Höller sees transforming. Sensors in smart buildings and energy-plus houses monitor consumption and sell excess power generated from solar panels or other sources back to the grid. Regulations are driving installation of smart meters in homes, impacting consumption, but also giving utility and energy companies inside information on consumer behaviour. "Even through it seems overwhelming already, this is just the beginning," Höller maintains.

Get on the grid

"The main point is, we need to be able to connect everybody and everything. Connectivity exposes data, and that enables value to be created, because value comes from what you do with the data," Höller states.

One example of a hyper-connected player is Google. But why would a software company be interested in driverless cars? "It probably started off as a fun project, with robotics and AI, but it has proven to be a good way to stay at the hub of digital development," Höller observes, "and they can apply that knowledge to other uses."

Meanwhile, Google's driverless cars are outrunning legislation, already sharing the streets with human drivers, and even crashing into the occasional

bus. So why aren't people more alarmed? Jan offers a key observation on human nature, one that is certainly a factor in the rapid adoption of digital technology in general: "If it is useful enough, we will take the risk. If the potential benefits outweigh the risks, we will try it."

And as the software inevitably becomes more reliable, Höller believes, such fictitious creations as robot taxis will not be science fiction much longer. "I recently read a foresight report by the Imperial College of London, predicting that some cities are likely to ban human drivers as early as the 2030s."

In another example of software saturation, Google recently bought Nest, makers of a learning, interactive thermostat. "The thermostat itself is not the most accurate on the market," Jan says, "but the unit allows Google to learn more about what happens in the running of the home. And it doesn't hurt that it looks good on the wall."

In other words, the real benefit of being connected may appear where you least expect it. "I was in a project that helped an ice cream company streamline their delivery service by simply monitoring the number of times the ice cream bin lid was raised. This allowed them to make more efficient deliveries, but then they saw that sales were going up. The reason was that items were kept in stock, so they sold more. The benefit from this unexpected side effect was in fact greater than the gain originally targeted from more efficient deliveries."

Protecting assets – and lives

If exposing data makes good things happen, it also implies responsibility. The recent dispute between Apple and the FBI, where Apple refused to grant access to a suspected terrorist's iPhone, offers a case in point. "Apple has simply decided that the customer comes first," says Höller.

"When data exposure explodes, consumer protection becomes of the utmost importance. The more we rely on software, the more vulnerable we are, and data needs to be secured. Privacy and integrity are important, but security becomes paramount when you start to connect things," Höller points out.

The way to build secure software, Jan Höller believes, is to develop and design products with security built in from the start. "Security cannot be retrofitted. It has to be in the foundation. We have to secure every entry point, and we can't rely on legislation to ensure security, because it will always be lagging behind. Security technology is there, we just have to know how to apply it."

The Apple-FBI case also raises the question of how much power states have in regulating market freedoms. "We have a very liberal society in Scandinavia. Individual rights and private information are strongly protected," Höller points out. "But what if the political climate changes?"

Nonetheless, he maintains, "Opening up is not something we can, or want to stop. What we can do is create an awareness of becoming dependent on something we will not be able to control. We don't really know where it's going, but we can monitor developments." Höller offers the analogy of a built-in smoke detector in society: "Just a device that will set off the alarm if something starts going wrong."

Are we there yet?

So what is Jan Höller's time frame? When will everybody and everything be connected? "The technology is available. It will only take a few years' time to embed it in virtually everything.

“The idea is to bring analytics to the data, not just feed data to analytics in the big centres.”

Ericsson offices, Stockholm

> “Our goal is making machines first class citizens on the internet, on a par with human users.”

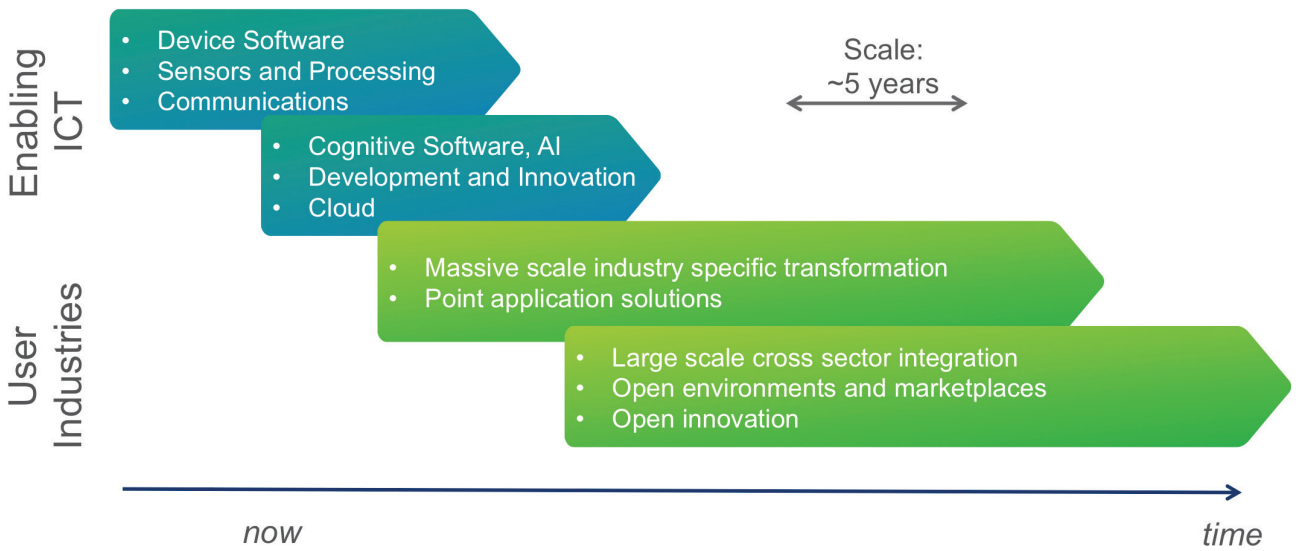
And Big Data already exists. The technology is there for the first wave of deep penetration, so it just depends on the pace of uptake in the different sectors.”

Right now, he points out, the wave of change is consumer driven. Revolutionising the heavier communications infrastructure takes longer. “I tell people around five years for the technology to mature, and 10-15 years for a broader implementation across different sectors.”

One key driver in this transformation: “Everyone is competing against each other. IBM has already transformed to a software company, and Ericsson has also come far in transitioning into software. Manufacturers like ABB are becoming software companies. These are now competitors in a space where they never thought they would be competing, and we are all targeting the connected industries in the digital transformation.”

As the competition heats up, something’s got to give, but for now, Jan Höller believes there is room for everyone. At least for those who embrace the challenge of being prepared for the unknown:

“I was presenting at an ABB symposium recently, and they asked me to give advice on how to be prepared for what is coming. I told them, ‘just pour sensors into everything you make’. Don’t try to justify it today. At some point in the future, you will need all the data you can get your hands on.”



Evolution of enabling technologies and industry uptake

Small steps to big data

The Internet of Things is definitely here to stay. With the first phase of connectivity basically in place, the developer community is now seeking to add value to the IoT, creating offerings that solve problems, and that users are willing to pay for.

Evothings of Stockholm was founded with the vision to make it easy and efficient to develop mobile applications for the Industrial Internet of Things (IIoT).

Alex Jonsson is an Evothings co-founder and their CTO. He holds a PhD in Computer Science and was educated as a mechanical engineer, but his career path led him to media technology, and on to the industrial interface between the mobile phone and embedded technology.

"These are two different worlds," he says. "Young people are comfortable with the mobile phone and how to develop for it, while the older guard traditionally work with embedded technology." For Alex, it's a matter of merging the two, in a way that inspires both camps.

"We want to expose the innards of embedded technology and open up for low-level, secure connectivity. For that we have to teach mobile devices new tricks."

This means adding embedded functionality, like Bluetooth and industrial-grade protocols to make phones and tablets smarter. With this approach, major manufacturers like Ford and GM are opening up for use of mobile IIoT to create diagnostic tools and user-friendly apps, and the technology is showing up on ships as well.

Enabling the pocket computer

The connection is also making its way into the classroom. BBC and Acorn came out with a microcomputer 30 years ago, in the 'BBC Computer Literacy Project'. The aim was to make at least one of the machines available in every school in Britain. "Now they aim to put one million single board computers in the hands of school kids across Britain," Alex says.

The new computer is no larger than a business card, with an exposed LED array, Bluetooth, and simple push-button programming devices. Evothings created the software to connect the computer to the mobile phone, to enable students to see what is going on in the chip, and control it.

"The chips are designed to be a bit makerish and geeky, and that seems to make it even cooler," Alex enthuses. "Kids with phones will now have sensor-prone computers in their pockets." Many major players were involved, like Lancaster University, ARM (the former Acorn), Samsung, Microsoft – and Evothings.

Right sized

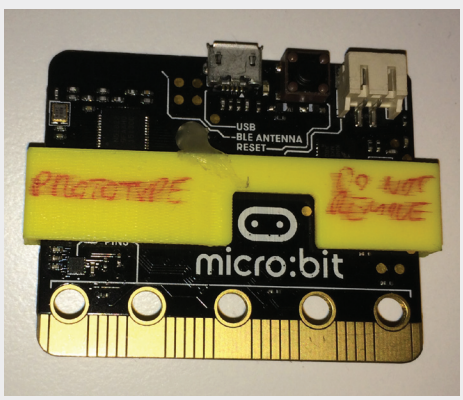
Small, but not without resources, Evothings mobilises a community of around 10,000 developers in 130 countries around the world. "Every day the community becomes more valuable," Alex says, adding that travelling light will be an advantage for companies looking to ride the new wave of industrial apps. "The kind of accelerated development we are talking about just doesn't happen in the big companies."

So where is this development headed? Alex and Evothings believe that so-called hosted apps, where part of an application comes from an appstore, and part from the cloud, are the wave of the future. "I have hundreds of apps on my phone, one for each thing I want to do, but it's starting to get a bit silly," he admits.

Smart infrastructure, though, places apps in places, in what Google calls the 'physical web'. The app resides in a particular space, and when the user leaves that space, the app goes away.

Above all, Alex Jonsson believes in opening up. Using open source solutions, the entire connected community can contribute to creating, fixing and improving products. "It's not really free like a free lunch," he maintains. "It's more like free speech."

According to DMI International, the average industrial app costs USD 200,000 to develop – and that's just the average. "We have to find other methods to make apps. In order to get the data out of systems and give it value, we need more streamlined methods to put more apps in the hands of more people."



The single board computer

Getting personal

Inmarsat's main business has always been keeping people safe at sea. Now they are also in the business of keeping them happy.

"Five years ago our business was driven by operational communication. Now personal communication is on the rise."

There's no contradiction here, assures Drew Brandy, Vice President in charge of market strategy at Inmarsat Maritime: "It's still about crew welfare, keeping them not just physically, but also mentally healthy. Allowing them to stay connected with home and conduct their personal business helps keep them happy. And a happy crew is a more focused and motivated crew."

While safety was the impetus of Inmarsat, founded by the International Maritime Organisation (IMO) in 1979 to ensure the safety of lives at sea, Inmarsat is increasingly involved in the personal lives of passengers and crew.

"Five years ago our business was driven by operational communication. Now personal communication is on the rise," says Brandy. "Passenger connectivity is the biggest growing need. On trains, busses, planes, ships; people expect to be connected 24/7."

Despite Inmarsat's obvious proximity to the maritime market, Brandy acknowledges that the maritime industry has been slow to adopt connectivity for crew. "Right now less than 36 per cent of deep sea vessels provide Internet for their crew."

He suspects that some owners and operators still see crew connectivity as a luxury item, even though it makes up only a small fraction of total operating costs, and certainly helps with recruiting. Regardless, Inmarsat expects the trend to catch up with shipping. "We are seeing an increase in demand for content rich services. In response to this we have launched our Maritime Entertainment Service. One thing we know, the price of technology will come down."

Diversification brings synergies

Aside from the personal connectivity aspect, Inmarsat's business has evolved significantly since its founding. Now they serve the enterprise, government, land, and aviation segments, though their business is still very much driven by maritime. One boost that diversification has provided is being able to take advantage of synergies between industries, most notably between aviation and maritime.

Drew Brandy

"The connectivity challenges are similar, on the bridge or in the cockpit, and for passengers and crew. Our technology roadmap will have to match the needs of both industries, and they will continue to influence each other," Brandy maintains.

"The two industries look to each other. Safety services in maritime, including position reporting, are carrying over to aviation," he reports, with recent incidents involving the disappearance of passenger jets obviously increasing the interest in being able to accurately plot the position of planes.

Maritime on its part is learning how to take advantage of access to real-time operational data. "Operational data is transmitted continuously from the air, and the amount of data is increasing." Inmarsat's vision for 'The Internet of Everywhere' addresses this for the maritime industry, allowing companies to capture every aspect of operations from anywhere on the globe, and use it to tweak or optimise performance. "Maritime operators are now developing an awareness of maintenance needs at the same level as in aviation," Brandy observes.

Keeping information safe, too

With so much critical data flowing through the airwaves, cyber security becomes of paramount importance. In order to ensure cutting edge technology and expertise in cyber security, Inmarsat has recently signed a partnership with Singtel Trustwave to develop a Unified Threat Management (UTM) solution delivered through Fleet Xpress, Inmarsat's next generation of maritime communications.

"We live in the internet age, where everything and everyone is connected. That means we need to take precautions," Brandy states. "Safeguarding information is absolutely fundamental

Inmarsat control center

to our future success, and that of our customers."

He also throws down a challenge to the maritime industry: "They need to educate themselves on threats and the need for mitigation. Many don't see the reason why anyone would hack a ship, but the motivation is out there. Whether it's economic or idealogic, the threat to crew and cargo is too great to ignore."

Meeting the next challenge

How does Brandy see the role of satellite communications in the future of the maritime industry? "A lot of understanding how we can help the industry is about spotting the next trend," he points out. In keeping with that philosophy, Inmarsat is in the process of relocating several of their offices to maritime innovation centres around the globe.

"We want to work closer with the industry where it makes sense. For that reason we have moved to a new location in Rotterdam, and we will shortly be moving to a new office in Ålesund, Norway," both well-known centres of maritime initiative and innovation. "We need to be in environments where we can be a part of the latest thinking and take advantage of that to our customers' benefit, but equally support and foster innovation through working with like-minded organisations."

One area demanding increasing attention is unmanned ships, or autonomous vessels, though Brandy cautions against confusing the two: "Autonomous vessels mean more automation on board. A totally unmanned vessel is something else entirely."

In both cases issues abound concerning safety and regulations: is either one even really possible? "Inmarsat is interested in increasing the autonomy of vessels, not in taking crew off the ships." Brandy believes the trend over next decade will be to more automation and increased efficiency, leading to a safer work environment for crew on board, and more attractive maritime jobs on land.

Does he see anything on the horizon that might disrupt Inmarsat's long record of steady growth? "There is a lot of fibre being laid, for example in the Gulf of Mexico. I think that would be the key challenge, other technologies rather than other satellite companies."

But perhaps Inmarsat's biggest challenge, Drew Brandy believes, lies in changing attitudes. "We need to help shipowners see connectivity and communication as more than just cost. This is now a part of doing business. If you exploit connectivity effectively, it can actually pull a out lot of cost out of your business model, and give you a stronger position for the future."

John Maley is the Global Leader for Freight Logistics in IBM Travel & Transportation. Generations asked John to share his views on connectivity, how it affects companies and communities, and where the road ahead will take us.

Q&A with IBM

John Maley

IBM built its reputation on computers and computing power. Now the focus is on artificial intelligence, or cognitive technologies, with IBM Watson. How will cognitivity shape connectivity?

While it's true that IBM has successfully built a very strong reputation for having both hardware and software computing power, IBM has also been transforming itself over the past several years. This transformation has been and continues to be essential in order to ensure that IBM meets the changing needs of our clients. As part of this transformation, we divested our commoditizing offerings and dramatically accelerated the growth of our strategic imperatives – Data and Analytics, Cloud, Mobile, Social and Security – to help our clients 'become digital'. Then last year, we launched integrated units to make it easier and quicker to put together solutions drawn from our expanding digital portfolio. Now, in 2016, we have reached a new stage in our transformation. As important as becoming digital is to our clients, it has become clear that it is not the destination. Rather, digital business is converging with a new kind of digital intelligence – what you will recognize as Watson. We call this Cognitive Business. Today, IBM is much more than a hardware, software, and services company. IBM is now emerging as a cognitive solutions and cloud platform company. And this capability will be our cornerstone as we enable connectivity across the enterprise, across the ecosystem and across the globe.

As one of the more connected companies on the market, what is IBM's vision for the truly connected world?

IBM's leading-edge cognitive technology is the starting point. The company is developing entirely new solutions businesses around that cognitive capability. For example, in 2015 the

> “The expression ‘data is the new oil’ is true in many ways. Without refinement, raw data is useless to an end user.”

Watson Health unit was formed, which is IBM’s first business unit designed around a single industry. The company is now also focused on cognitive solutions for the Internet of Things (IoT). It is estimated that there are more than 9 billion connected devices operating in the world today, generating 2.5 quintillion bytes of new data daily. Watson IoT will bring the power of cognitive to the challenge of extracting and analyzing data embedded in intelligent devices in real time. In addition, the recent closure of The Weather Company acquisition expanded the company’s IoT platform. Now we can collect, integrate and analyze data from three billion weather forecast reference points, including satellites, weather stations, airplanes, consumer apps, and more.

Are there any drawbacks to the connected world, or is it all good? If there are down sides, how does IBM deal with these?

This is one of the most common questions I get asked when I discuss IBM’s view of a digitally connected world. And without a doubt, the conversation will eventually navigate to the question of security. With more “things” talking to systems of record, systems of engagement, and each other, how do we ensure that all of this data is transmitted and shared with 100 per cent security? IBM views security as the foundation of any new technology or IT project. That’s why we have invested so heavily in this area. Not just as solution offerings for our clients, but also as security solutions used by the IBM Corporation to ensure our own information integrity. You could say, we eat our own cooking.

ABB is a global leader in power and automation technologies. Trending right now for the maritime segment are remote diagnostics and integrated operations, and automated container terminals. As ABB’s marine and ports business continues to embrace the concept of ‘The internet of things, services and people’ in their business model, what role can IBM play in ABB’s future success?

In today’s world, physical devices of all types are now instrumented with computing capabilities that allow for direct sensing and communication of data. IBM’s focus is enabling companies to use that data to improve operations, drive new business and work directly with clients. It’s a conversation that starts with data, continues to information and arrives at insights. The expression “data is the new oil” is very true. Without refinement, raw data is useless to an end user. But once the conversion has taken place, insights into business can be obtained. It is IBM’s mission to use our skills and technology to assist and advance our clients along their cognitive journey.

A very connected place

You know when you meet it: that atmosphere where all the players seem to work in harmony. A shared sense of calm urgency, a determination to make things work, and a willingness to pull together to secure a brighter future.

Rotterdam is one of those places. In a land where nothing less than the sea itself is kept at bay by human ingenuity and determination, the ties between the population and the surrounding ocean are deep and strong. It is here that the maritime industry finds one of its most interconnected communities, a society where the members compete, cooperate, and, most of all, communicate with each other to create maximum value from the resources available to them.

The best examples of connected Rotterdam are those that demonstrate its diversity: technological, human and economic capital, working together and reaching out time and again to find new opportunities for individual, but above all, collective success.

Rotterdam is a remarkably connected place in the maritime world. The next few stories are just some of the examples of why, and how.

The Erasmus Bridge in Rotterdam

Every link in the chain

With a history of marine finance dating back to 1720, ABN AMRO is perhaps among the banks in the world best qualified to spy good investments along the entire maritime value chain.

"We finance ships and ports, the supply industry, yards, inland waterways, global shipping and offshore equipment," says director of global transportation investment at ABN AMRO Gust Biesbroeck, in an emphatic confirmation of their broad maritime reach.

Not restricting their scope to operations and technology, ABN AMRO also deals in commodity financing, for example funding not just tankers, but their cargo.

"We try to understand how the whole maritime value chain works," Biesbroeck explains. "It's a fairly unusual strategy, but it gives us some advantages. By investing along the entire chain we gain access to more activities, and are better able to assess the risk."

Though not uncalculated risk. In kind with the mariners they have financed over the centuries, ABN AMRO embarks on their global journey emboldened buy sound competence built up on their home territory. "Being strong in our home market is the foundation for our global mandate," Beisbroeck maintains.

"The key is to see a ship not as a separate entity, but as an integral part of the logistic value chain."

And going global requires its own mindset: "We have offices in all the relevant maritime cities around the world. Keeping a global team connected requires special measures, not just technologically, but with an eye to the human side, making sure that people meet, and get to know and trust each other."

It all adds up

Reflecting their slogan, 'A better bank for a better world', ABN AMRO sees sustainability as an integral part of their strategy. "We try to use our capabilities to accelerate the transition to a more sustainable economy," Biesbroeck explains, adding that this has proven to be sound business practice.

"Sustainability is completely essential to long-term wealth creation in the world," he maintains. "We are convinced that the maritime companies who get this right will be tomorrow's winners."

Though they have proven their dedication to financing cleaner, greener newbuilds, ABN AMRO is also willing to invest in cleaning up today's outdated ships by financing

“I believe the next generation will be revolutionary.”

Gust Biesbroeck

green retrofits. A founding member of the Sustainable Shipping Initiative, a ‘coalition of the willing’ aiming to achieve successfully sustainable shipping by 2040, they participate actively in the organisation’s three pillars of a green foundation for shipping: dialog, sustainable recycling, and retrofitting.

Their financing of Grieg Green, a sustainable ship recycling enterprise in Norway’s Grieg Group, is one recent example of putting their money where their mouth is. “It was slow in the beginning, but now we see their growth is accelerating.”

Riding the green wave, ABN AMRO recently issued their first green bond to fund a sustainable real estate portfolio. Now they are employing the same methodology to investments in shipping. “We are looking for proven technology that creates additional cash flow from other savings. The key is to start seeing a ship not as a separate entity, but as part of the logistic value chain.”

Heading for a revolution

After 25-plus years in the maritime finance business, Gust Biesbroeck can still be inspired by the newest comers to the industry: “I recently attended the annual dinner at the Port of Rotterdam, where they presented around 20 startups from their new incubator. The companies each had 90 seconds to pitch their ideas, and I was very encouraged by the innovative concepts they presented.”

Focusing on digital technology and connectivity to drive improvements and rectify inefficiencies in the value chain, the startups are targeting that sweet spot that ABN AMRO looks for in sustainable investments. “Improved efficiency means better performance, and that makes any company a better risk client,” Biesbroeck confirms.

“In my years as a banker, I have seen relatively little technological innovation in shipping, but I believe the next generation will be revolutionary.” More than just ‘ships full of chips,’ Biesbroeck explains, the innovations to come will be more disruptive by making ships more efficient, and thus more attractive as investment objects.

“It could shorten the life of ships, making them obsolete much quicker than we have seen up to now, or they could force more new ships out on the market.” Either way, the revolution will have the same effect: out with the old, in with the new.

The bad brings out the good

Though they stand apart in their approach to the maritime value chain, ABN AMRO is in the same boat as

The Anthony Veder

nearly all other players on the maritime market in 2016: Times are hard, and they're not getting better soon. "Shipyards are running out of orders," Biesbroeck acknowledges. "Those who survive the current downturn will have to come up with something new. The next wave of innovation will be driven by companies with clear targets for improving logistics."

He sites a major Dutch conglomerate as an example, though there are many with the same approach. "Cargo owners demand green ships for green products." In turn, carriers put the same demands to their chosen shipbuilders: "Investment funds are moving away from anything that pollutes, and that will trigger reactions up the value chain."

In a down cycle, any innovation that conserves resources is welcome, Biesbroeck believes, because reduced consumption means reduced costs. "Honestly, a downturn will often be good for the banks, simply because it puts us in a stronger bargaining position. The upside for society is that it makes it easier for us to present stronger demands for sustainability to our clients. As a bank with green goals, we can use the down time to leverage more sustainable shipping."

ABN AMRO recently conducted a study to quantify the risk associated with going green. "We found a high correlation between the best run and the most sustainable businesses," Biesbroeck reports. "The best run companies are also the most sustainable, and they proved to be the best credit risks. Running a clean ship works in every way."

A strong link

Here Gust Biesbroeck may be on the trail of the answer to shipping's modern riddle: How to be perceived as part of the solution for society, instead of being blamed for the problems.

"In many of my presentations I try to make my audiences more aware of the role shipping has in their lives – the coffee you drink, the clothes you wear, the car you drive, your TV, your phone, all those things have come to you on ships, and that's a good thing, also for the environment. But most people know very little about shipping unless they hear about an accident of some kind."

So how to change the image of the industry? "Many in shipping feel that it doesn't matter what the general public thinks about us as long as we do our job, but I disagree. I believe we need to help people understand that shipping is completely vital to the life that we live. We are living in a connected world, and that is our business. Connecting people with the things they need to live. I believe the way to help people understand this is really just to keep telling the good stories," Biesbroeck concludes.

With 300 years in one of the oldest and most well-respected maritime communities in the world, now helping the industry to meet their most pressing modern challenges, ABN AMRO is certainly in a strong position to keep spreading the good word.

APM Terminal, Port of Rotterdam

“Investment funds are moving away from anything that pollutes, and that will trigger reactions up the value chain.”

The connection to sustainability

As Europe's largest seaport, and with the ambition to be recognised as the most sustainable in the world, the Port of Rotterdam needs to exploit every means available to strengthen its leading position. Digital connectivity is foremost among those means.

"We know that being connected can give us a competitive edge in many areas if we do it right," says press officer Tie Schellekens of the Port of Rotterdam, citing this as the prime motivation for the recent restructuring of the entire port organisation around connectivity.

Port director for containers Joyce Bliek has distributed executive responsibilities so that she can focus her full attention on the issue, and she has built up a team with its primary goal to take maximum advantage of the new digital dimension in logistics.

"There are many opportunities, but we are still in the early stages," Schellekens says. "For example, some years back, together with the port of Amsterdam, we established PortBase." Via the Port Community System, PortBase currently offers over 40 different services to approximately 3,200 customers in all sectors of Dutch ports. "This has proven to be a very useful system, but it has even more potential."

Before the port can fully realise the benefits of the communication system, all users must feel confident that their information is secure. That requires anti-hacking measures, data segregation, and a score of other sophisticated solutions. "If we want to reap all the benefits, the system must be accessible and dependable for everyone," Schellekens underscores. "For cargo owners, shippers, and for the port."

"We need the enthusiasm and energy of the next generation if we are going to stay ahead of the competition."

The physical connection

Rotterdam has another, less universal issue related to sustainability and connectivity: that of European inland transportation routes, and their interface with the port. "It really comes down to strengthening the value chain," Tie Schellekens says.

"For us the focus on connectivity also means being connected with the origins and destinations of the goods that are shipped to and from Rotterdam. That means organising the waterways and railways better in order to enhance flow through the port."

But digital technology can also be a helper here. "Automation will help us speed operations up, but we need

Port of Rotterdam offices

Port of Rotterdam

technological support to put efficiency measures into place. We literally travel the world looking for the innovations and start-ups that can help stimulate our business," Schellekens reports.

In response to one of their more interesting findings, The Port of Rotterdam is sponsoring a new 3D printing initiative. "3D printing is a very interesting technology for many young engineers. They see possibilities that later generations don't see, and we want them to work here, with us, to find ways to make 3D printing more useful, not just for the port, but for the whole value chain," Schellekens says.

In order to attract the brightest talent, the port will invest in a new, bigger metal printer far beyond the financial reach of young companies. The machine will have its home in the Innovation Dock at RDM Rotterdam, located in a renovated ship's wharf. The goal is to provide port-related companies with a collective location to pursue the development of knowledge in the area of metal printing, 3D scanning, 3D design and certification.

The human connection

At RDM Rotterdam, the port also supports the region's technical schools, to try and stimulate students to choose maritime technical education. "We need updated skills and knowledge to achieve our long-term goals," Schellekens says, "but we also need the enthusiasm and energy of the next generation if we are going to stay ahead of the competition."

In addition, the Port of Rotterdam finances five professors on different subjects relating to port activities. "They use the port in their studies, and we share their results with the entire industry," Schellekens says, illustrating yet another aspect of connectivity between players. "From our point of view, this is essentially an industry support initiative," he explains. "We do it to help all the players become more efficient, that makes us all more sustainable."

In Schellekens' view, sustainability is vital to a port's existence, and connectivity is the path to sustainability. "If we supply the right information to the right people, it can help improve efficiency, and improved efficiency means a more sustainable port."

For example, if a cargo carrier knows where cargo is waiting to be picked up, they can avoid transporting empty containers. But for that to happen, they have to know everything about inland terminals and port activities. "For everyone to get access to this information, they have to be a part of the shipping community, and they have to be interconnected," Schellekens emphasises. "That requires flexible, open, and secure systems."

In this and many other aspects, the Port of Rotterdam acts as a catalyst in stimulating efficiency and sustainability throughout the value chain. "We have seen that when we don't take these initiatives, nobody else does either. Connecting things and people is not just about technology. It still takes good cooperation to achieve true connectivity."

Finding common ground

If you are from the Netherlands, you probably know the term 'Polderen'. If you are not, you definitely have something to learn.

According to Michiel Spitzer, senior communications consultant in Nederland Maritiem Land (the Dutch Maritime Network organisation), polderen is the glue that binds the famously interconnected Dutch maritime community together.

"Our members are very occupied with being connected," he confirms. "The essence of polderen is working together and finding common ground, and it is at the heart of everything we do."

Citing it as one of the keys to the country's maritime success, Spitzer continues: "There is a fine line between competition and collaboration, but the Dutch maritime industry has no problem with working together, even if they might compete in some areas. We are always seeking common prosperity."

Tech too

Not limited to human interaction, the philosophy permeates the community's thinking on all aspects of connectivity, including investments in the exploitation of connected technology. The Dutch government partially funds Joint Industry Projects (JIP) on maritime innovation projects, and NML acts as a facilitator in organising these JIP's.

"We try to facilitate mutual cooperation between research and education, industry and public interests," Michiel says. "The traditional triple helix, binding together the central elements necessary for economies to grow. And to ensure that innovations are market driven"

With emerging automation and robotification, NML also sees a pressing need to change the way the Netherlands educates their future maritime heroes. "They will need to know how to share information, and how to join that information with mechanical innovation. That will be the key to our success," Spitzer emphasises.

Connected diversity

For now, Spitzer reports that the network and its members are doing relatively well, largely due to the Dutch maritime industry's investment along the whole maritime value chain. But the downturn in offshore oil and gas is definitely furrowing brows in the community. How do they see themselves surviving, and thriving, in the hard times?

"Marine maintenance and retrofitting will still need bodies and minds," Spitzer confirms, "and so will the operation of offshore wind parks."

But beyond immediate economic concerns, one of the NML's main worries, and one they share with their colleagues in the Netherlands and around the world, is the urgent need to prevent 'brain drain' due to negative media coverage of the sliding state of the offshore oil business.

Station keeping

As to how to keep the best talent choosing maritime careers, Spitzer offers an alternative: "Dredging will always be important in the Netherlands, but it is also in global demand. It can compensate somewhat for the decline in offshore." Regardless, he concedes that the maritime industry is in for a struggle to find replacements for offshore oil and gas.

Still Michiel Spitzer has faith in his chosen field. The main attractiveness of the maritime industry for new recruits, as he sees it, the universal value of a maritime education.

"Once people get in to the industry, they don't leave," he testifies, "or at least they don't have to." A maritime education provides a versatile package of skills, and Michiel Spitzer believes there will always be a need for that skill set in the industry. "The world is growing, and that means the need for bringing people and things together will grow too." People staying together, working together, and pursuing common prosperity. That's *polderen*.

"The world is growing, and that means the need for bringing people and things together will grow too."

Keeping pace, one step at a time

The reality of next year will be different than this one. Those successful in the past will not necessarily succeed in the future.

"The time of five-year strategic plans is over. Create a ten-year vision, and work toward it one year at a time."

This rather daunting description of the present reality comes from Ralf Schlaepfer, Partner and Country Lead for Manufacturing with Deloitte in Zurich. "The life-span for companies on the Standard & Poor's 500 index list is getting shorter all the time, and many at the top of the Fortune 500 list weren't even there a decade ago," he points out.

In fact, since 2000, 54% of Fortune 500 companies are gone, and it is the digital revolution that is changing or challenging business models.

"Sensors have gotten so small and so affordable that they are appearing everywhere." Schlaepfer recalls a conversation with a Space Shuttle astronaut flying the first missions in the 1980s: "He said they had three big sensors that could indicate up down, right and left. They were each about one square metre, and cost one million USD apiece. And they had to have three, because they were so unreliable."

The companies

Now, Schlaepfer says, Moore's law of exponential growth applies to all technologies: 3D printing, biotech, drones, robotics and more. And this is affecting virtually all enterprises in the value chain, from manufacturing and shipping, to shopping. Or, as Deloitte says in their Tech Trends 2016 report: "*Every* company is now a technology company."

What, then, is Deloitte's role in this changed world? "We help our clients understand where challenges are coming from. They need to reinvent themselves. If they were successful because of superior engineering and products, now they have to address the Internet of Things and exponential technologies to see where it will change their business models. Our job is to help clients understand the digital world, and which of these exponentials will change their businesses."

He believes companies need to

Ralf Schlaepfer

integrate themselves with their suppliers, and their clients. In an example of asset sharing, he cites Local Motors, a manufacturer of bespoke automobiles in the US. “They are crowd sourcing design, with 600,000 contributors and 3D printing, and producing one-of a kind vehicles.” This ‘audience participation’ also gives them automatic buy in from their customers, making them less dependent on dealers, Schlaepfer says.

The people

Of particular relevance for the marine sector as it seeks to plot a new course into the future, what does it mean for the people in more traditional companies when their employer makes the transition into the digital age?
“It starts with how to train the staff,” Schlaepfer says. He refers to a study done in Switzerland, where 4 per cent of companies felt they had the staff they needed, 16 per cent felt they had the wrong people, and 80 per cent believed they needed to re-train staff.

“In addition to training, there are other ways to transform a company,” he adds. “Change can also come from the edge.” In Deloitte, they still retain their core businesses, like accounting, corporate tax, and advisory services. “But we have to move beyond product innovation and change our business model. Our new initiative, Deloitte Digital, is being built from the fringe, and that requires a different kind of staff, and a new way of thinking.”

The new breed does not come to work in white shirts and suits, he says, but rather T-shirts and sneakers. And they don’t sit quietly in cubicles or offices. “They work in crowds, discussing and investigating. They look different, they act different, they think different. We still leverage our top ranking in IT and consulting, but these new people are helping us develop fresh angles and new approaches.”

The question virtually poses itself: How does a company like Deloitte, with a strongly conservative image, recruit unorthodox millennials? “We have to convince new recruits that they have a chance to do something new in Deloitte. We are in the forefront of trying to identify change and build new business models, and they can see in our reports that we are truly committed to understanding the changes.”

The risk

“Cyber security is the biggest challenge,” Schlaepfer states. “Most of our clients are not even close to having the right IT infrastructure to be secure,” though he cautions against thinking that using more money means getting more security.

“I was talking to a real estate developer who was renting out interim space. He was offering free business apps for these flexible solutions. There is always a risk, but the answer lies

in making smart choices. You have to balance between the risks and rewards, and you have to be willing to share in order to take advantage of new developments."

Schlaepfer tells of an artificial intelligence (AI) company that turned their technology loose on Twitter. After 36 hours, their tweets were displaying offensive language. The machine had simply learned from other 'unfiltered' tweets and was mimicking them. "That just shows that we have to be aware of what it means to put information out there. It opens up a lot of opportunities, but it can also go in the wrong direction."

The same goes for protecting your physical assets. Today it is possible to monitor tire pressure on a fleet of trucks or cars through pressure sensors in the rim. But, as Schlaepfer points out, "From that sensor you can hack through to the car's motherboard, and from there to the engine." The same might be true of sensors on board a ship. His point is that wherever you might think it's a good idea to produce and access data, you have to check impacts on the entire operation, whether it be a car, a factory, a ship, or even an entire fleet.

The learning

Meanwhile, innovation is outpacing institutions across the board. Google and Tesla have driverless cars on the roads while legislation lags behind, and, one of Schlaepfer's main concerns for the digital age, current educational models are proving unable to keep pace with developments.

"Long-term study plans are outdated before they are even implemented," he observes. "We need flexible curricula in universities. I am advising institutions where they have no fixed courses. The programs are changing as we speak."

AI is increasingly taking over standard tasks, allowing humans to focus on more creative, innovative work. As a result, education can focus less on standards more on the potential to create new business models. Schlaepfer also believes it is time once again for the generalist, rather than the specialist.

"We can't be focused on one single target. We have to have broader goals, and we can't be afraid to try and fail. In Silicon Valley they have a culture of 'failing forward', or learning from failure in order to succeed. In more conservative cultures, failure is fatal, and we have to put that behind us and learn from our mistakes."

Cultures, though, have a way of being surprisingly resilient. "In many places in the world, they are dealing with the same issues as 3000 years ago." Resistance to change is often built in, and that applies especially to companies in tradition-bound industries like shipping. "They must learn to adapt, learn to get rid of the 'stickiness' of things that they have always done."

And back to the people

"The most innovative start-up communities are always trying to devise new ways for their people to interact with each other. There is often no clear leader, just a group of individuals collaborating on new ideas." Keeping pace with change, in other words, is all about what we can share with each other.

Even industrial behemoth GE has set up FirstBuild, a micro factory where development of appliances is reduced to four or five weeks, instead of three to four years. "In order to achieve such quantum leaps, you have to bring people together who are

Every company is now a technology company.

interested in other peoples' ideas. This is the kind of incentive that creative people are looking for."

Ralf Schlaepfer has a Japanese colleague who lamented the lack of passion at his workplace. He told Ralf: 'People leave their soul at the door. They live their real lives at home.'

"These are the cultures that need to be challenged. Challenging brings positive energy, and even the most established cultures are learning this." In a more enlightened example from Japan, Schlaepfer knows of companies who assign the challenger role to employees in turn, just to make sure that at least one dissenting opinion is voiced in the highly conformist Japanese business environment.

"Always encourage creativity, and invite people to make mistakes. This is important in attracting the right people. You want them to feel energised. The biggest problem we see in established companies today is lack of motivation."

Cautioning against trying to extrapolate from the past to predict future, Schlaepfer encourages businesses to experiment continuously, zooming in and out, but staying focused on the big picture. "The time of three- or five-year strategic plans is over. It simply makes no sense anymore. Instead, create a ten-year vision, and work toward that vision one year at a time."

Rounding off with a story of inspiration, Ralf tells of a friend who was having a conversation with Elon Musk, a true visionary known for tirelessly pursuing his goals. They were talking about Musk's vision for hypersonic-speed transport of people in vacuum tubes, the Hyperloop concept. He questioned whether the extreme acceleration and deceleration wouldn't be harmful to humans, which it most certainly could be. Musk's undaunted reply: "It's an issue."

You won't solve everything at once. The best just keep trying – and learning – one step at a time.

Building relationships

Building ships is what Kleven does. But CEO Ståle Rasmussen knows that building good relationships comes first.

"We don't have our own design, so we team up with designers to compete for projects with owners," Rasmussen says. "That means we have to have good relationships all around." Relationships that last, and that help Kleven navigate through rough seas and calm.

"Only a few years ago most of our work was for regional customers, primarily in offshore oil service. But we could see that things were going to change dramatically in that market, so we began to pursue work in other segments where we had experience. Now our clientele is mostly international, and we are serving many segments, not just one."

For proof, just take a look at the recent deliveries from Kleven, and their orderbook: Luxury yachts, fishing vessels, a diamond mining ship, a cable laying vessel, and Explorer-class passenger ships all witness the fact that Kleven cultivates good relationships across the board, and around the world.

The diamond-mining vessel is for gem giant DeBeers out of South Africa, and departed Kleven Verft for Africa in of June 2016. "Underwater mineral exploration is a new segment for Kleven," Rasmussen said when the contract was announced, "and we look forward to working closely with DeBeers on the realization of this highly advanced vessel." One key to winning the ground-breaking job was cooperation with world-class designer Marin Teknikk, located just down the road from Kleven.

"We could see that things were going to change dramatically, so we began to pursue work in other segments."

Big things in small places

"Shipbuilding and design are really global businesses," he points out, "but it just happens that many of the best designers are in our same neighbourhood." The team of Kleven and Marin

Ståle Rasmussen

Teknikk also attracted the attention of New Zealand's wealthiest businessman, and ultimately led to a contract with him for the offshore-influenced Explorer-class superyacht Ulysses, delivered in 2015. Another, similar yacht is on order at Kleven from the same customer.

"We have worked systematically to expand our portfolio, and the combination of local expertise and an international focus has paid off." Rasmussen also believes the high-end market for private luxury vessels is on the rise. "They are impressive at quayside in Monaco, but even more so sailing among icebergs in the Arctic."

The same might be said of the four new Explorer-class small cruise vessels on order from the Norwegian cruise and ferry icon Hurtigruten. "These are not icebreakers, but ice class, meaning that they can sail in ice-infested waters, and that means they can go places conventional cruise ships cannot." And that is precisely what increasingly sophisticated cruise passengers are hungry for. The Hurtigruten orders will make up Kleven's largest order in their history, at a time when other shipbuilders are struggling, not just in Norway, but around the world.

From supplier to buyer

Kleven and ABB Marine also have a good relationship going back many years, with ABB as a trusted supplier of propulsion and automation solutions. Now ABB has ordered its own vessel, a cable layer that will be loaded to the gills with the very best equipment ABB Marine has to offer, from propulsion and electrical, to automation and advisory systems. "We built the Dina Star OSV with the first Onboard DC Grid system from ABB Marine, and this cable layer will have the same system. I think our success with Dina Star is part of the reason we won this new contract," Rasmussen maintains.

He sees further potential in the cable layer segment as well, as society

transitions into ever more electrification. Connecting offshore installations to power from shore, island societies to cleaner power sources, and not least, offshore wind farms to shore, will all be drivers in the demand for cable laying vessels, Rasmussen believes.

High tech, hands-on

While Kleven has been among the most creative users of automation and robotic technology in their production processes, Ståle Rasmussen is adamant about maintaining a physical relationship to their very physical job of putting ships together. “The technology is becoming cheaper and more accessible, but we still have to have a good understanding of steel and how to work with it. Robots and automation make it possible for us to compete from our remote location, but we will always be a hands-on industrial company.”

As with nearly every industry, information technology has also changed the way business is conducted in shipbuilding – but for Kleven, the attitude remains unchanged. “Connectivity allows us to work directly with clients and partners globally, and to deliver safer, more efficient ships, but it doesn’t shift the responsibility. We have to maintain our core competence, and the ultimate responsibility lies with us. It’s an illusion to think that everyone can be a consultant.”

That rock-solid approach to a business built on water definitely has its appeal. The proud owner of the Ulysses has another, even more ambitious craft on order at Kleven, to be delivered in 2016. “Before we got the contract for Ulysses, he visited Kleven Verft at Ulsteinvik. I think we won him over on our competence from both offshore and yacht building, but we also had a good chemistry, and I think he liked the atmosphere.” Again, it comes down to personal relationships. “We will always be highly involved, with our partners and with our customers. We may be on Facebook, but the way we really work is face-to-face.”

Ship construction at Kleven

Kleven Verft

Rapid developments in information and communications technology have already transformed how shipping companies collect, process and use data. But the real digital revolution is yet to come.

Embracing the digital world

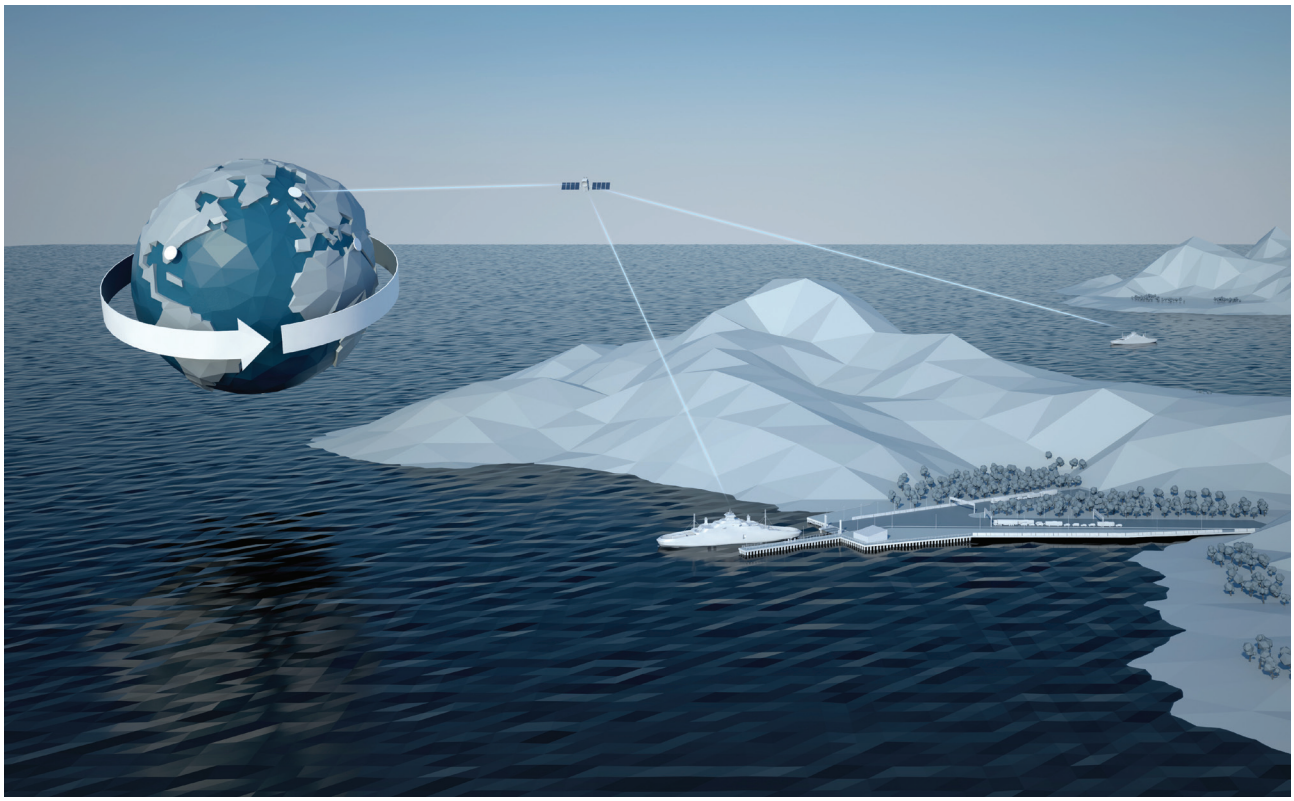
Gabriele Manno

Today, we live in a world that is continuously becoming more data-driven and automated, where physical systems and people are increasingly connected and mirrored into a virtual space. Key developments in Information and Communication Technology (ICT) include sensor technologies, improved ship-shore connectivity, advanced software tools and algorithms, increased computing power and faster processing times. ICT has also enabled more far-reaching concepts (e.g. Big Data, the Internet of Things, Cloud Computing, etc.) that will provide the shipping industry with new ways to collect, sort, store and utilise valuable data.

According to DNV GL's Gabriele Manno, Digital Innovation Manager, Digital Solutions and Innovation, DNV GL Maritime, these new technologies will have far reaching consequences for shipping. "No one is sure exactly how fast all of these technologies will mature or how they will be applied to the maritime environment," he says. "But we can say that change is inevitable."

Smart maintenance

Manno says that there are already a number of suppliers, including ABB, which have developed land-based stations to provide remote monitoring of on board systems. At present, these shore-based monitoring stations are utilised to collect data on specific systems and support on board personnel on predictive maintenance and diagnostics. In time, manufacturers, system integrators and related service providers will be able to support owners with information in real time about the conditions on board, providing specific guidance to maintenance



crews via virtual-space software and hardware.

"Developments in ICT are enabling owners to move from the existing scheduled maintenance approach, a process often driven by supplier recommendations, to condition-based maintenance, a process driven by the actual condition of on board components and systems," he says. "This significantly reduces costs related to maintenance and more importantly, improves safety performance. Crew access to real time data and shore-based support will improve situational awareness and reduce operational risk."

Leveraging big data

Improved connectivity and sensor technology is also providing owners access to more data, which can be analysed and shared with other stakeholders. By combining data streams from multiple sources, the sheer volume of information available will enable the industry to make more informed decisions, faster, leading to more efficient and responsive organisations. The network of connected physical objects able to collect and exchange data, known as the Internet of Things (IoT), is growing, encompassing buildings, products, even clothing. In time, these databases will be accessible through vast information management systems, which, combined with fast computing and advanced software via distributed networks, will help owners integrate more closely with suppliers.

Shipping in the cloud

Manno points to a number of developments in this area now taking place on land. "We are seeing how many land based industries are developing and utilising connected, cloud-based data services to optimise efficiencies in everything from factory operations to maintenance, supply chain networks to purchasing," he says. "By some estimates, about fifty billion devices will be connected by 2020, sending terabytes of data about every aspect of operational efficiency to computers to be analysed."

Companies developing the tools to manage all this information are springing up all over the world. For example, PTC, a US-based software company, has developed a number of IoT services to collect and capitalise on the information now being generated by customers, suppliers and products themselves. One service developed by PTC, called ThingWorx, is the world's

“The vessel operator of the future will know more about software, predictive algorithms and virtual reality than engine parts or piping.”

first open platform to build and run applications for the connected world.

Another example is the industrial cloud Platform-as-a-Service (PaaS) that helps collect and analyse data. “It’s an open platform, a bit like Apple’s the App Store, a market where developers can create and monetize innovative new industrial apps,” says Manno. “At present, most available services cater to land based industries, but we expect developers to produce apps to meet the specific needs of the shipping industry as well.”

Sharing data

While shipping is often criticized for being slow to adapt to new technologies, today’s tough markets are a good incentive to innovate to gain a competitive advantage. Besides, in an increasingly connected world, the shipping industry can no longer afford to act independently – increased public scrutiny of the industry has resulted in more attention from government agencies, seeking to improve safety and environmental performance.

For example, the MonaLisa 2.0 Project, developed by the Swedish Maritime Administration in cooperation with the EU, is a sea traffic management system designed to provide vessels with the ability to see each other’s planned routes, (helping navigators to avoid congestion in areas with high traffic), steer clear of environmentally sensitive areas, and share maritime safety information. The information exchange between vessel and ports will also improve planning and performance regarding arrivals, departures and turnaround times.

The unmanned vessel

Looking ahead, perhaps the greatest potential impact connectivity will have on shipping will be to dramatically reduce – and perhaps eliminate – crewing on merchant vessels. “As sensor and software technologies and connectivity become more robust, remotely operated vessels, or even unmanned vessels, could become a reality,” he says. “We are also likely to see many of the traditional activities performed on board shifted to shore-based centres, which will be responsible for vessel condition monitoring, control and logistics.”

Weighing the risks

Manno acknowledges that (like self driving cars or pilotless commercial aircraft), unmanned vessels remain controversial, but notes that the benefits may well outweigh the potential risks. “By some estimates, 90 per cent of maritime accidents are due to human error,” he says. “By removing the human element, owners can eliminate on board safety risk and significantly reduce potential damage to the vessel, cargo and the environment.” Manno adds that removing the human element will also lower construction and operational costs.

To see how this innovation might look, DNV GL developed a fully functional, scaled down 1/20 model of a remote controlled, battery operated short-sea concept vessel. Known as the ReVolt, this unmanned concept vessel was designed to be a cost-effective transportation alternative to alleviate The EU’s highly congested road network. “While some technologies need to mature before the concept is commercially viable, the ReVolt proves the concept,” says Manno.

A brave new world

For Manno, the shift towards a more connected, data driven shipping industry may take time, but is inevitable. “For companies today seeking to lower maintenance costs, reduce component failures and get just-in-time access to parts, embracing connectivity is a no-brainer,” he says. “The challenges are that many owners don’t yet have the competence to manage such complex systems. Furthermore, the absence of industry standards and concerns about security has lead to a kind of organisational inertia.”

Manno points out that shipping has been more or less unchanged since it transitioned from coal fired engines to oil in the 1920s. “Shipping is by nature traditional and conservative, but once owners understand the benefits of these new technologies, shifting to a new, more connected and data driven business model will be irresistible,” he says. “As for the vessel operator of the future, they will know more about software, predictive algorithms and virtual reality than engine parts or piping. And the best part is, they will be able to go home to their families at night!”

In a recent article on digitally-aided ship maintenance in Ship Management International, David Tinsley noted: “In the aviation sector, unerring development and adoption of condition monitoring is considered to have been a key contributor to the industry’s improved safety record over the last 20 years. The potential safety implications of such initiatives in the shipping sector should not be understated.”

The sky’s the limit

Martin Frutiger

The airline industry is known for leading the way in applied technology. What other industries might not realise is just how far ahead air transport is in the digital sphere.

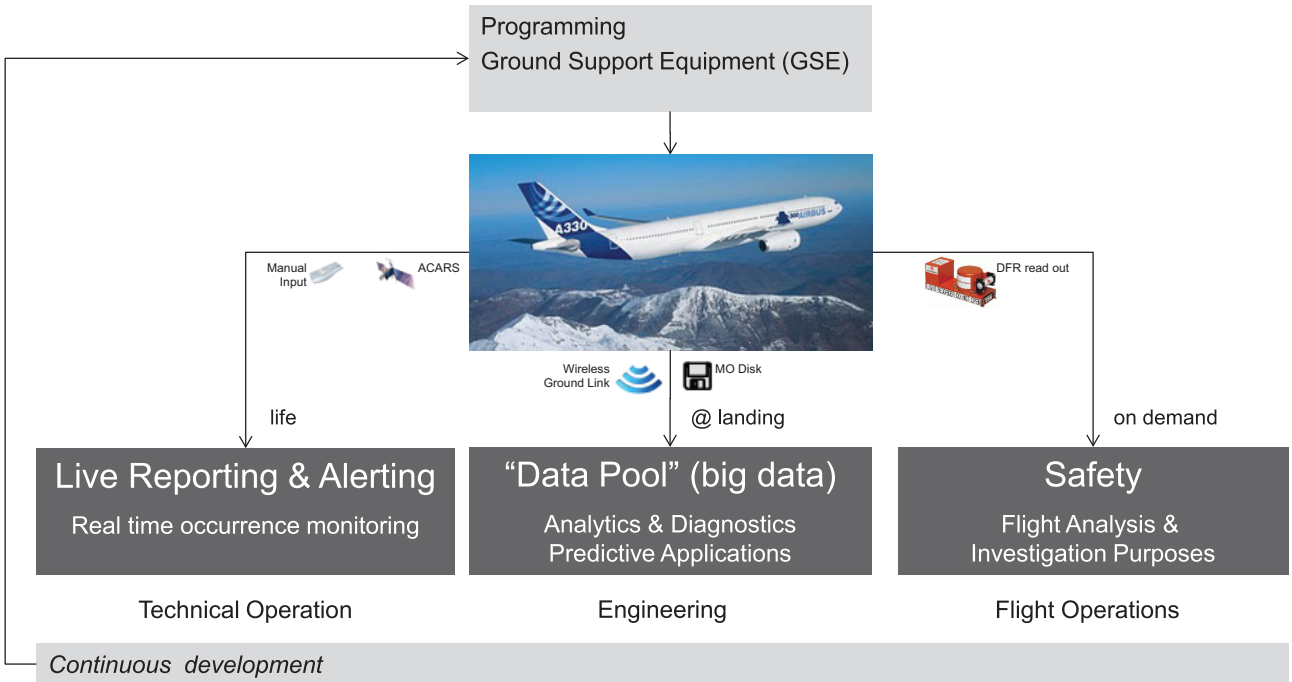
A modern passenger jet can generate up to half a terabyte of data on a single flight, reading from as many as 200 000 parameters. While not all this information can be put to use from every flight, enough is being used to make Boeing state that operators and service providers need to be fully networked in order to operate their aircraft efficiently.

“These are what Boeing calls ‘enabled aircraft’”, says Martin Frutiger, customer program manager at SR Technics, a world leading MRO service provider with more than 80 years of operational experience serving both large and small carriers.

A veteran of airline maintenance ICT since 1991, Frutiger remembers the old analogue aircraft as well, but is not nostalgic. His enthusiasm is too great for today’s giant generators of data for that. “The aircraft from the 1980s were highly mechanical, with fewer sensors and none of today’s data busses, and of course very limited data storage, and no real-time transfer.”

“Today, connectivity is everything,” he maintains, “Not only for passengers who want WiFi onboard, but for the aircraft, the manufacturers, and the service providers. Working with live streaming data gives us the opportunity to have a true picture of the real-time state of the aircraft.”

The global coverage network for air to ground communication is provided by satellite over the oceans, or by surface antennae over land. “But regardless of infrastructure, the system will always try to select the least expensive con-



Aircraft connectivity and data flow

nection for data transfer," says Frutiger.

The data he refers to is technical information, not large files, but mostly snapshot data. "The sensor data is the same as the crew uses in the cockpit, simply relayed to a ground station," he explains.

For each discrete component of operation there are standardised reports: for the engine, superstructure, performance monitoring, etc., in addition to an array of customised reports. Any parameter limits exceeded are captured and transmitted to enable planning and mitigation from the ground. Pilots can also report from the cockpit to the main operation centre, allowing a combination of human and machine communication.

More than just the machine

Airlines are required to maintain flight operation quality assurance programs. These programs monitor the pilot and crew as well, not just the plane, providing a continuous data stream that enables analysis of historical records in order to track performance over time.

"Any patterns that require correction can be addressed and mitigated as necessary," Frutiger says, illustrating the interaction between the human element and Big Data.

But the airlines are not alone in wanting to use the data generated by these aircraft. "Manufacturers also want to use the data. They are interested in the after sales market too. They want to provide total service to operators," Frutiger reports.

Another positive effect of data exploitation, Frutiger reports, is that in addition to using data to maintain the aircraft, manufacturers use the information to improve future models. "In that way streaming and accumulated data is contributing not only to more efficient maintenance now, but to better designs in the future," he observes.

Big Data, big savings

But for Martin Frutiger and SR Technics, the big advantage of streaming data from aircraft in service is in better, more efficient maintenance. "The standard today is rule-based, planned maintenance at fixed time intervals, with replacement and maintenance of parts and equipment regardless of condition," he relates.

"Real-time diagnostics can reduce unnecessary expense by allowing service only as needed. I think conditioned-based maintenance will be the future standard," he says, adding that predictive maintenance will probably not be far behind. "The data is available, we just need to be able to use it

in a structured and 100% reliable way."

And therein lies one of the conundrums of rapid digital development: "Some airlines lack the necessary expertise due to rapid progress in technology," he relates. "Many smaller airlines are suboptimal in monitoring and use of data in maintenance. They feel backed in a corner by all the new demands," he confides. "They can literally be overwhelmed by the changes."

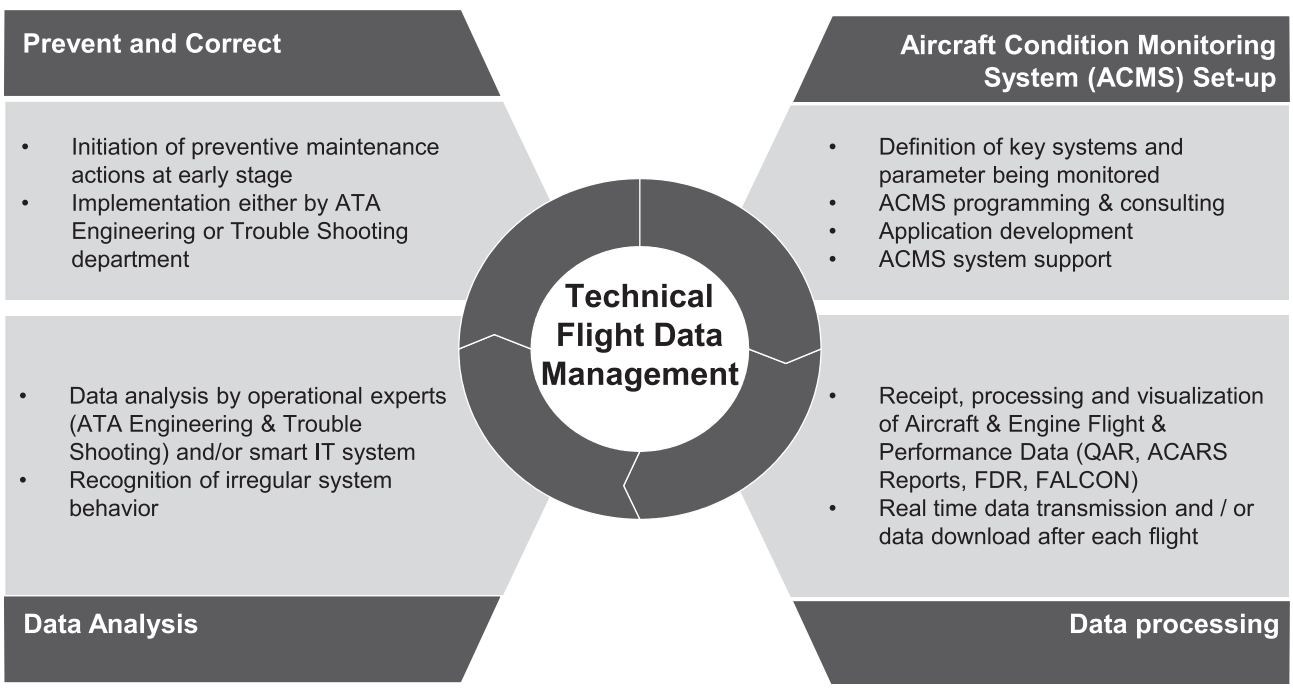
Ready, set – gone

Those who may be feeling overwhelmed today, better be prepared to get caught up. The pace of development is certainly not lessening with time, as witnessed by Martin Frutiger's prediction for the next steps in air transport connectivity:
"I believe direct communication between aircraft is next. If one crew has information about weather, or anything else of importance, that information can be streamed to aircraft following behind, or queries can be sent ahead."

Aircraft-to-aircraft, passenger-to-passenger, locating black boxes from streaming data, data streaming and full phone service from the air – all this will be standard in the very near future, Frutiger believes.

While in some of these areas maritime is actually ahead of aviation, there is much for shipping to learn from the airline industry, in both the pace and the scope of data generation and utilisation. More than just sensors, devices, and 'smart things,' shipping can look to aviation for new approaches to managing data, leveraging infrastructure, transforming services, and building new business models.

The sky's the limit.



Aircraft engineering services – capability and service overview

With its fleet of heavy lift vessels, Boskalis subsidiary Dockwise moves some of the most intimidating cargoes on the water.

Making the impossible possible

Jan de Jonge

Dockwise moves primarily oil rigs and platforms, many of the loads reaching over 100 meters high. Or, in the case of the Sevan 1000 FPSO for the Goliat field in the North Sea, one of the biggest loads ever moved at sea, measuring 75 metres high and weighing in at 64,000 tonnes. Try moving that across four oceans from Korea to Norway.

ABB caught up with Captain Sergei Zatcarinin on the Dockwise Mighty Servant 1, getting ready to transport an oil rig. Captain Sergei has twenty years in the business, and he has his priorities straight: “The cargos are very heavy, so it is very important to control the forces that affect the centre of gravity.” In other words, don’t tip the ship.

The captain is glad to have some help in keeping an even keel. Better ship connectivity and advanced software have given him advantages that previous generations didn’t have. Combining weather forecasts, on board sensors and loading parameters, ABB’s marine software Octopus lets Dockwise generate a polar chart indicating the safest heading for the voyage.

“We can understand what to expect on any given course, even two and three days ahead, and select the one that is the safest and most efficient for us,” he says. “The system works, and you feel more confident. The level of reliability is raised.”

Shore support at sea

A strong shore side team supports the crew on board. Jan de Jonge is a Dockwise Senior marine engineer supporting sailings around the globe. “Software is a big part of my job. Using the ABB system we can track ship motion to make sure they stay within the limitations of the vessel.”

Combining recorded data and predicted conditions, the crew can

“The cargos are very heavy, so it is very important to control the forces that affect the centre of gravity.”

Dockwise Vanguard Semi submersible heavy lift vessel with Goliat

On shore monitoring centre at Dalfsen

actually see how the ship will respond with cargoes of varying size and weight under different conditions. “This allows for safer voyages, making sure that the ship stays within its operational margins.”

Past data can also be used to improve future performance, de Jonge tells. “We used data collected since 2008 to perform a major study that gave us a lot of new knowledge on ship motion. This knowledge allows us to make more intelligent route choices.”

Dockwise can also communicate with ABB during the voyage. Martin Eilander, Service manager in ABB Marine, tells that Dockwise can go to their myABB portal and download all voyage information. “They can access all available data and do their own analysis. This can also be applied to other cargo types, to avoid wind forces on containerships or sloshing in tankers.”

Keeping owners happy

Jaap Jan Stoker, Product management in ABB Marine, relates that fuel is both cost for owners and operators, and an environmental burden. “Controlling consumption is more complex than just carrying out the voyage, and software is a very important tool in achieving this. With the right software you can offer solutions with payback within one year, rather than two or more years with mechanical solutions.”

Using software together with the Internet of Things delivers safer and more efficient operations. Shipowners need to be informed of all aspects affecting voyages – safety, fuel costs, environmental impact, time – and advisory systems can assist in optimising all these aspects, advising on weather routing, optimal vessel trim, and power and propulsion optimisation, among other factors.

“It’s not just important on board, says Jan de Jonge. “Ship and cargo owners want to access this information too. Not only the post voyage reports, but real time information on the performance of the ship and anticipated performance. Being able to see for themselves how the voyage is unfolding increases their level of confidence in Dockwise.”

With so much sharing of mis-

sion-sensitive data, security is paramount, and Martin Eilander assures that ABB systems are designed to ensure completely secure data transfer.

Some things never change

With all this information flowing from ship to shore, and advice from shore flying back to the ship, one thing remains unchanged:

"This is purely advisory information," Jan de Jonge assures. "It is additional assistance to the captain, designed to enhance vessel performance and efficiency. If the captain chooses to override the advice and lay by or seek refuge, that is his decision. In the end, the captain has the ultimate authority."

"Controlling consumption is more complex than just carrying out the voyage, and software is a very important tool in achieving this."

Polar chart generated by ABB's marine software OCTOPUS

Industry Update:

The cruise wave is cresting

Not only the big ships, but also smaller expedition vessels are in demand.

The cruise industry is currently going the opposite direction of many other marine segments – right through the roof. Every cruise shipyard in Europe is fully booked, leading among other things to Chinese interests purchasing three yards in Germany to secure slots for their own newbuild projects.

And the growing Asian cruise market, forecasted to be the second largest after the USA by 2020, is prompting some Chinese yards themselves to enter the fray. China State Shipbuilding Corporation (CSSC) and the Italian shipbuilder Fincantieri have announced plans to invest some USD 3.7 billion in the building of five cruise ships in China. Construction on the first of the five, designed for up to 5,000 passengers, is scheduled to commence in 2017, with delivery scheduled for 2021.

Not only traditional cruise is riding high, but the expedition or explorer class of vessels is also experiencing a surge. A recent order in Germany from Crystal Cruises for the largest ice class passenger vessels ever built signals that cruise companies have faith in growing volumes in polar cruising, and they are willing to invest at the highest level:

"When delivered, Crystal's 'Exclusive Class' ships will not only be the largest and most luxurious polar cruise ships, but also the most powerful, safest and most technically advanced in their class," said Fleet Captain Gustaf Gronberg, Senior Vice President of Marine Operations & Newbuilding for GHK, owners of Crystal Cruises.

The Asian cruise market is forecasted to be second largest after the US by 2020.

Access, and the environment

With polar sailing heightening concerns for passenger safety and comfort, Crystal turned to a supplier who could deliver on all counts, choosing ABB's Azipod propulsion system for their pioneering ships: "ABB's long

ABB to power Crystal Cruises new 'Exclusive Class' ships

experience in podded propulsion and power generation for both cruise ships and ice breaking vessels makes them the ideal and most reliable partner for these projects," Gronberg confirmed.

Marcus Högblom, vice president in charge of sales for passenger vessels in ABB knows they can back up that claim: "An order like this brings together two of the core competencies in ABB's marine business, cruise and ice going vessels. We have been supplying power and propulsion to icebreakers since the 1930's, and efficient electrical propulsion to the cruise industry for nearly three decades. Polar cruise is right in the middle of our sweet spot."

Concern for the environment is also paramount when sailing in sensitive areas. In order to keep emissions to a minimum, the Crystal ships will also feature ABB's flagship 800xA automation system, complete with EMMA Energy Management System and fleet management suite. The system helps the ship's operators to run it in the most energy efficient way possible by analyzing historical data and comparing it to current conditions, and then advising on improvements, in addition to allowing benchmarking across the whole fleet.

Another operator in the discovery cruise niche has also given ABB the nod for Azipod technology. The new Azipod D will power the luxurious 10-deck discovery cruiser Scenic Eclipse to some of the world's most remote destinations. Built to Polar Class 6, the vessel will have the ability to navigate the summer waters of Polar Regions.

The biggest come back for more

When it comes to building the bigger ships, few can match the team of Fincantieri and Carnival, a team with a long history of working with ABB. The first electrical propulsion system was delivered by ABB and installed on a Carnival cruise ship at Fincantieri in 1990.

In all 14 ships have been outfitted with Azipod propulsion at Fincantieri,

and Carnival now counts 24 of its ships driven by Azipod propulsion. In November of 2015, Carnival signed up for another set of power and propulsion deliveries from ABB:

"These beautiful new ships on order from Fincantieri signify our ongoing commitment to provide the best possible guest experience across our industry-leading brands," said Arnold Donald, president and CEO of Carnival Corporation. "New ships with the latest features, accommodations and innovations really bring the modern cruise experience to life and will help us continue to grow new demand for cruising."

Also Royal Caribbean Cruises puts its faith in the cruise propulsion leader. Upon her delivery in 2016, the RCCL Harmony of the Seas became the largest cruise ship on the water, propelled by the tried and true ABB Azipod XO thrusters.

"ABB's long experience in podded propulsion and power generation for both cruise ships and ice breaking vessels makes them the ideal and most reliable partner for these projects."

More complex, yet still safer

Proving their penchant for raising efficiency through technology, the cruise industry has been an early mover on the concept of Integrated Operations as provided by ABB, just as they were the first segment to embrace Azipod propulsion.

"With cruise ships carrying more passengers and becoming increasingly complex, taking a proactive approach to monitoring mission critical systems is more important than ever," said Marcus Martelin, VP Services for the passenger and cargo segment at ABB. "From the Integrated Operations Center we can identify on board issues before the crew even know about it, and make many interventions predictable."

The Integrated Operations Center facility in Helsinki serves the passenger and ice going vessel segments, and follows in the wake of the successful launch of the first such facility in Billingstad, Norway. The Helsinki center is able to connect to any passenger ship and monitor the performance of ABB technology on board, including the vessels' Azipod units.

The Integrated Operations Center also connects to the shipowner's

onshore operational centers to support their operations department in troubleshooting, maintenance planning, and fleet benchmarking.

Strong market, tough competition

Though the cruise market may be booming, competition for passengers is increasingly intense. Owners and operators will have to keep coming up with new concepts like polar cruising, and that requires enabling technologies like Integrated Operations and Azipod propulsion.

Managing director Juha Koskela of ABB's marine and ports business is happy to take a leading role in helping cruise companies meet demands for innovative offerings: "There is growing interest in the Polar Regions from the passenger segment, and recent orders have shown that shipowners trust our solutions in these areas," he concludes.

ABB's Azipod D will power the Scenic Eclipse

Not just a visual treat, the new hybrid tour boat operated by The Fjords is a technical marvel as well, introducing the cleanest, most efficient and quietest marine technology to a place that definitely deserves careful treatment.

A vision for the fjords

The Brødrene Aa-designed and built *Vision of the Fjords* whisks tourists at a brisk 18 knots to Nærøyfjord, a Unesco World Heritage Site. Once on site, batteries send the striking craft gliding silently and with no emissions through one of the most spectacular of Norway's many stunning fjords.

"Many of the tourist boats in this area, including some of our own, are 50 to 60 years old," said managing director Rolf Andrè Sandvik of The Fjords in a May 2016 press release. "As operators, we are drawn here by the pristine environment and then proceed to poison it. It's our vision to demonstrate that there is another way – by building a fleet that utilises the very latest clean technology to preserve this ancient, natural treasure that surrounds us."

Forty metres long and with a passenger capacity of 400, the design, dubbed Seasight, has demanded a re-write of the rulebooks in order to accommodate her many revolutionary innovations. "This is the world's first hybrid ship built with carbon fibre sandwich, and building a prototype is never easy," Sandvik acknowledges.

Hybrid harmony

Power systems on board are every bit as modern as the design itself. ABB has supplied a compact, lightweight version of their cutting edge Onboard DC grid to manage and control energy flow between the charging station, batteries, engine and propellers, ensuring the quietest and most efficient operations available.

"This is a typical example of the green wave that we are seeing now: using batteries in combination with the machinery, but also using DC power distribution instead of AC that we have been used to seeing," said Jorulf Nergård, Head of Short Sea Shipping at ABB Norway. "And if we had bought the batteries today, we would have twice the amount of energy with the same weight, more or less. Development has moved forward just that fast."

"It's our vision to build a fleet using the very latest clean technology to preserve this ancient, natural treasure that surrounds us."

The *Vision of the Fjords*

Connecting with nature

The *Vision of the Fjords* transports passengers from around the world, offering them a unique opportunity to connect with Norwegian nature:

The Freedom

Perhaps the most striking feature of the Seasight design at first glance are the walkways winding up the sides of the craft to the top deck. Inspired by a twisting mountain path, the concept allows for full freedom of movement on and around the entire ship.

The Scenery

"Passengers can walk on this ramp and not be in the back seat or the back row when they are going through the most spectacular fjords of the west coast," said Sandvik. "And with the panorama windows for inside passengers, everyone will have a front row seat on this ship."

The Silence

Adding to the experience will be the absence of disturbing engine noise – and exhaust fumes – when cruising Nærøyfjord on electrical power at a serene eight knots, the legal limit in the fjord.

Travelling light

The Seasight concept was conceived not just to enhance the tourist experience, but to lighten the footprint of tourism in a sensitive environment. Carbon fibre construction reduces weight, which in turn reduces energy consumption, allowing the *Vision of the Fjords* to make its runs using less fuel, and running longer on battery power. Batteries will be charged by the ship's own motor, and from shore connections.

Rolf Sandvik and The Fjords have plans to stay the green course set by the *Vision of the Fjords*: "With the backing of our owners Fjord1 and Flåm AS we'll be looking to expand our fleet with more vessels like the *Vision of The Fjords*. These newbuilds will eventually replace our existing vessels, allowing us to minimise our emissions while maximising the experience of a growing number of visitors to this incredible natural landscape."

All in all, the *Vision of the Fjords* delivers not just spectacular views, but an inspiring vision for cleaner, sustainable and more enjoyable touring of the pristine waterways of the world.

Comments from Jorulf Nergård were made to Engineering and Technology Magazine

The first days, the next years

On 1 January 2016, Juha Koskela took over the running of ABB's marine and ports business from Heikki Soljama, after 12 years with Heikki at the helm.

When Heikki took over in 2004, the marine business had survived a near crisis and was looking ahead to years of growth based on AC drives and Azipod propulsion. As Juha Koskela assumes command, the big news is in DC and digitalisation, with Onboard DC Grid looking to gain traction, and the Internet of Things, Services and People changing the way work is done in virtually every aspect of the marine and ports business.

All in for ABB

Juha has spent his entire working career with ABB, joining the company in 1996 after graduating from Technical University.

He started working with high power drives software and commissioning, programing software for steel mills and marine applications. Early on Juha's work took him around the world, starting up rolling mills and cruise ships. "The laptops were thicker and we were still using floppy discs, but we were essentially providing connectivity even back then," he reflects.

His first post in Marine and Ports was to develop the service business in Finland and help establish the new global service organisation. In 2003 he moved to Singapore to expand the existing service unit into the systems business unit for drilling rigs, also handling drilling process drives. "We hired around 100 people from the region, many of them from other industries." Establishing in South Asia gave good results, and Juha notes that the unit in Singapore is now one of the strongest in the Global Business Unit. "After working four years in Singapore I was asked to return to Finland to work with the Azipod propulsion business and cruise industry, which was already a big success back then. Eventually I took over responsibility for the cruise and ferry markets and the propulsion business."

"Our management team agrees that diversification is the way to go."

Juha Koskela

"Flexible and dynamic will be our key words."

Smooth transition, still learning

Any big surprises in his first six months as BU managing director for Marine and Ports? "No real surprises. I have been a part of the management team for several years, so I was familiar with our present work and future plans. What we have to do now is find new opportunities while some segments are in down cycle. Our management team agrees that diversification is the way to go."

There is one area where he has a lot to learn, though: "The ports business is new to me. Even though marine and ports are connected, they are very different worlds, and I am finding the ports world fascinating." He feels certain that the team will find even more potential for realising synergies between the two segments: "There is already consolidation in the market between lines and terminals, but I think this is just the waking phase."

Juha acknowledges that the ports business will not be driven by growing volume for a while. "Container volumes have stagnated, so we need to find other pockets of opportunities." One area is upgrades, with many terminals in need of modernization due to increased ship size, and the opening of the expanded Panama Canal likely to generate substantial upgrade activity. Port automation is also coming on strong, with opportunities in the Americas, Asia, and probably Africa as well. "But we are looking at terminal upgrades rather than expansion," he emphasises.

Cruise, on the other hand, is booming: "All the cruise yards are busy until 2025, but that still means only 15-20 ships a year. They are very high value, but it isn't really a lot of ships on a global scale."

And there is no relief in sight offshore: "Changes like the ones we have seen in the offshore market take time to shake out, so I don't see that segment picking up soon."

Flexible and dynamic

That means seeking out and conquering new markets. New technologies like energy storage, electrical propulsion enabling variable engine speed, and innovative digitalisation are all key factors, regardless of segment. "DC grid is an attractive option for smaller vessels, and now we offer Dynamic AC for larger vessels. Economy and the environment go hand-in-hand to make these technologies attractive on today's market."

The Dina Star OSV kicked off the move to DC Grid, but Juha believes the ferry market will be more active

Juha Koskela and Mirva Nevalainen in the Vuosaari factory

going forward, as well as inland marine transportation. “We have to find the right niches. We can apply this technology to all segments. Flexible and dynamic will be our key words.”

Meanwhile the competition is getting tougher in all markets. As an example, Juha cites participation at a recent Electrical and Hybrid conference: “That topic brought forward the smaller players, so you could really see how many people are looking at promising markets. Digitalisation and Big Data are offering more opportunities for new competitors. It’s becoming clearer every day that we will have to really focus on our development activities.”

Mix and match

Competition will strengthen the industry, but not without cost, Juha observes. “One aspect is that this may be a good time to consider acquisitions and partnerships. I believe we will be working more across the gap from bridge to propeller, integrating systems through software. The ultimate goal is to bring fully integrated systems on board. We will see vertical and horizontal expansion of systems through integration, and there is potential for mergers and acquisitions to cover the complete system.”

Heikki Soljama once said that it takes around ten years for a manager to make his or her mark – five to start something new, and five more to establish it on the market. What expectations does Juha have for his own turn at the helm? “There are so many changes happening so fast now, I believe it will become more and more important to have people with current skills and experience in charge. In that setting, a ten-year perspective might be a little long. It will be interesting to see where we stand five years from now.”

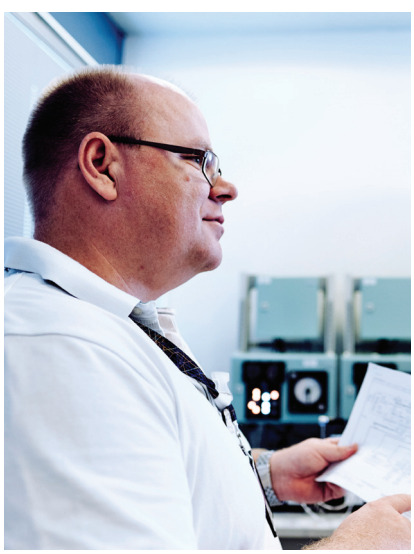
Facing one of the most challenging marine markets in history, those promise to be five very busy years for new BU leader Juha Koskela and his team.

Technical Insight


ABB

From subsystems to super system

Propulsion systems, crane systems, jacking systems, automation and control, advisory; all these former sub-systems are being connected today in integrated vessel and port systems through the use of advanced information, sensor, and communication technology.



Jan-Fredrik Hansen

This Technical Insight section of Generations presents a variety of new technical solutions from ABB's marine and ports business unit, focusing on integrating and connecting systems for a higher level of performance in efficiency, safety, and reliability. We lead off with the themes of Integrated Operations and Remote Diagnostics, which have opened new ways of thinking in the field of operations.

Beyond that, the articles take you on a journey covering case study descriptions, new ideas on propulsion products, energy storage solutions, and how these can be automated and optimised. The expansion of electric propulsion in short sea shipping and fully battery-driven ships and ferries is explored. New automation solutions for both shipping and port industries are also discussed, with some novel ideas on how to improve overall systems by taking a broader overview.

For marine transportation, the technology shift towards greener operations is taking place right now, with progressive use of energy storage as a hot topic, having already made its way onto several vessels. The technology in this field is moving fast, and this section contains several articles discussing solutions and applications. Energy storage has been covered in previous editions of Generations, and in the period since the last edition, only two years ago, the technology has moved from conceptual designs to actual implementation.

Other fields commanding major interest today are the dawning autonomy of vessels and systems, and the ability to utilise all subsystems optimally for the benefit of the whole vessel, and even the entire fleet. As you will see, this philosophy of sharing intelligence to improve efficiency is also being adopted for use in ports.

We hope you will enjoy the insight and updates that the following articles offer on these subjects – and a handful more.

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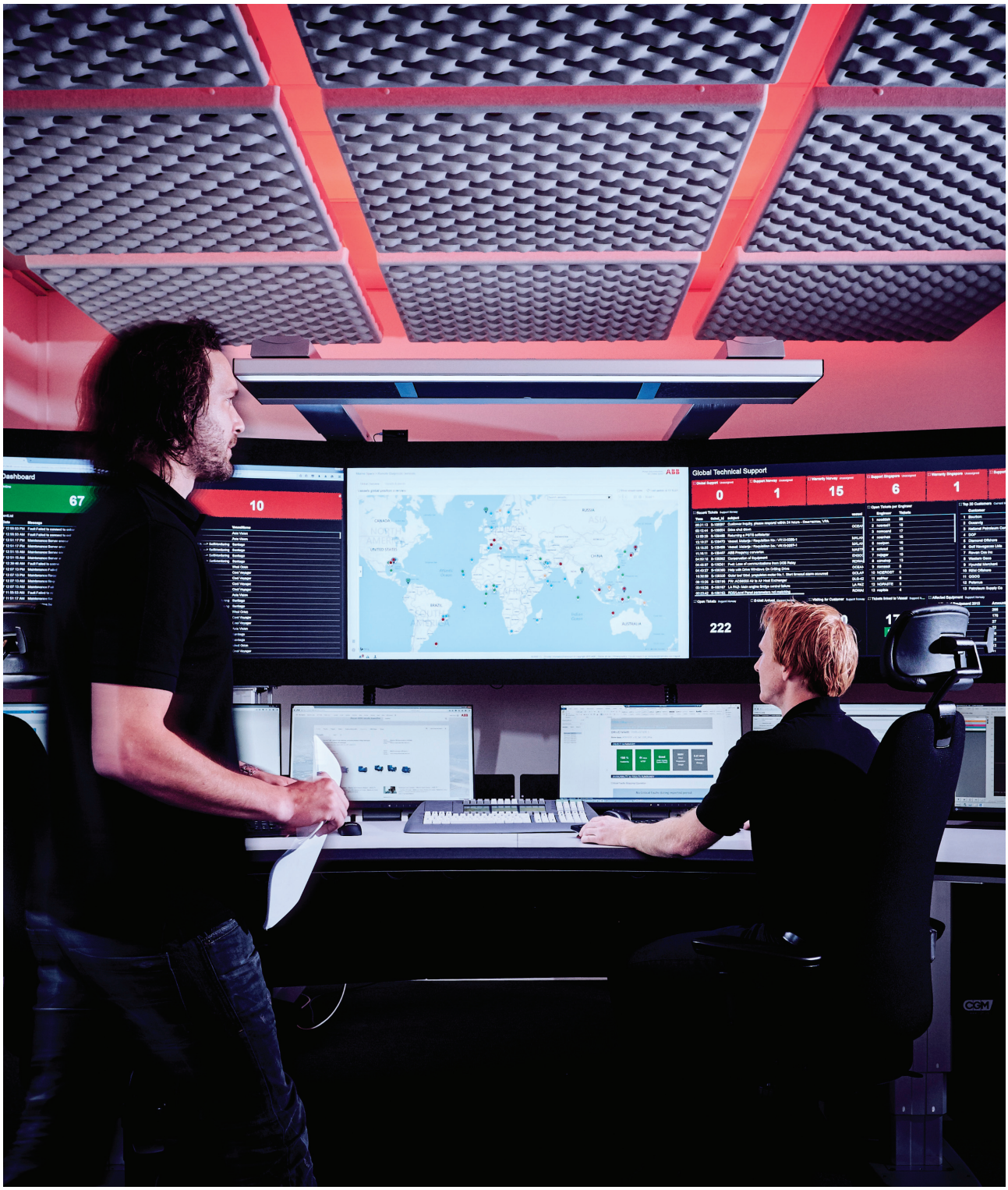


Integrated Operations Center at Billingstad

ABB's digital business transformation for the maritime industry

Integrated Operations

The concept

The previously conservative maritime industry is now tapping into the possibilities of connectivity and digitalisation, taking advantage of improved satellite coverage and cloud computing. Owners and operators are increasingly looking for suppliers that offer remote troubleshooting, performance monitoring, and condition-based maintenance. This allows operating the fleet at lower fuel and maintenance cost, while improving crew, passenger, and cargo safety and productivity. In order to facilitate the change, ABB is adding sensors and software to system deliveries on board vessels, improving data transfer storage, and analysis of the data. Our service centers now utilise the information to support customers in emergency situations, in maintenance planning, and in helping to optimise ship operations. The future fleet will be better connected to the owner's shore side technical department, and to ABB's technical departments, by having access to the same information and monitoring systems. We call this way of operating Integrated Operations. Combining the new technologies with our traditional on-call and maintenance services will enable us to be part of our customers' daily operations and make better decisions together. Because vessels will become more complex, ship owners will want to simplify how they manage their fleet. ABB will offer customers a package that is integrated from office to propeller - provided by a partner with strong domain knowledge. This way of operating will enable suppliers and customers to take the first steps towards autonomous shipping.

A conservative industry is changing

Shipping has come under scrutiny by regulatory and environmental bodies for its environmental and safety record. Speculation in shipbuilding and slow economic growth have put the industry under significant economic pressure. The maritime industry needs to become more modern, efficient, and safe. In fact, we are witnessing how this industry is turning from being one of the most conservative industries to being open for new ways of operating.

Life at sea as we know it, is going to change profoundly. And so will the life at the office. Digitalisation will affect everything, 'from office to propeller'. Planning, operational tasks, and decision-making will be carried out by involving more people and information, and by creating virtual teams whose members are located on board, on shore at the owners' offices, and at the suppliers'.

One of the biggest operational improvements lies in the integration of the operations taking place on board the vessel and on the shore side, from anywhere, and with anyone who is critical to the value chain, such as original equipment manufacturers (OEM) like ABB.

Any company that aims to supply to the maritime industry will have to master the following four megatrends:

- Digitalisation and connectivity
- Automation and electrification of systems
- Emissions reduction and electrification
- Automation of work

The era we are dealing with here is the 4th Industrial Revolution. Work will be revolutionalised, as will the production and use of energy. Even if these changes still seem far away for many of us, some shipbuilding tenders include exactly the kinds of features laid out in this paper.

Operators and their suppliers will integrate and automate their processes

We believe that only a vertical integration of the entire product and activity chain, from the machine, sensors, historian on board, the cloud platform, applications, and dispatch of service engineers, design, and R&D is going to provide ship owners and their fleet with a next-level standard in safety, productivity, and low carbon footprint. Or as one of our major customers put it, “our ambition is to operate by aviation industry safety and productivity standards by 2020”.

Large amounts of data will be collected by using professional IT architectures and technologies, but a meaningful analysis and interpretation of the collected data is only possible through the application of domain knowledge. Much of the technology we are developing now aims at integrating ABB with its customer, for the purpose of sharing knowledge and making better decisions on both sides of the table.

Today a hundred highly skilled service engineers are able to support 500 vessels with phone and on-call technical support, but in the future, the same number of engineers and technical experts will be able to support a significantly higher number of vessels at sea, if a remote connection exists. The amount of on-call visits would be reduced dramatically as well which means safety and reliability goes up. Already today, we reduced the on board visits by service engineers to those ships with remote condition monitoring on propulsion drives by 70%, and with improving predictive monitoring we are able to inform the crew before damage occurs.

The most progressive ship owners and operators have already implemented advanced operational models and tools, and they look for partners who are on a similar technology level, in order to integrate with them, and run the business at next level safety, and productivity. The automation of work will affect every company, and every department inside the company.

Five steps to autonomous operations

The first steps towards autonomous shipping involve combining new digital services with our existing technical services. We call this phase Integrated Operations’ because it speaks to a

new way of operating, not intended to replace the crew, but to support them. We also believe that new technologies will help to improve efficiency to a similar level where best-in-class industries (such as the aviation industry) operate.

Through the Integrated Operations concept, critical equipment and control systems on board a vessel can be monitored, and are used at ABB on shore service center and the customer's on shore fleet operational center, for optimising the vessel and fleet operations.

Some of the data provided by these systems is analysed on board the vessel, by automated algorithms, which allows immediate and fast reaction from the crew to act on anomalies, performance issues and emergency situations. In addition, we can send some of that data to shore and make it accessible to the customer wherever they need it, whether that is in an operational center or just on a laptop or a smart phone. This data transfer takes place either through a cloud server or within their own IT network. This gives the customer's technical department on shore better visibility of each vessel and the total fleet, and enables it to react in a more efficient way in emergency situations and to plan better for maintenance and operations. In addition, we are using this information ourselves, in our own service centers, from where we can remotely access key equipment in order to troubleshoot, or to analyse losses and support our customer in maintenance planning and making improvements to systems during operation.

We can also run a virtual copy of the system on a server and make it 'age' according to the vessel that is operating at sea. This concept, also often described as 'Digital Twin' will soon be a commercial reality and it will be a key to provide condition-based maintenance.

The modular offering

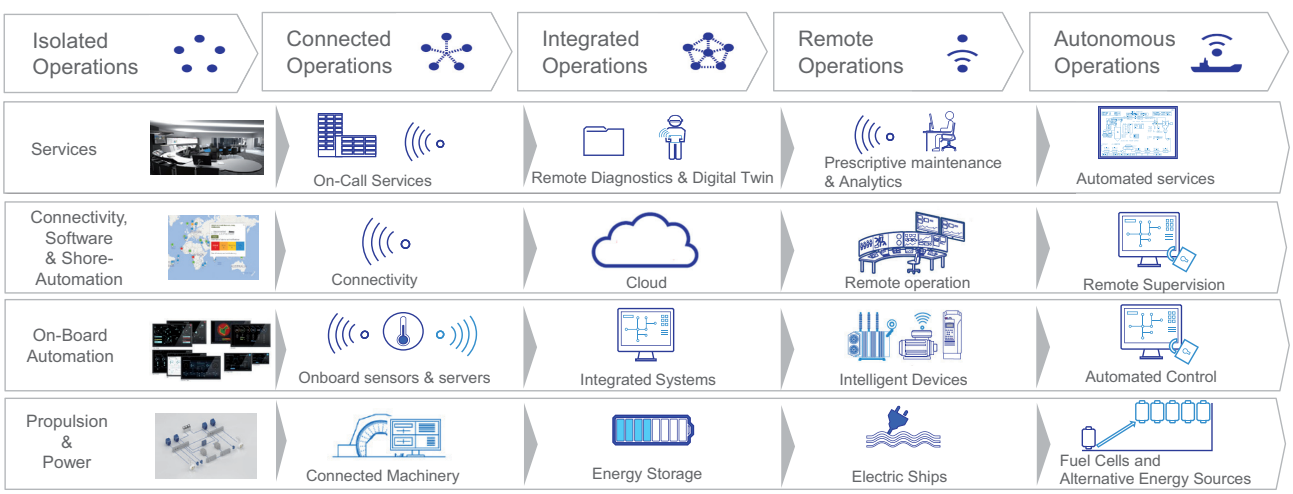
Our service offering is modular and customers can start with whatever service addresses the issues they have at that given moment. Because we are performing the services 'with' our customers, we need to be able to integrate with the tools and providers they are using as well.

The Internet of Things, Services, and People is an emerging industry megatrend that will change the way the maritime industry and many other industries operate.

The key is to know which new solutions and services to combine with the existing core of our business, in order to provide the customer with enhanced productivity of their assets, and investments – whether that is a productivity improvement in the production process, in safety, quality, or in cash.

Working closely with our customers and using the same tools means there will be more interdependencies between our work processes and value chains. The work we perform in engineering, service, and supply chain will become more performance-driven and customer focused because Integrated Operations improves our ability to provide our knowledge and services to the users.

The more all parties in the value chain are connected, the higher Operational Excellence will move on the agenda. Improvement initiatives will be joint efforts between the owner, oper-



ABB's 5 steps towards autonomous operations

ator, and supplier, for example in supply chain and spare part management, handling emergency procedures, and asset lifecycle management.

Integrated Operations is also a good example of ABB's Internet of Things, Services, and People (IoTSP). We have taken action to accelerate the digitalisation, by improving our competencies in new areas and integrating them with the existing organisation. Our new Integrated Operations Centers are proof of that. We consider this the beginning of the next Industrial Revolution and a wave of shipbuilding activity that will see more connected, integrated, electrical, and autonomous vessels and maritime operations.

We believe the next step-change in productivity and safety in shipping comes from integrating ships better with shore side operations. Integrated Operations is the concept that will drive this change in the coming years.

Customer benefits

- Full transparency of critical systems down to detailed level
- Visibility of critical processes and alarms
- Detection of failures and analyse together with the OEM
- Ability to reduce voyage speed of ships and the whole fleet
- Higher availability of systems and vessels by accepting known, low risks
- Incident management combining onshore, OEM, and vessel crew
- Plan, manage and increase maintenance during operations
- Save man years in technical planning department, by better OEM cooperation
- Comply with classification in extended and reduced maintenance
- Help plan fuel efficiency during voyage and operation
- Develop new solutions that solve challenges based on data
- History of systems performance, condition, and intervention
- Attract and retain a new generation of professionals
- Improved exploitation of staff and OEM expertise through improved cooperation
- Manage documentation globally, easy to update and locate files
- Manage software installed base, and upgrades, globally and reliably
- Leaner global footprint due to better access to OEM and internal resources

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For more details on ABB Marine's Integrated Operations model, see
http://new.abb.com/marine/integratedoperations

The latest developments in RDS4Marine

Remote diagnostics for the marine industry

The ABB RDS4Marine system has been deployed in its latest release, version 5.1. The following is intended to provide a general overview of improvements, the thinking behind changes made, and a brief instructional guide.

New system functionality in RSD4Marine 5.1

A chat option guarantees there will be no misunderstanding while communicating with the crew onboard over remote desktop. An intuitive user interface makes it easy to switch between remote and local on board users while typing sentences. The entire chat is always stored in the local RDS database and can be put back to the screen whenever needed. In addition there is a site comment option, facilitating the recording of all maintenance actions performed by the local crew on the equipment being monitored. This is an excellent way of keeping track of what service actions have been carried out and allows planning of future maintenance actions with better accuracy.

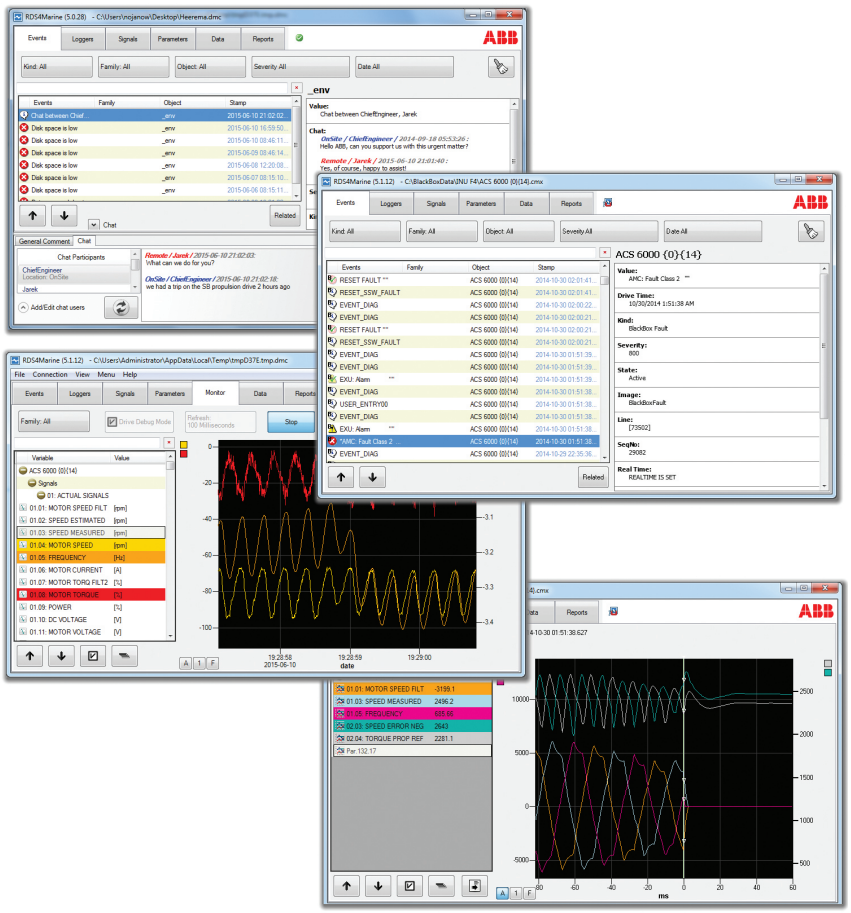
DriveDebug mode is an answer for demands from ABB drive commissioning engineers for better use of the RDS system while drive commissioning. They required a much higher sampling rate that the normal monitoring mode through DriveOPC could provide. After switching to Monitor tab, the user can select DriveDebug mode that would deactivate standard monitoring scenarios for drives but at the same time allow to select ad hoc interesting signals from the drive and monitor them with sampling resolution of 2ms pers signal. After fast monitoring is complete, data collected by the RDS can be stored to a database and the system can be set back to normal operation.

With each installation of RDS system there is a predefined number of self monitors that act as a watchdogs to monitor the performance of the RDS itself, like CPU load, memory consumption, specific processes and services behavior, as well as checking connectivity with external devices such as drives, controllers, and other RDS computers. With simple customisation and adjustments, the IT RDS responsible can set the time intervals for various tests and see the online status of the installed base in the RDS dashboard.

There are many more improvements in addition, such as an improved calculation engine, support for multiple DDCS cards, improved time synchronisation for frequency converters, and extended configuration wizards.

Cost effective and scalable hardware

Optimised software requires adjustments on the hosting hardware side as well. The aim is to minimise the number of computers wherever feasible. The new cabinet includes a high performing Panel PC that can host multiple monitoring configurations for switchboard, DGMS and rotating equipment. External RUSB for communication with the drives that can be installed inside the cabinet are also included together with Panel PC, resulting in a high performing, cost effective RDS hardware solution for a multi-drive system such as drilling or jack-up drives. In order to tighten security, an additional RDS firewall configured to allow for RAP communication traffic only is also included. This firewall has also 3G capabilities that may be activated for remote support from office during RDS commissioning in the yard, as well as acting as a main connection to the Internet if a customer satellite solution is lacking (e.g. in the tug market or small vessels operating close to shore such as the US Great Lakes fleet).



New system functionality

Enhancements for new and existing assets in monitored portfolio

Monitoring of frequency converters has a new functionality

BlackBox upload, which is very useful in the case of Medium Voltage (MV) drive monitoring, brings even more detailed insight into conditions and internal recordings of the drive during trip occurrance. Black box is additional memory embedded in the MV drive that continuously collects very detailed parameters and events from the main control board. In the event of drive trip, those measurements are dumped into file that can be imported into the RDS system to display on the same UI as all other recordings acquired by the system.

Improved time synchronisation between RDS and ABB drives

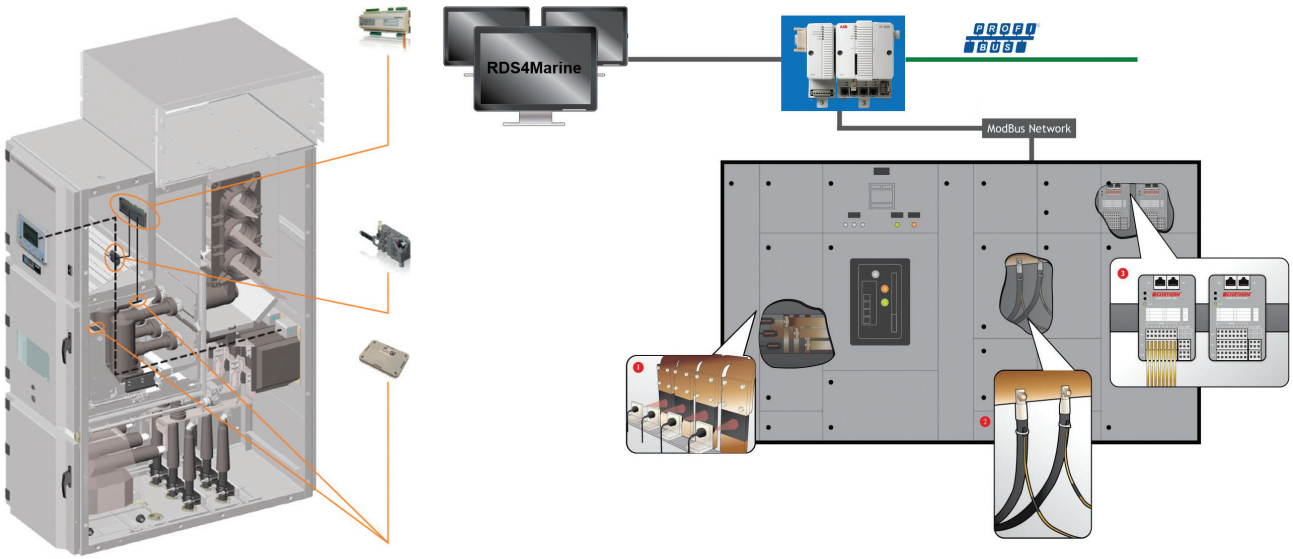
The variety of control boards supported by RDS required individual approach for time shifting and time stamp adjustments for faults and data loggers fetched by the RDS. At present, the mechanism is tailored for the MV drive AMC boards with real clocks and absolute time stamps, as well as for LV RMIO boards where time can be represented in absolute format as well as relative (number of ticks after drive was powered on).

Parameter reading for RELION protection relays

The RDS monitoring solution for RELION-type protection relays enabled periodical reading of all parameters exposed by the embedded IED web server over http protocol. In particular, a software version, protection function settings and the outputs of condition monitoring block for the main circuit breaker are recorded in RDS.

Integration with MySiteCare

Diagnostic solutions offered by the PPMV service department, named MySiteCare and MyRemoteCare, are now integrated on board with the



Enhancements for new and existing assets in monitored portfolio

RDS system. Measurements acquired from the switchboard by MySiteCare hardware are then processed by the MyRemoteCare gateway, and results are posted to an RDS computer installed on board that automatically forwards them to the MV Switchboard factory service centre in ABB Italy. From that moment, an expert team from the MV Switchboard division is able to analyse the data and provide a periodic maintenance report to ABB Marine that is merged with RDS reports and sent to end customer.

Diagnostic solution for bus bar and cable joints infrared temperature monitoring

A solution that answers market needs for online temperature monitoring of MV and LV connectors. In order to avoid costly human inspection with use of infrared cameras, cost effective online monitoring solution using Exertherm infrared sensors are proposed. Switchboards, motors and generators can now be equipped with the IR sensors connected through data cards to RDS, either directly or through controllers (gateway or DCU). In the end all temperature readings (multiple measurements per single SWBD panel) are recorded continuously by the RDS and can be used for periodic reporting and early warning if temperatures deviate from their normal state.

Release of Diagnostics for Machines package

A long awaited launch of the Diagnostic for Machine package is hitting the market. Already deployed for a pilot retrofit project and few newbuilds, it offers an enhanced condition monitoring solution for critical machines such as propulsion and thruster motors and main generators. Based on the hardware and software integration of MachSenseR with RDS, the on board infrastructure facilitates integrated data flow and analysis, starting from the sensor (vibration, current and voltage) up to the main RDS computer, where condition monitoring analytics are fired. Measurements from MachSenseR are trigged by the RDS under precisely defined operating conditions to normalise the calculation results. Some raw readings as well as end results are automatically sent to our Service Center databases to feed periodic reports.

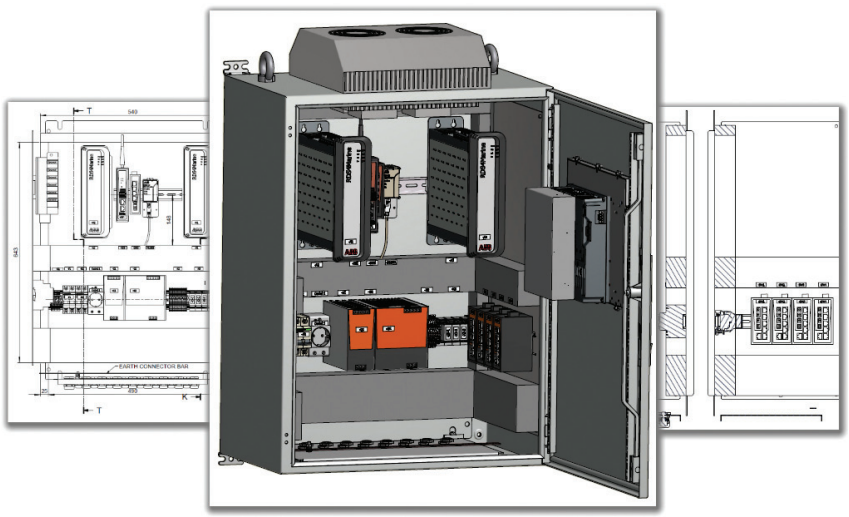
Cyber security enhancements

In order to address stricter cyber security requirements set for ABB products, RDS4Marine has been assessed against all possible aspects of cyber security as defined by ABB. Some immediate actions such as documentation and hardware update have been already taken, resulting in enhancements released in version 5.1. Additional topics have been identified and will be progressively addressed in consecutive releases of RDS systems. The project delivery and service organisations will continue to follow up cyber security requirements.

RDS dashboard deployed with Integrated Operation Center at Billingstad

Started at the end of 2014, the development of RDS dashboard was initially aimed at creating a portal for ABB's internal RDS operational personnel. The goal was to provide a single screen overview of all RDS with the location of ships and status of both monitored equipment and the RDS system itself. The first release of RDS dashboard got very good feedback from users, and a second generation of RDS dashboard has now been developed, using myABB technology and sharing the common Marine Portal landing page.

With the recent launch of the Integrated Operations Center at ABB Marine Norway, Billingstad, RDS dashboard found its key role in providing immediate overview of RDS installed base and status of all customer assets monitored within RDS service contracts.



Cost effective and scalable hardware

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The fundamentals of RDS were previously addressed in the 2013 issue of Generations, in the article "Remote Diagnostic Services – always on board".

Time to distribute intelligence in container terminals

Empowering the machines

Many terminal operators are currently making the necessary investments to meet the challenge of larger ships and the subsequent higher peaks of containers that need to be handled. It is essential to be able to toggle between low activity and high peak periods. Clearly, container terminals will need to keep on top of productivity under these circumstances in order to stay competitive. In adapting to the new operating environment, automation and information technologies play the key role.

Björn Henriksson

Considering the changes in the operating environment and the new opportunities provided by technologies, it is more than relevant to ask whether a different approach to the organisation of the tasks within and between the systems and equipment in container terminals would serve a modern, automated container terminal better. ABB Ports analysis suggests that as more or less all equipment in a container terminal is now 'system-enabled' and communicates with other systems and equipment in real-time, it is now time to re-evaluate the system architecture.

Reorganising system architecture will help terminals to gain the full benefits of automation, information technologies and connectivity. This article presents an architecture that considers all these aspects. We call it node automation architecture based on distributed intelligence.

Autonomous teams

Let's start by looking at modern organisations where highly educated and self-motivated specialists work with complex tasks and with special knowledge. In such organisations managers can no longer know everything in detail, and they need to rely on their teams. Traditional management methods form an obstacle, hindering the organisation from performing at its full potential. How should such organisations be managed and led? The answer is empowering teams and individuals, and leading, not managing them, through targets and goals. This means that the management level focuses on strategies, keeping the company on the right course and setting targets while empowered teams figure out the best ways to achieve the targets given to them. This typically also makes for lean organisations, with few hierarchical levels.

The node automation architecture for container terminals based on distributed intelligence follows the analogy of a modern specialist organisation. In this architecture the teams of automated and intelligent equipment are capable of acting like the

specialists above. They have the best knowledge required to decide on the best and most efficient way to perform the tasks based on real-time process data. All they need are the targets from their manager, the Terminal Operating System (TOS).

Node automation architecture based on distributed intelligence

STS cranes, horizontal transportation, automatic stacking cranes, intermodal yard cranes and gates form the nodes of the node automation architecture. Each node is capable of making decisions and taking action independent of other nodes or upper level systems. Each node is also capable of exchanging information and making a "handshake" with other nodes to ensure that correct action will be taken at the right time. Additionally, each node is responsible for safety related functions such as access gates, emergency stops and monitoring of transfer-zone interfaces.

Automation and remote operation is already the standard for stacking cranes, and STS cranes are now becoming more and more automated, intelligent, and operate based on work orders from the TOS.

Intermodal yard cranes are also now being equipped with the same automation functionalities as stacking cranes and unmanned units are being introduced. All this equipment is part of a network that is capable of handling, exchanging and acting on real-time information. With the addition of intelligent fleet control for horizontal transport, everyone and everything is becoming connected and able to communicate with each other directly, reducing the need for interactions with the upper level system.

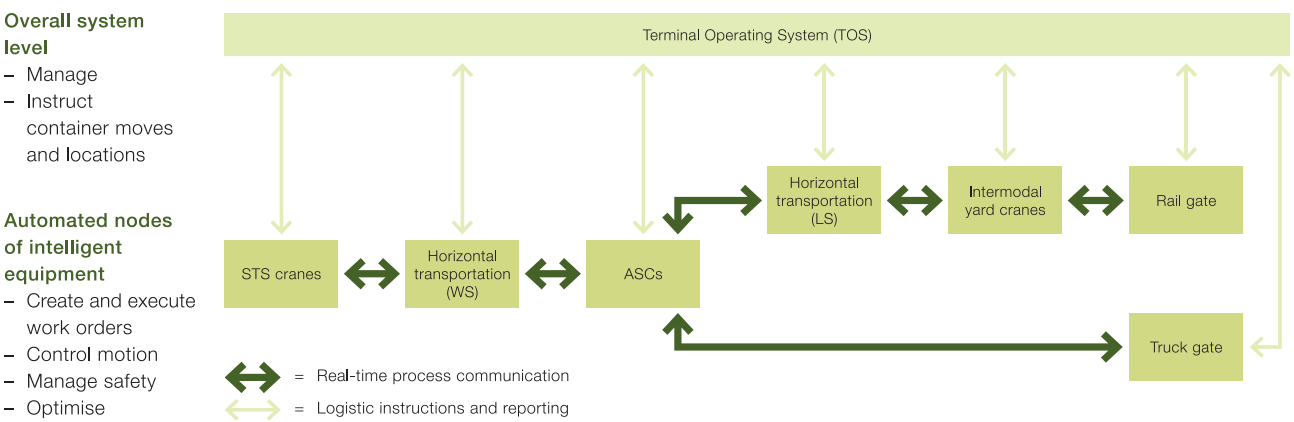
The various types of cranes and horizontal transportation systems are increasingly being equipped with the means to collect information and identify and verify both containers and vehicles. This enables an automated container hand-off at transfer points that is faster, safer and more reliable than a manual hand-off. Information has become an integral part of the process and the driver for more productive container handling in terminals.

Thus, container terminal operations are now very much about the information regarding the container at all the hand-off points, and about the utilisation of that information to create a more efficient and reliable process that allows a large number of containers to be moved as fast as possible. Today it is crucial that information arrive at the hand-off point before the container reaches it, so that the next node in chain can use the information to optimise the next steps in the process.

Lean architecture with node automation

Real-time information is the backbone of the node automation concept. Based on the information, intelligent equipment can:

- Create work orders based on higher-level instructions from a TOS (e.g. a list of containers that need to be moved and on their location in the storage block/on the ship)
- Optimise the execution of work orders within the node based on real-time data
- React to changes in an already distributed instructions list
- Automatically handle sequence optimisation, like dynamic calculations of handover positions to balance the



Node automation architecture based on distributed intelligence

workload of the equipment involved
- Take corrective measures if the reality deviates from the plan (e.g. at discharging the container in the given cell is not the one it should be)
- Communicate with other nodes to achieve seamless flow with minimum interaction with upper level system
- Report the status of the tasks to the TOS

Just like specialist organisations, the equipment team's ability to operate without continuous interaction with upper level systems, node automation makes the system architecture lean. In fact, as one can conclude from the list above and the examples given later in this paper, deploying node automation leads, for instance, to:

- Simpler system architecture with less vertical interactions and data exchange
- Clearly defined responsibilities between the nodes and decision-making based on real-time process data on the "grass root level"
- Reduced need for integration testing at site since each node can be pre-tested individually
- System upgrades can be made per node without impacting the whole system

Node automation architecture is flexible and can be implemented in all nodes or just part of them depending on the terminals needs. However, the full benefits will be realised only if it is implemented throughout the chain from ship to gate.

Optimised yard operation with node automation architecture

Automatic stacking crane blocks are able to respond to varying seaside and landside volumes and ensure a timely delivery of containers for quay and rail terminal processes. The scheduling function allows optimisation of the use of the cranes within the block based on instructions from the TOS and based on various criteria sets, like fastest total execution, minimum energy consumption, importance of the task and vehicle waiting time. This improves productivity and reduces empty travel and, consequently, also energy consumption.

Intelligent stacking cranes interact with the gate to prioritise tasks to be performed. The gate can notify a stacking crane about a truck with/without container(s) which will arrive at the stacking crane transfer zone. Based on this notification, intelligent stacking cranes can prioritise work orders to minimise the truck turnaround time, or another work order depending on which task is the most important to complete at that time.

Higher throughput at the quay

At the quay STS cranes optimise the discharging and/or loading processes based on the instructions from the TOS. Intelligent STS cranes can exchange information about bay/tier/cell locations in real-time for faster loading and discharging, and to optimise moves.

In addition to the TOS, intelligent STS cranes also interface with vehicle control systems. Using the information on their exact position, acceleration and speed of the main motions, as well as the optimum path of the load, they are able to calculate when the container is ready to be picked up by the horizontal transportation or when the next container for loading should be delivered to the crane. The cranes are also able to calculate the completion times for a number of subsequent moves and can thereby request the horizontal transportation system to dispatch vehicles to the right positions at exactly the right time. This enables teams to avoid waiting times and makes it easier to plan for double cycling of the equipment making both the cranes and the horizontal transportation more productive.

At the STS node the identity of each unloaded container is verified using a crane OCR. The information is compared with the stowage and work order information, and the TOS is notified of any discrepancies. The container identity is passed on to the horizontal transportation system.

When loading, the cranes collect accurate stowage information based on the OCR reads and the actual loading positions on the vessel. This information is updated and passed on to the TOS to ensure that correct stowage information is available there.

Empowering the machines

Shipping patterns and requirements with regards to the number of containers to be handled at one time are changing. To keep up with productivity, and thus stay competitive, is the biggest challenge many terminals are currently facing. With the new capabilities of automation and information technologies it is time to challenge the traditional thinking regarding roles and responsibilities of the various systems and equipment used in terminal operations.

Deploying node automation architecture based on distributed intelligence allows a leaner and more efficient system architecture with fewer hierarchical levels. In this architecture the TOS has the opportunity to take the role of manager of operations, leading the empowered equipment teams by setting targets, i.e. instructions related to the container moves to be made. The intelligent equipment organised in nodes takes the necessary decisions and collaborates to perform the given tasks in an optimised, safe and accurate way to meet the targets given by TOS and ultimately, terminal's production targets.

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Shore power can be a game changer

Short sea solution

A new breed of battery operated short sea vessels offer opportunities to eliminate all environmental emissions, especially if batteries can be charged on shore.

On-going advances in high power and energy dense battery technology are opening the doors to emission free operation for ferries and other short sea vessels. Hybrid solutions enable charging at sea, yet compromise in terms of environmental performance. For optimal emission and fuel results, on shore charging is the answer.

Shore side power utility infrastructure for vessel battery charging is an ideal solution for emissions free short sea ships, but several crucial factors must be considered. Most vessels with batteries on-board have short port calls, typically between 5-15 minutes, and this sets boundaries for on shore connection technology. Amongst key criteria for consideration are:

- Shore side availability of power
- AC or DC energy transfer technology
- High Voltage or Low Voltage
- Standards to be followed
- Automatic or manual connection

Time and power

From the above, the most critical consideration is whether to establish an automatic or manual connection. When this choice has been made, the remaining factors need to be assessed based on the available infrastructure and energy demand for battery charging.

A first evaluation point for choosing either an automatic or manual connection is time. How many minutes does the customer have to charge their batteries? Two examples can be seen in tables 1 & 2 where the total energy to be transferred is 1.2 MWh & 120 kWh, respectively. Comparing the peak power and the current demand from the grid, there is a major difference in required power. For the example used in table 1, we also need to evaluate the size of the electronic systems linking shore side and the batteries. With a charging power of 7.2MW, the physical size of the equipment and the power demand can be reduced by 30%. As this type of vessel is typically limited in size, the available space for equipment cabinets is at a premium. In addition to this physical size and demand for space, manual connections also have additional implications for the potential risks they pose to personnel.

Automatic shore connection enabled by the ABB Robotic solution

Highs and lows

The second factor to be evaluated is the use of high or low voltage for energy transfer. Power equals voltage multiplied by current. If one goes up the other must go down, and vice versa, in order to reach the same power level. In AC systems the limit between low voltage (LV) and high voltage (HV) is set at 1 kV. Low voltage connections and procedures are less regulated than high voltage solutions. Crews operating with HV systems are required to have high voltage permits. Furthermore, safety systems, precautions and procedures are more complicated, meaning more time is needed to establish a connection.

As can be seen in the tables, there is a significant variation in the amperage required at the different voltage levels. In practice, LV currents from 5 to 1.5 kA are challenging, meaning a HV solution should be considered for power transfer.

Current rating naturally affects the cable cross-section and weight. High amperage low voltage cables are heavy and difficult to handle, due to the amount of copper needed. In many cases a bundle of lighter cables must be used to make them easier to pull and connect. The availability of flexible cables in high cross sections is also limited. In high voltage solutions the current is much less, whereas the voltage level requires more insulation. This in turn makes the cables less flexible.

The answer is automatic

Taking into consideration the above factors, as well as the typical charging profile for a vessel operating exclusively on batteries, choosing an automatic shore connection, rather than a manual one, is the natural choice.

Automatic shore connection systems, such as the ABB Robotic solution illustrated above, offer greater flexibility for selecting a voltage level that best suits the vessel's charging profile. In addition, automatic connections eliminate the need for manual interfaces, reducing the demand for high voltage training while minimising risk for personnel.

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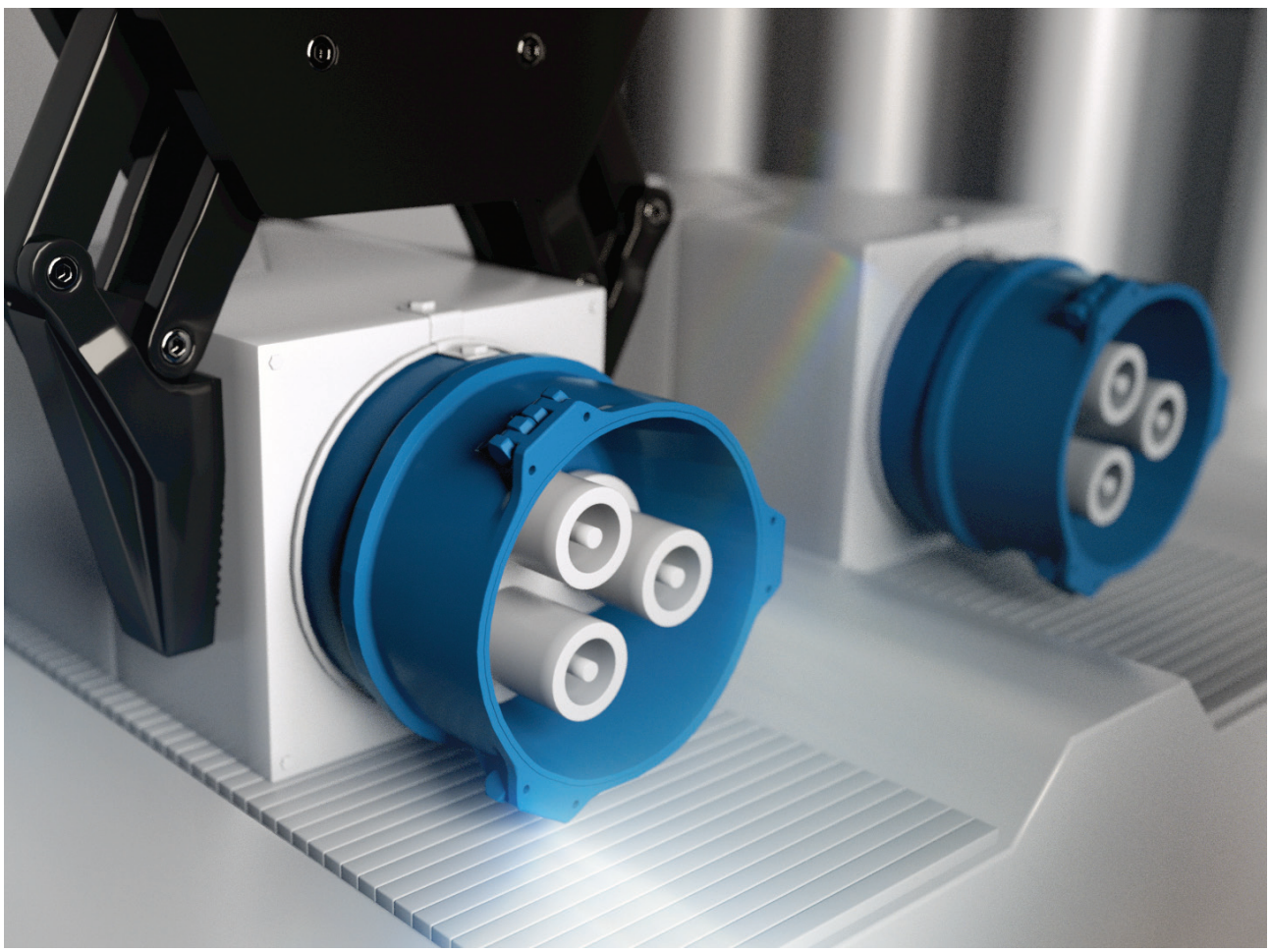
Energy transferred: 1.2 MWh	
Automatic connection charging time: 10 min	Manual connection charging time: 7 min
Charging power: 7.2 MW	Charging power: 10.3 MW
Charging current	
0.4 kA @ 10 kV	0.6 kA @ 10 kV
10.4 kA @ 400 V	14.9 kA @ 400 V

Table 1



Automatic shore connection

Energy transferred: 120 kWh	
Automatic connection charging time: 10 min	Manual connection charging time: 7 min
Charging power: 720 kW	Charging power: 1030 kW
Charging current	
40A @ 10 kV	60 A @ 10 kV
1040 kA @ 400 V	1490 A @ 400 V

Table 2

Automatic shore connection

Optimising efficiency in DFDE for LNG carriers

The best of both worlds

Optimisation is the key to unlocking continued benefits for dual fuel diesel electric (DFDE) propulsion solutions in the LNG carrier segment.

DFDE propulsion has been widely used by LNG carriers (LNGc) over the course of the last decade. However, the recent introduction of two-stroke dual fuel mechanical propulsion has shaken up the segment. This study compares the propulsion efficiencies of these two rivals, discussing the pros and cons of each. The results clearly demonstrate that DFDE still has much to offer the market.

Background

This study utilises DNV GL's COSSMOS computer process-modelling platform – a comprehensive tool featuring 200+ component models and 2500+ non linear equations. Here the platform has been used to assess various machinery configurations with respect to energy efficiency and economic performance for a case specific vessel, taking into account vessel speed and various trading profiles. All data relating to the LNGc examples studied is either supplied by ABB, based on equipment delivered for on-going projects, or publicly available data from manufacturers.

The study follows an actively trading vessel equipped with a variety of sensors continuously measuring more than 2000 parameters to verify the models used and prove their accuracy.

The main results show that DFDE delivers highly competitive fuel consumption if optimised, and is superior to the mechanical solution in the speed range below 16 knots and equal to it above 16 knots.

Delivering benefits

1) Fuel efficiency

According to the findings in this study, an optimised DFDE propulsion system for a LNGc will have better overall efficiency and less fuel consumption than a two-stroke mechanical solution. A DFDE solution with a four-stroke engine uses less pilot fuel and more LNG. By optimising the PMS strategy – shutting off engines - even lower fuel consumption can be achieved.

DFDE propulsion also negates the need for an auxiliary power plant as less installed total power is required on-board. Standard two-stroke solutions require auxiliary power plants, typically of 10MW, for vessel loading/unloading.

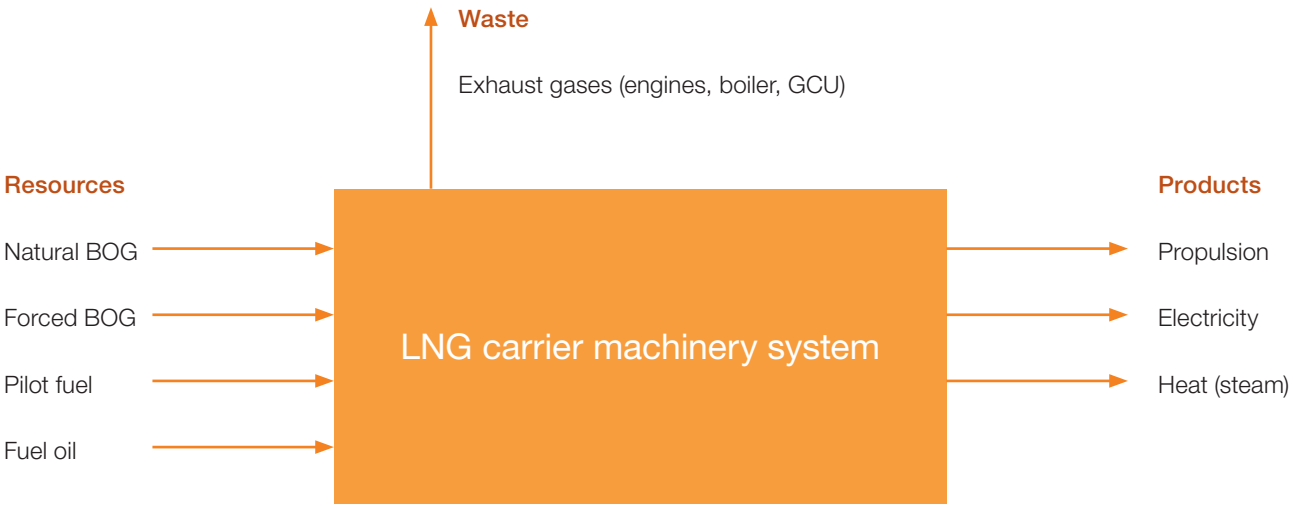


Figure 1: LNG carrier machinery system

2) Proven technology
DFDE propulsion units have been by far the most commonly used propulsion systems for LNGcs over the last decade, with ABB establishing itself as market leader. The firm delivers both induction motors and the more efficient synchronous propulsion motors, utilising its effective on-site commissioning organisation to fulfil orders for the biggest international yards. As of September 2015, over 100 LNGc vessels have been fitted with DFDE propulsion from ABB.

3) Flexibility
DFDE propulsion allows ship owners to adapt to the technology of tomorrow, with possibilities for installing alternative energy storage mediums and/or energy transformation devices, such as fuel cells. Hybrid power plants with energy storage capabilities reduce operational costs by optimising the dual fuel engine loads. In addition, they improve safety, availability and increase dynamic performance.

ABB's Dynamic AC concept, often referred to as DAC, enables optimisation of total fuel consumption in the vessel by adjusting the rotational speed of the dual fuel generating set and allowing the frequency to vary within a specified range. A fixed 60Hz frequency is not required to operate the propulsion system. The small proportion of consumers who require fixed frequency would need to install an island converter. LNGc simulations on specific trade routes have indicated that fuel savings of up to 6% can be achieved.

Optimising efficiency

This study marks the first time a system provider has cooperated with DNV GL for an LNGc machinery assessment. To date, the market has generally held the perception that two-stroke dual fuel solutions are superior to DFDE propulsion in terms of efficiency. However, with optimisation measures and updated figures for DFDE propulsion systems it was found that, compared to previous studies, overall efficiency was greatly enhanced.

The LNG carrier integrated marine energy system

On board an LNGc there is a multi fuel and multi product energy system. All inputs and outputs are taken into account when considering overall vessel efficiency.

If the boil off gas (BOG) rate of the LNG containment system produces more gas than consumed, the excess boil off must be either burnt in the gas combustion unit (GCU) or re-liquefied back into the tanks. If the BOG rate produces less gas than needed, the boil off must be forced.

Optimising PMS strategy to enhance efficiency

By optimising a vessel's PMS strategy – for example, by increasing the loading of some engines while shutting others off – higher overall efficiency can be achieved. For Wärtsilä four-stroke engines running on gas, which normally drive ABB generators, relative fuel consumption decreases with loading, and reaches its minimum at 100% of maximum continuous rating (MCR). Higher loading gives a better combus-

Ship overall efficiency – comparisons

Fuel oil, pilot & cargo energy consumed – Propeller, Electricity & Heat demand

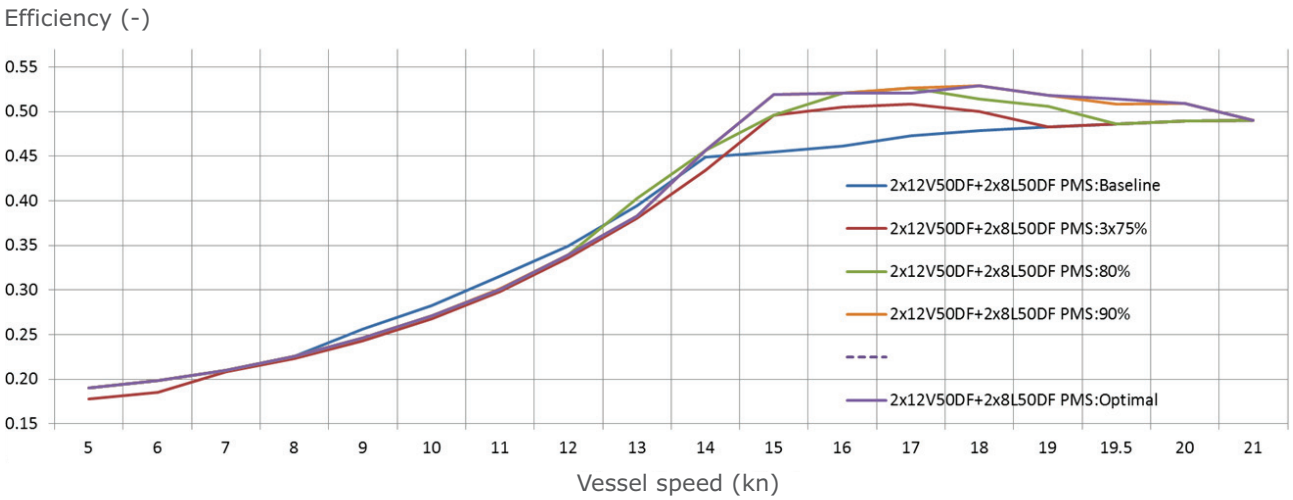


Figure 2: PMS strategy efficiency improvements over speed range

tion process, while less running hours for each engine reduces service cost. A fast load reduction feature is already built into the frequency converter, reducing the risk of both overloading the generators and black outs.

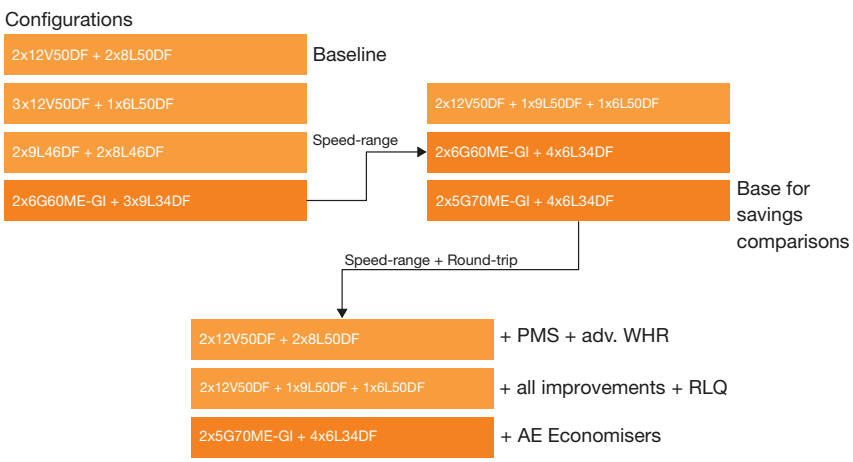
PMS strategies

- Baseline – A 'business as usual' scenario as derived from historical data. Equal load sharing.
- 3x75% – three engines on continuous operation, switching to four when 75% load is exceeded, switching to two when the load drops below ~30%.
- 80%/90% - Starting with one engine at low loads, a new engine comes online when loading of the engines exceeds 80 or 90% of MCR and vice versa.
- Optimal – Same as 80%/90% but with a variable maximum load limit, giving approximately 1000kW reserve capacity for any engine combination.

Compared to the PMS baseline, a significant increase in efficiency is achievable, especially at speeds above 13 knots. An optimal PMS strategy was found to have the biggest single contribution to increasing overall efficiency for the DFDE concept. It should therefore be implemented in future LNGc newbuildings.

Engine layout

A 174kbm LNGc will traditionally have four four-stroke engines of various sizes. Increasing the number of different engine sizes also increases



Simulated configurations: This configuration has improved performance in the high-speed range

Ship overall efficiency – comparisons

Fuel oil, pilot & cargo energy consumed – Propeller, Electricity & Heat demand

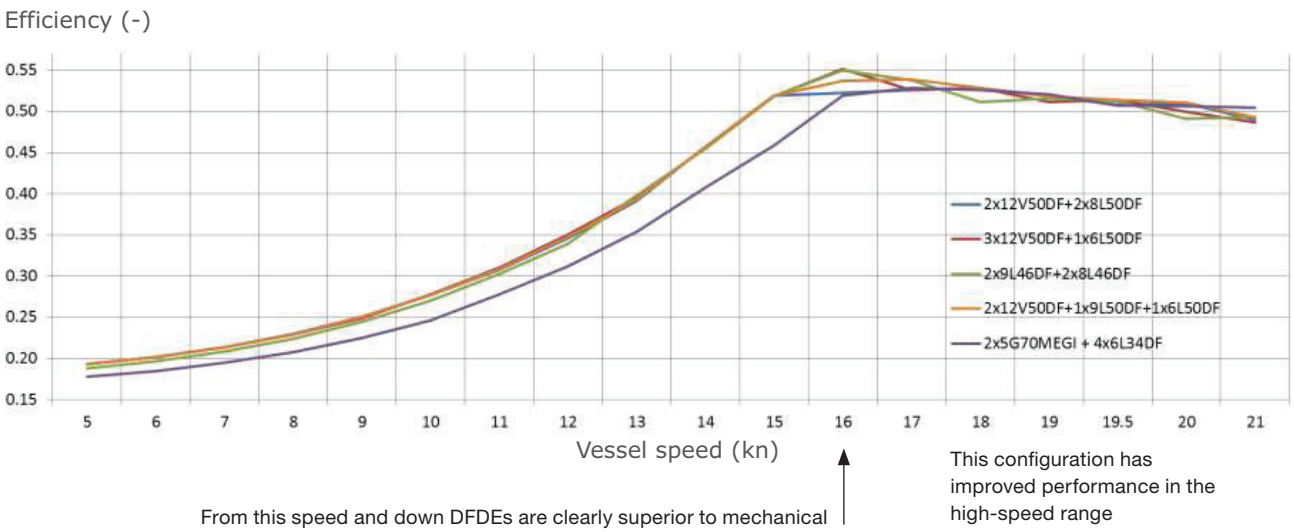


Figure 3: Speed range results for various configurations of machinery lay out

possible power combinations, thus augmenting the power resolution. Comparing DFDE to two-stroke dual fuel mechanical propulsion over the vessel speed range, it is clear that DFDE is still very competitive and should be a feasible solution for owners.

Waste heat recovery

Steam is used for various applications on board an LNGc. Its contribution to overall power consumption for the vessel is significant (up to 3MW). The four-stroke Wärtsilä engines have higher exhaust temperatures than the two-stroke engines, giving the four-stroke higher potential for exhaust economizers / waste heat recovery (WHR) to create steam.

Usually economizers are dimensioned to create steam and fulfil the vessel's steam demand at design speed. However, if the economizers are increased in size, more steam can be created over the speed profile and therefore overall efficiency can be enhanced.

When adding extra waste heat recovery, more optimal PMS and an optimised engine layout, fuel savings of up to 14% are achievable when compared to the DFDE baseline, and of up to 12% compared to two-stroke dual fuel solutions, at certain speeds.

Partial re-liquefaction

Re-liquefaction plants are not standard on LNGcs due to high CAPEX. In this study a smaller/partial plant with a capacity of 500kg/h was simulated as an option. Dependent on LNG price and the speed profile of the vessel, partial re-liquefaction may be feasible.

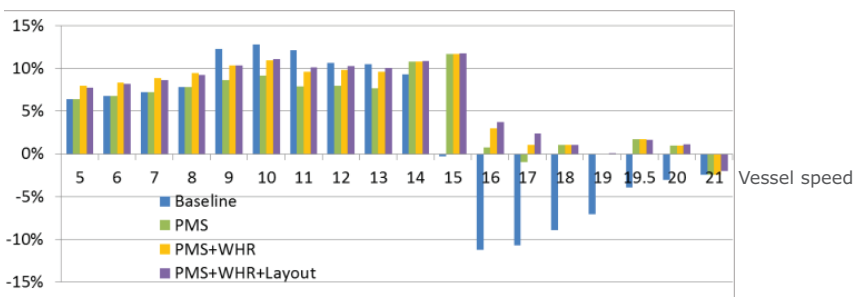
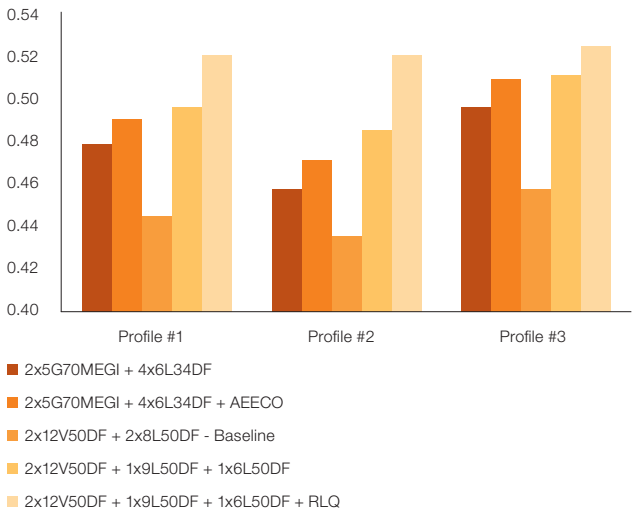


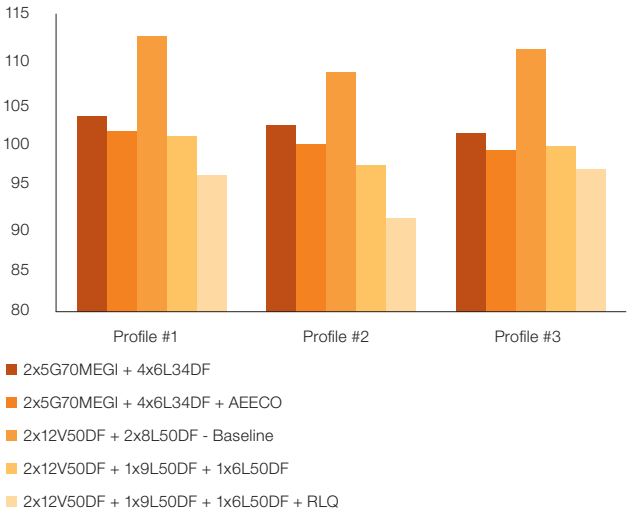
Figure 4: Fuel savings relative to two-stroke engine

Effect of operating profile on technical and economic performance

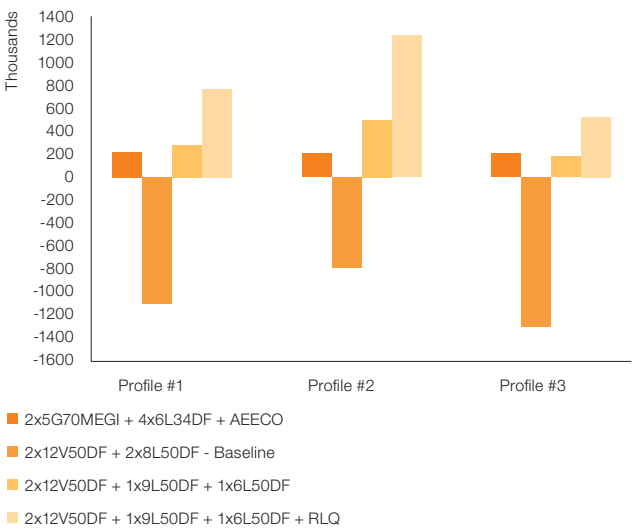
Ship overall efficiency



Fuel cost (USD/nm)



Annual fuel cost savings (USD/year), compared to ME-GI



Reliq, system payback period (years)

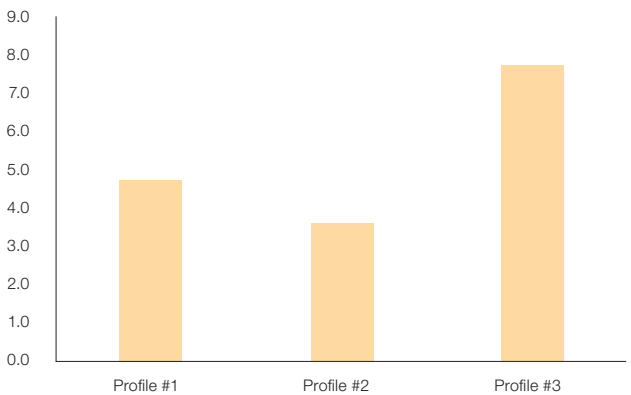
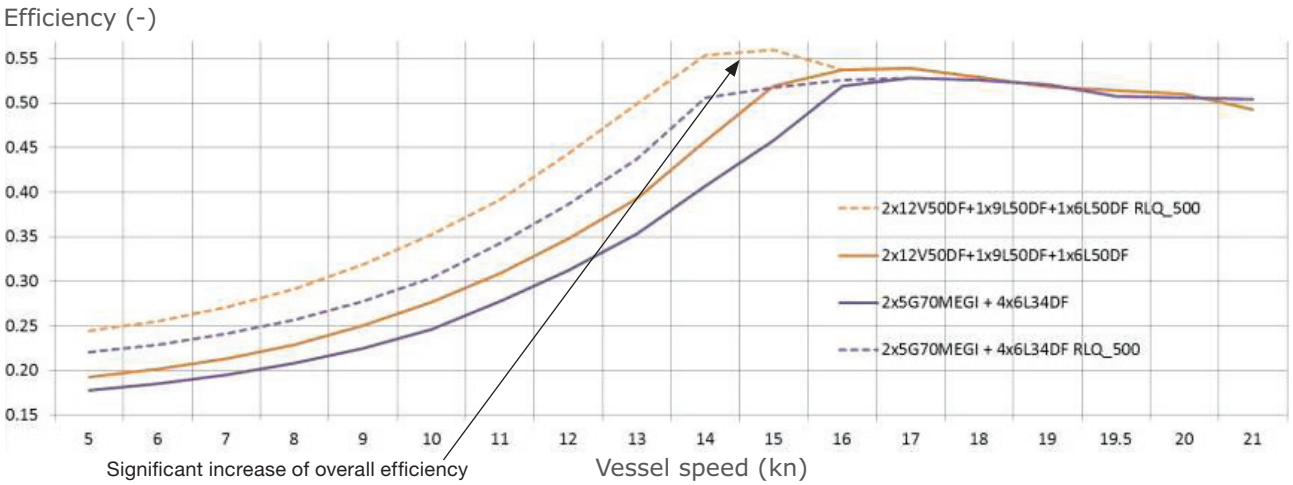


Figure 5: Round trip results

Ship overall efficiency – comparisons

Fuel oil, pilot & cargo energy consumed – Propeller, Electricity & Heat demand



Partial re-liquefaction

Round trip results

When considering a vessel round trip, data for the following sailing and non-sailing modes must be considered.

- Laden
- Ballast
- Loading
- Unloading
- Anchorage loaded
- Anchorage ballast

The characteristics of the round trip profile are as follows

- Speed distribution
- Hours in each mode
- Steam demand
- Propulsion power
- Electricity demand
- Boil off gas rate

The route used in this study was a typical LNGc route, from west coast USA to Singapore. This route has a distance of 7200nm. Three different round trip profiles were simulated, with the result that the optimised DFDE propulsion system was shown to be the most fuel (and therefore cost) efficient solution.

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Smart, connected, safe solutions for Arctic LNG

ABB Ice Mode

A new, smart, connected development for safer and more available electric ice milling with gas-fired engines in Arctic LNG Carriers.

Ice Mode is the new control technology development from ABB Marine and Ports, commissioned within DSME HN2418, the first of the series of Yamal ice-class LNGs with Azipod®-based electric propulsion. Ice Mode is a set of connectivity and control functions that allow electric-propulsion LNG carriers of the Yamal type to increase availability for ice-breaking operations with dual fuelled engines running on boil-off gas. Running more often for longer periods of time, and with fewer requirements for the switchover from boil-off gas to marine diesel fuel, greatly increases the economy and safety of operation of the long sea ARC 7 ice-classed LNG carriers. The increase in availability and safety is only possible by leveraging connectivity between individual Propulsion Control Units (PCUs), a stable, mature, and capable embedded automation product from ABB Marine and Ports, delivered in its present form for over 15 years.

The issue at stake is dealing with fast load reduction in the AC electric network of a typical electric-propulsion ice-classed LNG carrier, which occurs when the propeller blades of Azipods encounter large chunks of ice while milling. In such conditions, the rotor of the electrical motor stalls extremely quickly from mechanical braking on ice, and as a result, after the drive of the Azipod thruster reaches its maximum torque capability, the produced power or speed of revolution of the shaft in rpm dips precipitously, thereby cutting the electrical load. Ordinarily, the unbalancing of load vs. produced electrical power would be seen by the prime mover – the diesel engine running on boil-off gas from the LNG tanks – as reduced mechanical load, freeing it to spin faster. The governor would then throttle down the engine in a ramp-down action that would need to be fast enough to counteract the almost instantaneous loss of load. However, since such a fast ramp-down is impossible when the engine is fired by gas, the engine would need to switch over to marine diesel-burning mode. To work together with the ramp-down action of the governor of the prime mover on the mechanical side, in these scenarios, ABB's standard solution is to design the electrical system such that a part of the load is temporarily kept on the electrical

From the Vuosaari Azipod factory, Helsinki

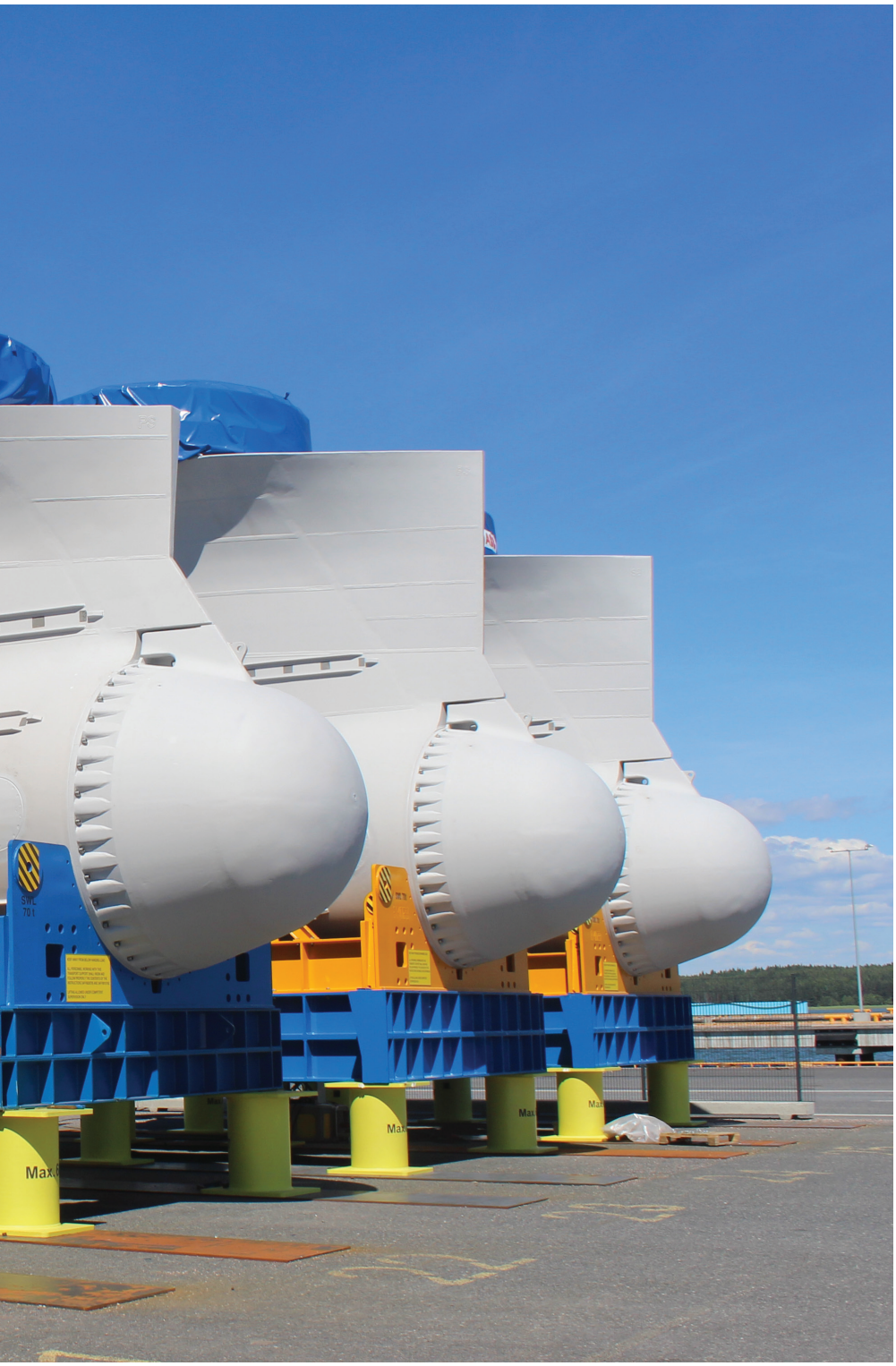
network by using braking resistor load-banks. This gives additional time to the mechanical equipment to ramp down production in a way that is feasible for the gas-burning regime, at the expense of heating up the resistors.

The Ice Mode functionality takes this principle further, by connecting the individual PCUs, and allowing for the optimal use of various high-capacity electrical loads on the electrical network. First and foremost, assuming the electrical system is operated with closed bus-ties, more than the one load bank, with one connected to the DC link of the stalling pod's drive, may be used. Additionally, provided that other Azipods are not currently functioning at peak performance, part of the load may be taken up by those Azipods. Of course, the redistribution of the electrical load is transitory in nature, since it is assumed that the originating event – the stalling or mechanical braking of the pod hitting ice, is temporary, and normal operation will be resumed.

Ice Mode comprises two main parts: 1) the distribution algorithm that kicks in when a difference is detected between commanded power (as load) and the actual load on the system, and 2) the various protection mechanisms required for safe operation of the more complex interlinked system. The local calculation of load difference requires the mutual connection of all PCUs to one another, and effective and timely exchange of critical measurements. Likewise, protection functions require communication of critical state parameters and status feedbacks from all machinery, regardless of place of installation, to all PCUs. With ABB's time-tested AC800M™ controller technology, and the Inter-application Communication (IAC) protocol for fast, high quality, and easily engineered communication between individual PCU applications, the required communication is easily implemented.

The Ice Mode algorithm dynamically and responsively shifts the instantaneous electrical load from the stalling or braking Azipod to the other available loads in the network – available load banks and load reserves on other Azipods that are not already functioning at peak performance. The algorithm provides a qualitatively different, better and increased level of availability of ice milling on boil-off gas than existing solutions. This is achieved by intelligently playing off the complementary capabilities of the remaining loads in the system, while operating with closed bus-ties. On the one hand, somewhat slower, but with extremely high-capacity loads presented by rotating electrical machinery, the remaining Azipods are used to optimal effect if the braking or stalling

Ice class Azipods ready for delivery



is protracted. On the other, quickly reacting resistor load banks, albeit with limited capacity, and duty cycle are used for instantaneous reaction, but must be quickly unloaded to prevent build-up of heat and subsequent interlock in future events. Ultimately, a provision for feasible ramp-down of electrical power production by the diesels burning gas is also taken into account and accommodated.

The protective functions of Ice Mode concentrate on measuring the duration and intensity of over-torque operation of Azipods, and on calculating the duration, intensity and duty cycles of pulses of current sent by the DC link in the Azipods' drives to the resistor load banks. Internal models are used to model resistive heat shunted to the resistor load banks and Azipod exciter rotor diodes. The models are monitored and updated so that interlocks are safely emplaced, and alarms and events issued to denote that the capability of the system to handle further disruption is reduced due to the operational limits of the machinery.

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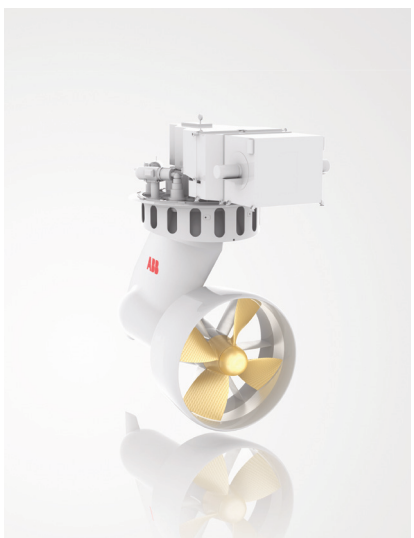
New Linear Flow Propulsor technology provides better efficiency across a wider range

The Azipod XL

What is Azipod XL and linear flow propulsor technology?

Azipod XO is the state of the art for podded propulsion, enhancing the already excellent efficiency of earlier models. Linear flow technology takes Azipod technology one step further, building on ABB Marine's 30 years of Azipod propulsion experience and knowledge.

The basic principle of linear flow propulsor (LFP) technology is simple; the water flow behind the pulling nozzled propeller is straightened by guiding plates, reducing turbulence and energy loss. The new Azipod XL utilises LFP technology, but is still based on proven Azipod XO solutions.



Azipod XL: The next level in efficiency

Background of innovation

LFP technology is a result of systematic innovation work, creating, investigating and evaluating a huge number of different ideas and concepts.

This process led to several potentially feasible concepts, and one of the most promising was LFP. Other very promising technologies were also uncovered, and these are being investigated as well, raising expectations for new propulsion-related innovations to be revealed in the coming years.

Development of Azipod XL

Once a new technology is developed and verified, there is still long way to go before commercialisation. Technology must be implemented in products that provide customers real value, and still fit perfectly into a product portfolio.

The initial idea was that Azipod XL should provide same benefits to the customer as the current Azipod XO, but with even better efficiency. This presented several technical challenges for the engineers; for example, preserving the possibility to maintain the shaft seals underwater, without dry-docking, requires careful engineering and testing in a model environment. Ultimately, in the case of shaft sealing, the selected solution was an improvement on the XO solution. In Azipod XL, the shaft seal can be replaced even faster and quicker underwater, thanks to additional static seal arrangement for maintenance.

After the concept had been verified by CFD calculations, model tests were necessary in order to verify its potential. Model testing allowed the performance comparison of Azipod XL to the existing Azipod XO propulsor. Improvements were a clear step forward, even though the existing Azipod XO had the best efficiency on the market, proving that LFP technology can make the best even better.

Benefits for shipowners

The direct benefit for ship owners and operators is an improvement in

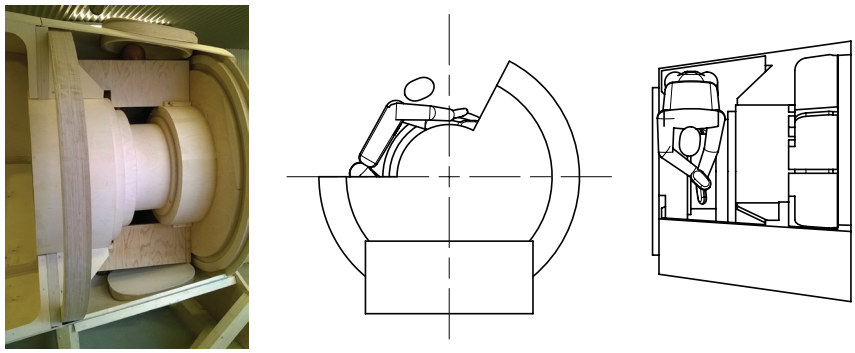
efficiency from 5 to 10 per cent, depending on the operational profile. LFP technology also expands vessel speed range while still operating at high efficiency levels. This means that bollard pull capability is also increased, while maintainability is also improved due to faster shaft seal replacement.

Next steps

Implementing of LFP technology has started on one Azipod frame size of up to 17.5 MW. After compilation of the first experiences, the same technology can be applied to other power classes. Due to improved efficiency and bollard pull capability, this solution may open for totally new application areas and vessel segments in future.

In principle LFP technology can be applied in any of the members in the Azipod product family. When the need is for higher hydrodynamic efficiency at a wider operational speed range, LFP technology can provide the solution. Even vessel types where the benefits of electrical propulsion are only now being realised may in the future be equipped, not only with electrical propulsion, but also with LFP technology.

It will be interesting to see which doors are opened by the new, energy saving LFP technology.



Wooden full-scale space model to verify shaft seal maintainability underwater

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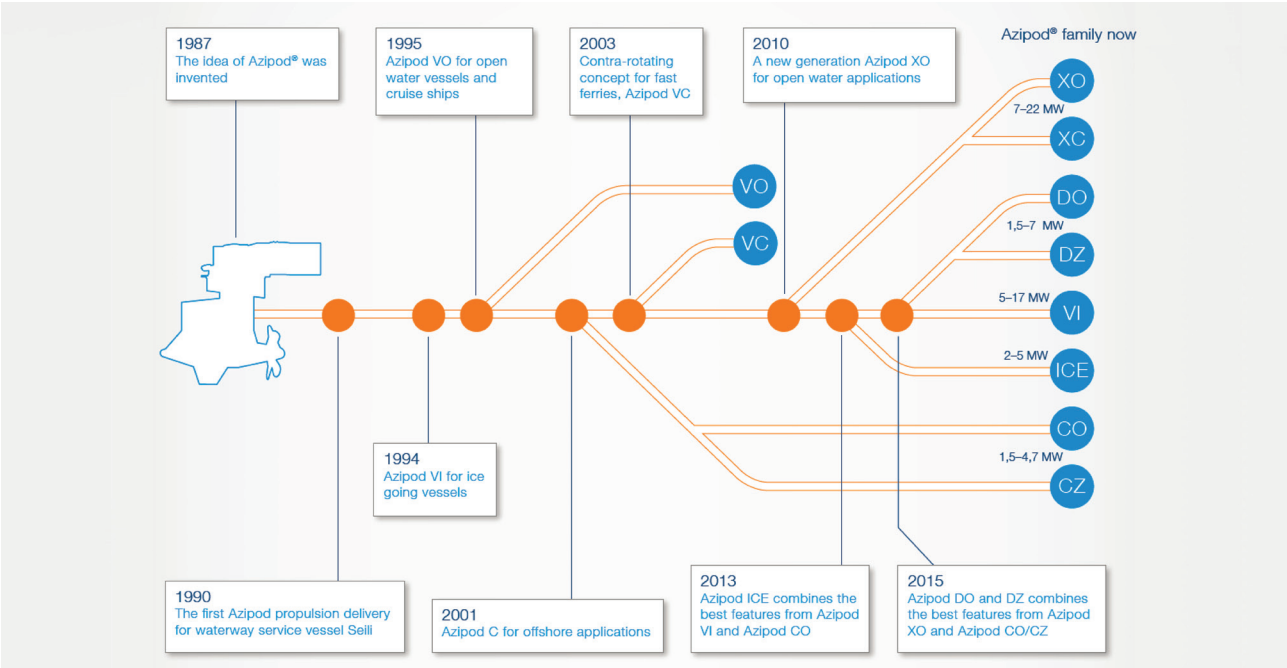

Development path from the initial Azipod idea to Azipod XL2100

Optimal operations from office to propeller

Next generation control

Traditionally, ship systems have been independent and segregated, largely due the fact that different subsystems are typically provided by different vendors. This leads to subsystems performing seemingly well independently, but less than optimally together, seen in a system-of-systems perspective.

However, system level performance of a ship can be optimised using a novel vertical and horizontal communication concept and closed-loop optimisation, as well as ABB Integrated Solutions for propulsion and remote control, power plant and main switchboard, power management, optimisation, on board advisory and integrated operations.

This impacts the technical performance of the systems, but also their overall fuel efficiency. This article describes how vertical and horizontal connectivity can improve the overall system level efficiency and facilitate smooth operation of a ship. In addition, the integrated solution enables increasing the level of automation, thereby making operation of the ship easier. The article also addresses how ABB's integrated solution utilises the vertical and horizontal connectivity and closed-loop system level optimisation to achieve optimal operation from Office to Propeller.

Vertical layers and horizontal segments of operation

In a complex system-of-systems, the overall system can be broken down to vertical levels and horizontal segments of hierarchies. In principle the vertical levels are defined by the time constants of the operational dynamics typical for that level. Systems working on the same vertical layer have approximately equally dominant time constants. The vertical layers can be divided into horizontal segments, where each segment corresponds to an individual subsystem or a device.

Each vertical layer can be divided into horizontal segments, which concern of certain aspect of the operation. An example of the horizontal segments is shown in Figure 2. The number of segments in each vertical layer is not necessarily the same. However, in the example figure three main horizontal segments can be determined: Propulsion, Fuel and Power, and Waste segments.

Next Generation Control – Connected vertical layers and horizontal segments

Typically the horizontal segments in each vertical layer are isolated. The information is not transferred automatically between the segments and it is

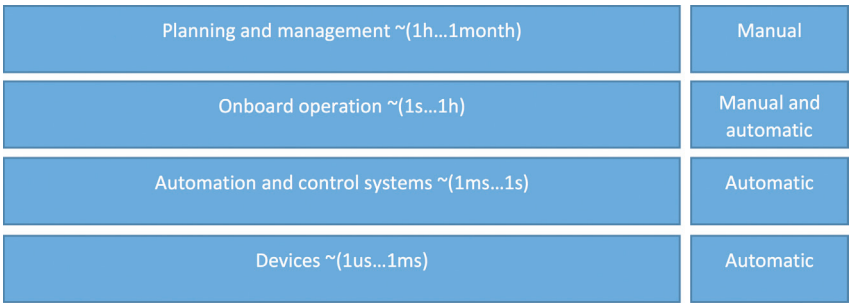

Figure 1: The vertical levels of hierarchies in ship operation and illustrative time constants for each level. The column at right describes whether the operation in this layer is automatic or manual

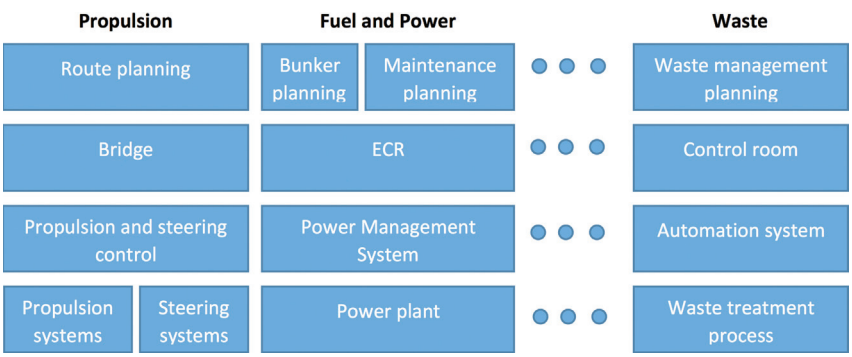

Figure 2: Horizontal segments in each vertical level

not utilised in the most effective way. In addition, the information available in higher levels of hierarchies is not typically automatically utilised in the lower levels 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 Next Generation Control systems provided by ABB aim at optimal system level operation by introducing novel vertical and horizontal communication, as well as an additional optimisation layer to enable optimal system level operation. The hierarchy of the Next Generation Control is shown in Figure 3. The idea of the horizontal connectivity is to enable the communication of the plans, decisions, constraints and capability information between the different horizontal segments.

The Adaptive closed-loop system level optimisation layer continuously estimates the performance of each subsystem or device based on measurement data and uses the estimated models together with the plans and forecasts from higher levels as well as the diagnostics and performance of the lower levels to operate the ship systems optimally.

Optimal closed-loop operation from Office to Propeller

The Next Generation Control concept described in the previous section has currently been implemented in ABB Marine systems as shown in Figure 4. The top layer contains the ABB Integrated Operations where the full cloud software and service offering can be utilised. The Remote Diagnostics System (RDS) for asset monitoring, maintenance and troubleshooting, and the ABB Advisory Suite for voyage and energy, offer the customers tools to plan the vessel operation optimally and continuously understand the performance and condition of their assets. Based on the planning performed in the top layer, the ABB Advisory suite calculates accurate operation profile forecasts by using semi-physical models trained using machine learning, and weather forecasts. The ABB Onboard Advisory Suite adaptively

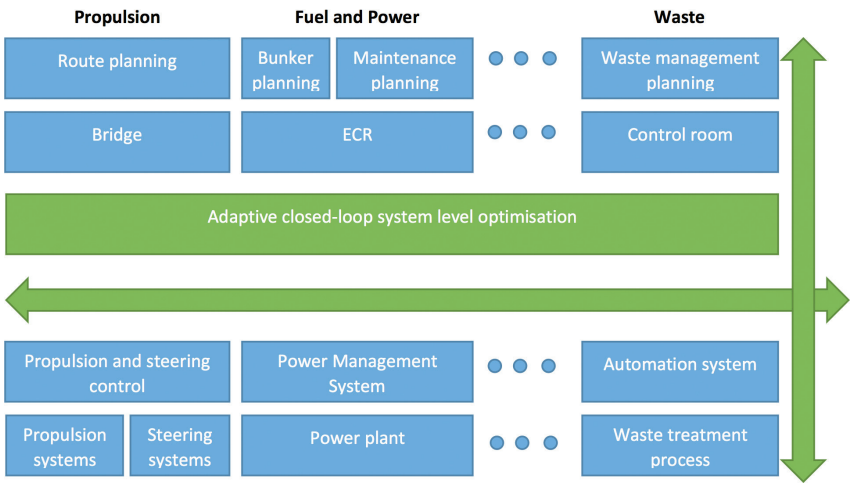

Figure 3: Next Generation Control with horizontal and vertical connectivity as well as the Adaptive closed-loop system level optimisation layer

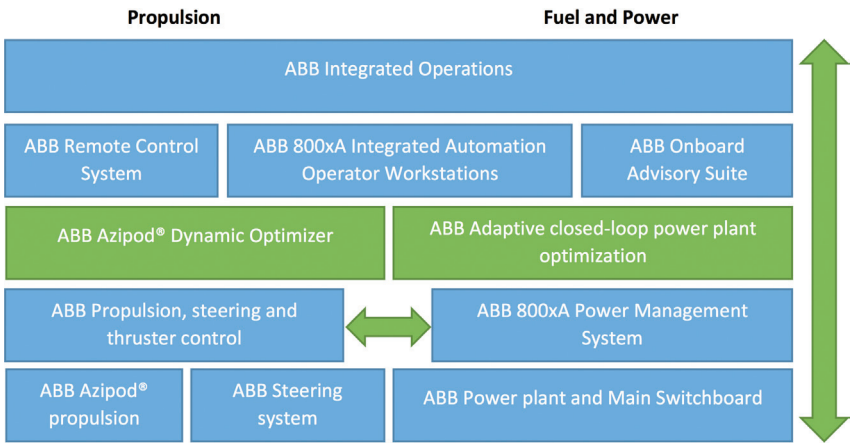

Figure 4: Currently available ABB solutions for Next Generation Control

estimates and tracks the performance of each diesel generator.

All ABB equipment is continuously monitored using ABB software solutions. The monitoring and performance information is automatically transferred to higher levels to enable the systems and users to use the information in decision making and planning. If performance of some device or component has declined, the ABB Integrated Operations centre will observe this and inform the user. In addition, ABB solutions for operation planning and closed-loop optimisation take the decreased performance into account and forbid the use of the faulty component, or at least minimise the running hours of that component until maintenance has been performed. Thus, all layers are continuously tracked in the performance of the systems and the ship and that information is used in planning and decision-making. This enables optimal operation from Office to Propeller.

Advisory Suite for power demand forecasting

The ABB Integrated Advisory Suite consists of technology to enable optimal speed profile calculation based on voyage plan, schedule, weather forecasts, and a ship and propulsion model that is partially trained using measurement data using machine learning. The model takes into account external operation conditions such as wind speed and direction, sea currents, waves, sea depth, etc., and calculates accurate motion response in various operating conditions. The motion responses as well as the forecasts of the other external operating conditions, and other variables such as speed, are used to calculate accurate propulsion power profile forecast for the whole voyage. The propulsion power model has been developed in collaboration with ABB Corporate Research Center (CRC).

In addition to the propulsion power profile forecasting, ABB Machine Learning models in the ABB Advisory Suite can predict the auxiliary power demand very accurately based on ambient conditions, time of day, operation mode, etc. An example of the ABB Machine Learning modelling prediction capability is shown in Figure 5.

Advisory Suite for adaptive SFOC curve estimation

The ABB Advisory Suite includes a module for continuous adaptive Specific Fuel-Oil Consumption (SFOC) estimation for each diesel generator or other power producer. The SFOC curve is estimated from continuous measurement data using technology developed together with ABB Corporate Research Center. Based on literature, the SFOC curve of a diesel engine can vary from 2-5 per cent during maintenance intervals. Therefore

it is critical to track the SFOC curves of each engine in order to achieve optimal operation of the power plant at all times. In the ABB Advisory Suite the SFOC module includes a diesel generator monitoring user interface where the user is able to compare the currently measured performance of each individual diesel engine with respect to a baseline from a chosen baseline period, and even a baseline from manually entered data (e.g. test bench results). The SFOC curve is calculated separately for each fuel type. An example view of the SFOC monitoring user interface in ABB Advisory Suite is shown in Figure 6.

Adaptive closed-loop power plant optimisation using Advanced Process Control

The adaptive closed-loop power plant optimisation solution has been developed using ABB Advanced Process Control (APC) technology. The APC is an optimisation platform, which is designed for industrial Nonlinear Model Predictive Control (NMPC) implementation. It also performs nonlinear receding horizon state estimation and can utilise soft sensors to estimate non-measurable values or filter very noisy signal values. The APC can handle binary and continuous decision variables and is therefore ideal for solving production-consumption balancing and planning problems when forecasts of the input signals are available. The APC integrates seamlessly on ABB 800xA automation system.

Thrust optimization using Azipod Dynamic Optimizer (ADO)

The Azipod Dynamic Optimizer (ADO) is a software module for optimization of the towing angle between two or more Azipod® units. The towing angle has significant impact on the hydrodynamic efficiency of the propulsion system. The ADO utilizes measurement data collected from full-scale operation of the vessel, and uses machine learning to estimate a model that can be used to calculate the optimum towing angle in each operating condition. The ADO integrates seamlessly to the ABB Remote Control System. When the ADO mode is activated from the bridge, the towing angle is automatically optimised continuously.

Integrated Propulsion and Power Management System

The ABB Marine Power Management System (PMS) comprises a modular solution built on top of ABB 800xA Industrial Extended Automation system. The PMS has all the basic functionalities such as automatic start and stop of diesel generators, symmetric and asymmetric load sharing using droop or isochronous load sharing principle, etc. In addition, the PMS has seamless integration with ABB Propulsion Control System to enable optimal dynamic behaviour of the power plant even in case of manoeuvring, accelerations and slow-down situations. The closed-loop automatic power plant optimisation is designed for integration with the ABB PMS. The integration of the power management and propulsion control functionalities as well as the closed-loop optimisation enables the ABB integrated solution to provide significant fuel savings throughout the life cycle of the vessel.

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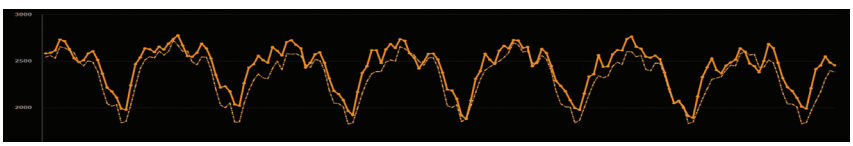

Figure 5: Actual (solid) and predicted (dashed) auxiliary power demand

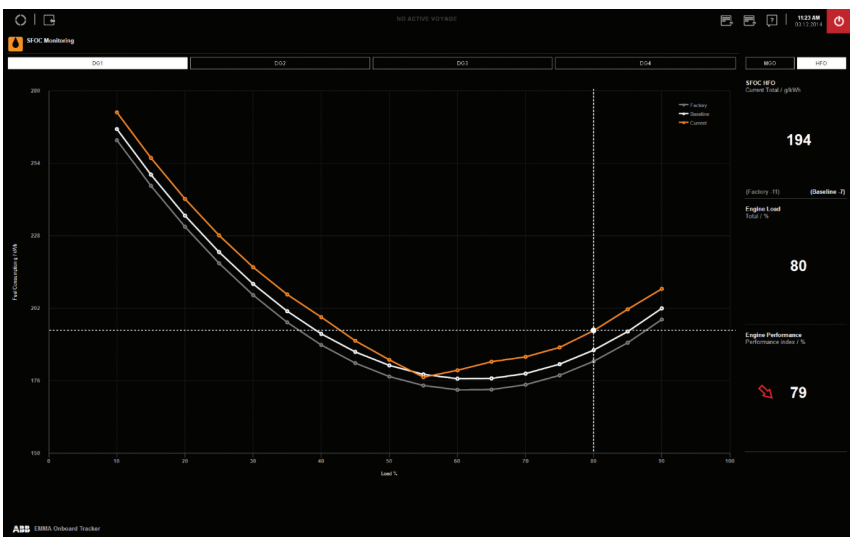

Figure 6: Adaptive SFOC curve estimation in ABB Advisory Suite

Jacking Control System

Abstract

ABB's Jacking Control System (JCS) is an advanced VFD control system, which consists of variable speed drives and controls. The key advantages of a VFD driven jacking system include controlled start-up operations and accurate and precise speed control, resulting in improved efficiency. It optimises the power consumption under various working conditions, and enhances operational and system reliability. ABB's jacking system is fully integrated with the electric power and automation systems on the high performance 800xA automation platform. Powerful inter-systems connectivity and advanced reporting functionality allow operation in a smarter, safer and more efficient way.

Figure 1: Liftboat with jacking legs

Background

Jacking systems are widely used in the offshore construction and drilling industries, such as in jackup vessels for oil drilling and offshore wind turbine installation and maintenance. Each vessel type places different requirements on the jacking system. There are two main types of jacking systems: pin-and-yoke and rack-and-pinion. For high-speed operation and deep-water application, rack-and-pinion systems are preferred. ABB's jacking packages are designed to drive rack-and-pinion jacking systems.

ABB jacking power system

ABB provides a complete jacking power system including power distribution, jacking drives, and motors. Different from the conventional electrical rack-and-pinion jacking system where the jacking motors are typical direct-on-line (DOL), ABB utilizes advanced variable frequency drives (VFD) and VFD motors to optimise power consumption under different working conditions and improve operating flexibility and system reliability. With the traditional DOL system, the jacking motors are directly connected to the power networks via jacking MCCs. The jacking speed is not adjustable during the operation unless two-speed motors are chosen. A typical jacking system for a four-leg liftboat uses 72, 120, and even up to 144 motors working in combination to share the load to elevate or lower the hull against gravity.

ABB jacking drives are selected from ABB ACS800 / ACS880 range of marine low-voltage drives. The variable frequency drives are configured in a multi-drive line up, replacing the traditional jacking MCCs. Each inverter is designed to drive a single jacking motor. The multi-drive is arranged by leg or by layer, depending on the jacking operation requirements. High power braking units and resistors are

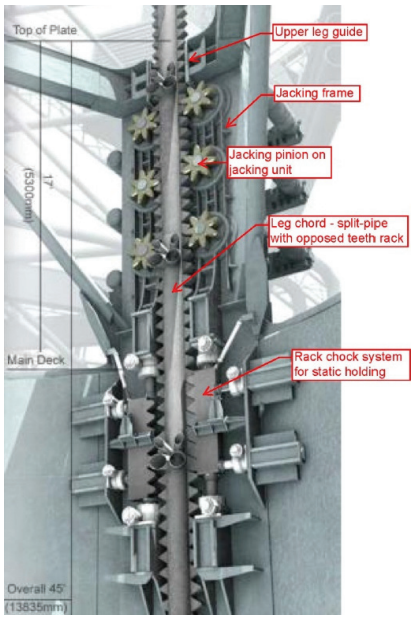

Figure 2: Typical electrical rack-and-pinion jacking system for truss legs[1]

Figure 3: ABB jacking control console

provided to dissipate re-generated energy during leg down operations or lowering the hull.

ABB jacking control system

ABB's jacking control system is based on advanced 800xA control platform, which provides the operators with the information needed for jacking control and system maintenance. Its design principle is to provide simple, familiar controls for safety and ease of operation. It supports two or more jacking control stations and combines physical control panels with intuitive computer screens for information and monitoring. In addition, it is also possible to integrate the ABB remote diagnostic system (RDS), which allows connectivity to shore and provides remote system monitoring and expert services.

Figure 4 shows the HMI graphics of ABB jacking control system, which provides streamlined and intuitive design with optimised colour contrast to further improve effectiveness of operation and safety. Advanced reporting functionality enhances the smart, safe and user-friendly operation experience.

Figure 4: ABB control system HMI graphics

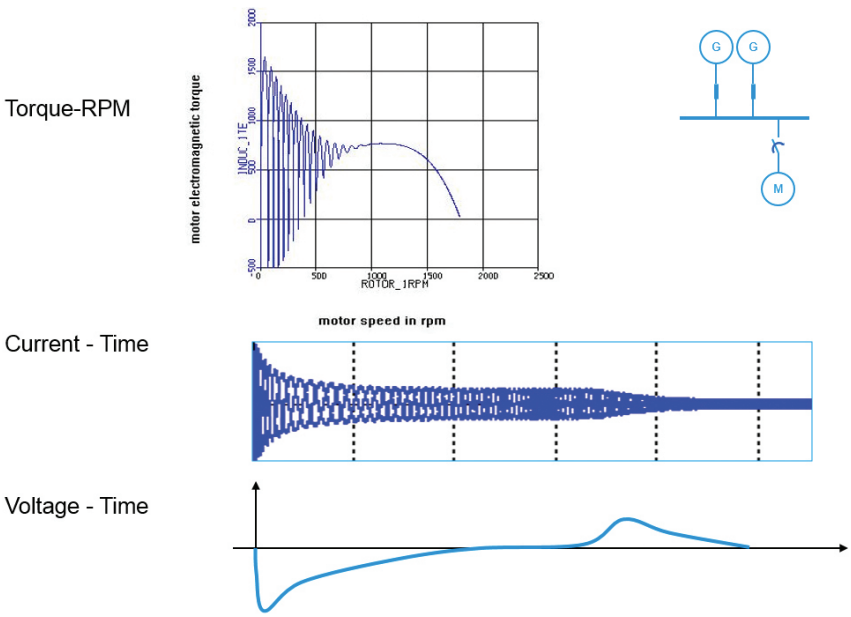

Figure 5: Typical transient behaviour of DOL motor

Benefits of variable-speed jacking system

With the traditional DOL system, the starting currents are very high, causing large voltage and frequency variations. The power system reliability is therefore significantly degraded when the jacking system is started, which causes vessel blackout. For jack-up vessels with dynamic positioning (DP) system, the transition period from DP to jacking operations is critical. Blackout while maintaining position close to an offshore construction site would be highly dangerous, and represents a risk that must be eliminated.

ABB's VFD-driven jacking system has many benefits. First of all, standard marine approved electric motors can be used to replace the special DOL high-slip jacking motors, which is very expensive and with low efficiency. On the other hand, ideal brake control during starting and can be achieved with VFD control, where a torque memory function is used to transfer the load smoothly between the brakes and the motors. In addition, the jacking control system can be integrated with the power management system (PMS), reducing the risk of overloading the power plant to minimum.

Another issue with conventional DOL jacking systems is the inflexible jacking speed, with the jacking legs moving too fast for levelling and load-balancing operations, while moving too slowly during leg handling. Variable speed systems solve these problems. The operator can select a lower speed as needed in order to prevent rushing and promote safety. Higher speeds are available during leg handling, without the electrical and mechanical shocks caused by two-speed motor switching.

ABB direct torque control (DTC) VFD helps to enhance the system safety, especially during the starting/stopping period. The DTC control method makes it possible to control full torque at zero speed, and provides smooth starting or stopping jacking operation.

Compared with the scalar control (V/f control), an open-loop control method, DTC displays superior performance, especially during starting and stopping. During starting, the V/f control needs to estimate the frequency that will provide enough torque to hold the load without causing a jerky start. This might be difficult due to the variable load, which can vary from -10% to 60%. ABB has chosen a smarter way: the speed reference is maintained at zero speed while the closed-loop control is used to measure the load and to hold it without moving. Once the motor brakes are released, the speed reference is slowly accelerated to the set point. The entire starting process is very smooth and fast. Similarly for the stopping operation, the V/f control needs to estimate a frequency that will keep the load still without dropping or fighting with the brakes. ABB's Direct Torque Control allows the motors to support the load while brakes are engaging, providing a smooth load transfer from motors to brakes.

Case study

ABB has successfully delivered a complete jacking control system for Swire Blue Ocean wind turbine installation vessels *Pacific Orca & Pacific Osprey*. The vessels are currently operating in the North Sea. For this project, ABB provided the retrofit solution to upgrade the conventional DOL jacking system to VFD-driven jacking control system.

The jacking multi-drives are arranged by leg, and each leg is equipped with one jacking control unit (JCU). A redundant network is provided between the control cabinets and the bridge. As indicated in

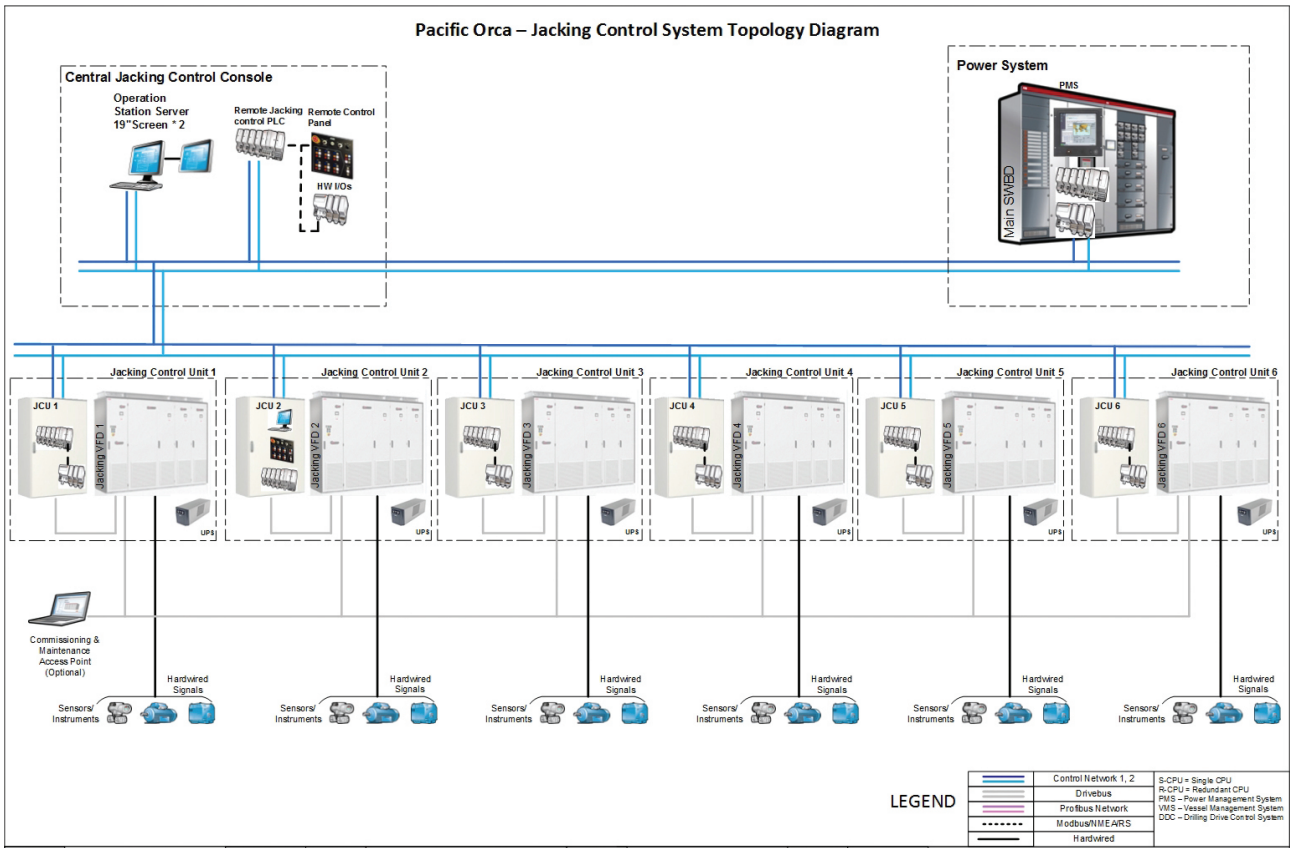

Figure 6: ABB jacking control system topology diagram

Figure 6, the jacking control topology, one central jacking control console works as the main operation station, as well as one local control panel for back-up purposes. In addition, ABB also provides power management system (PMS) integration on the same network.

The success of the Swire jacking project represents a significant milestone for ABB in the jack-up or liftboat market. As the leading electrical systems integrator, ABB continues to work closely with ship owners, builders and designers. The connectivity with the entire marine industry provides inspiration to design the optimal jacking control system for each vessel.

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[1] Knud E. Hansen A/S "Design of Wind Turbine Installation Vessel – Pacific Orca for Swire Blue Ocean"

World's biggest wind turbine installation vessel: Pacific Orca – Swire Blue Ocean

Empowering innovation in energy efficient marine solutions

Hybrid laboratory

Increased efficiency and reduced emissions are essential for the sustainable development of maritime industry. The experts at MARINTEK in Trondheim, Norway, have created an advanced laboratory to put the latest hybrid energy solutions through their paces.

The Hybrid laboratory at The Norwegian Marine Technology Research Institute (MARINTEK), part of SINTEF, Scandinavia's leading independent research organisation, has been created to support the study of energy efficient ship power- and propulsion systems. ABB's technology plays a pivotal role in the pioneering work undertaken here.

This case study details the equipment, structure and capabilities of the Trondheim-based laboratory.

Diesel engine – generator – rectifier

The lab has been constructed to house two sets of diesel engines, generators and rectifiers supplying a 540V DC bus. The diesel engines are four-stroke six cylinder units, of a different size, with a net engine prime power of 209kWb and 412kWb at 1500rpm. ABB has manufactured the generators, which have a rating of 230 and 400kVA at 1500rpm. One of the key benefits of the DC grid is that the engine/generator speed is not bound by electrical frequency; hence both generators are designed for variable speeds. The 450V AC output from the generators is rectified through two thyristor rectifiers, also supplied by ABB, which offer a controlled amplification of the voltage.

Drives line-up

The lab power system has two drive line-ups separated by a bus tie. The load consists of two 200kW squirrel cage ABB induction motors, featuring eddy current breaks. The breaks provide the motors with an adjustable load torque and can run pre-programmed load profiles to simulate ship propulsion. The motors are supplied by ACS800 multidrives. One of the advantages of a DC grid is that the drives do not need a rectifier. The diode supply unit (DSU) or inverter supply unit (ISU) used in conventional AC systems is replaced with a DC supply unit (DCSU).

The ABB-developed incomer module (input circuit, or IC) is part of the protection system of the onboard DC grid. The IC will be transparent most of the time, allowing power flow between the motor loads and energy storage systems at different line-ups.

Only in the case of a sudden drop in grid voltage will the IC block return currents from the drives to the generator side. This will ensure selectivity of the installed fuses, and quick recovery of the system after a fault.

Battery bank

The battery bank has a capacity of 159Ah and 55kWh at nominal voltage, with a peak charge/discharge current of 400/800A at nominal operating temperature. These batteries are considered to be high power and can discharge with a peak of 277kW at nominal voltage and temperature. High power batteries usually require more space and are heavier than high-energy batteries. The battery bank consists of two strings, each of which feature four sub-packs made up of 12 battery modules. A DC-DC converter, which allows bi-directional current flow, provides controlled charge/discharge of the batteries. The battery voltage can vary between 286-384V, with a nominal voltage of 346V.

Capacitor bank

The capacitor bank features 200 Maxwell super capacitors connected in series. Super capacitors have higher energy density than conventional capacitors, but can still deliver high currents at fast discharge rates. The capacitor bank has an energy capacity of 316Wh when discharging between 450V and 225V.

Control system

The laboratory control system includes a PEMS (Power and Energy Management System) that communicates with the GRCS (Generator and Rectifier Control System) and ESCS (Energy Storage Control System). The ESCS handles charging and discharge of the energy storage and contains different operational modes, such as Peak Shaving, Spinning Reserve, Enhanced Dynamic Performance, Enhanced Ride Through, Strategic Loading and Zero Emissions Operations. There is also a BMS (Battery Monitoring System) responsible for monitoring and protecting the batteries from operating outside their safe operating area.

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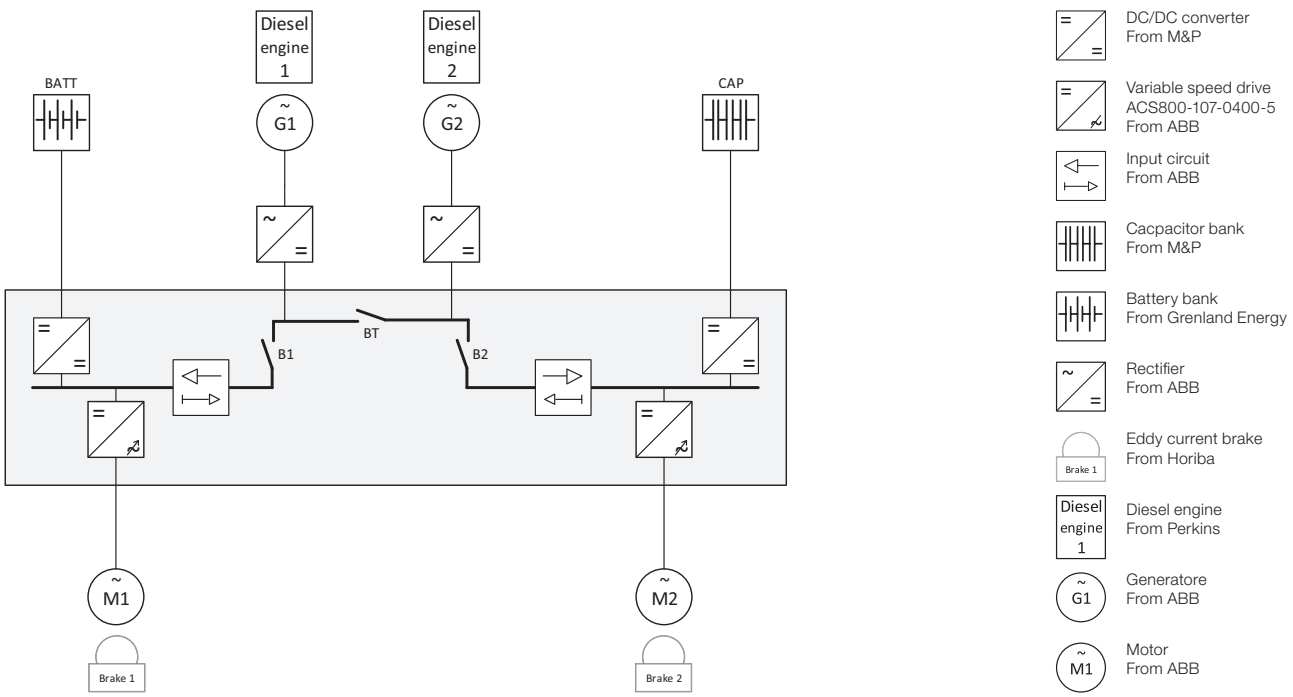

Single-line diagram for the hybrid lab

Examining the possibilities of battery powered car ferries

Electric potential

The combination of ABB's recent advances in marine electrical systems and the on-going improvement of battery technologies is opening up fresh possibilities for all-electric vessels. This case study plots the potential for an electric powered, zero emissions car ferry.

Over that last five years, ABB has developed an electrical system platform that enables the simple integration of energy storage media, such as batteries, into vessel power systems. At the same time the increasing sophistication, availability and performance of battery technologies has enhanced their potential, pushing them closer to a wide-scale adoption within marine power systems.

These two factors combine to make battery powered car ferries a viable alternative to diesel powered units, even for locations where the available power from shore is limited and charging times are short. Such systems are fully scalable and have strong potential for vessels with transit times of up to at least 25-30 minutes. In this scenario there would be little or no need for alterations to vessel timetables.

Ferry facts

This case study focuses on a ferry with a capacity limit of 300 passengers and around 110 cars. It has a diesel-mechanical propulsion system, with power output of 2 x 750 kW, is 100m in length and utilises a service speed of 12 knots. The ferry operates continuously through the night. It spends three minutes quayside in the early morning, five minutes during the day and 15 minutes at night.

The graphs in Figure 1 illustrate the power demand across a standard journey. Transit times are 15 minutes for most of the day except for early morning, when power is increased to reduce the journey to just 12 minutes. This requires a higher demand from the batteries. Charging facilities can be found at both ends of the route, with 400kW of power available.

The following sections describe the main characteristics of a fully electric version of the above vessel.

All electric system details

The onboard DC grid system platform forms the basis of the vessel's power system. The nature of DC battery power allows for an efficient flow, and easy control, of power.

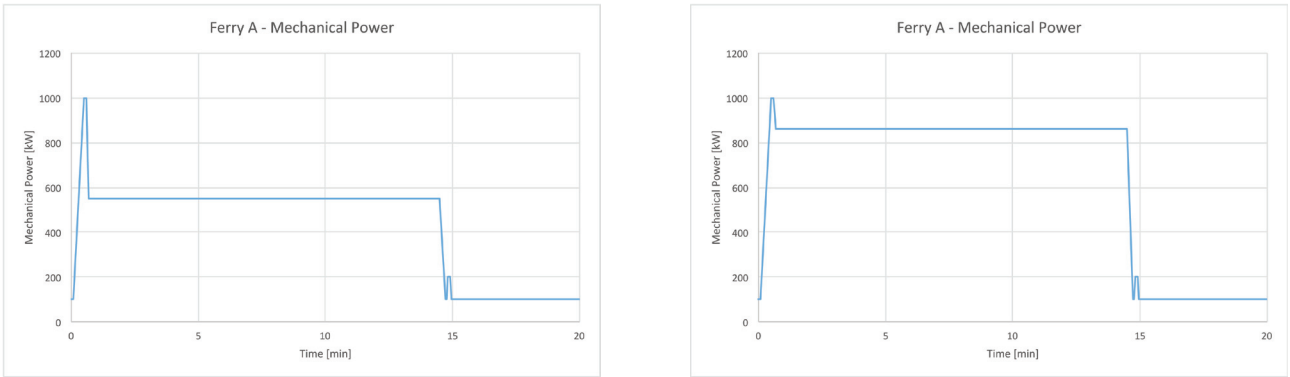

Figure 1: (Left) Power consumption during 15 minute transit. (Right) Power consumption during 12 minute transit

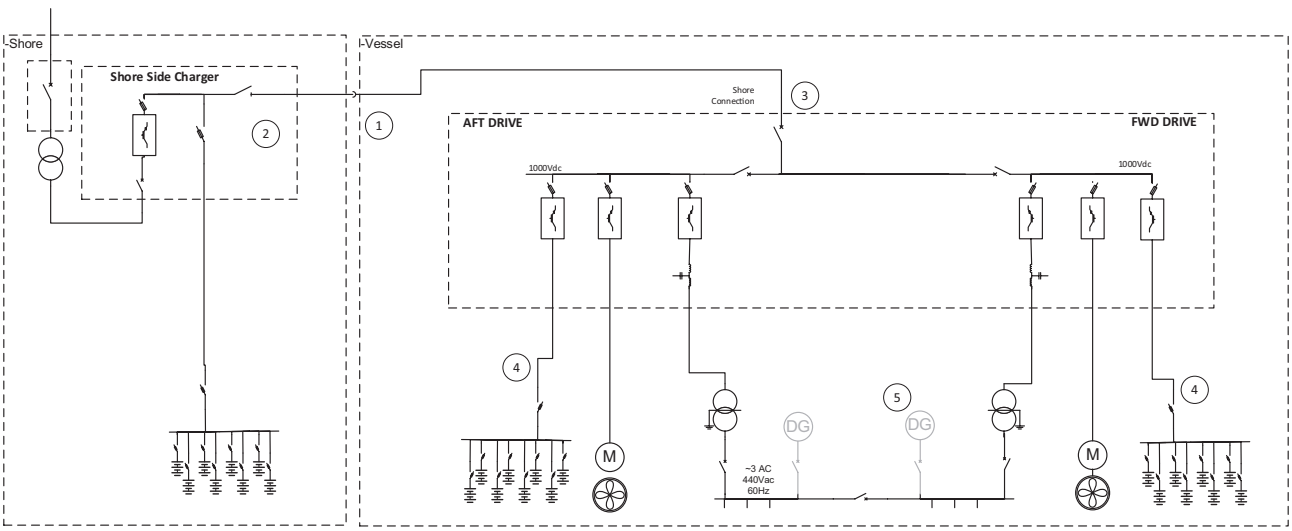

Figure 2: Conceptual drawing of shore and vessel hybrid power system

1. Vessel's onboard power system.

2. Charging station on shore: The voltage is rectified and transferred to the vessel using DC voltage. A battery of 500kWh is used to buffer energy from the grid. The principal two reasons for this are: A) Energy transfer can be significantly increased without increasing power drawn from the grid. This means that the size of the battery onboard can be decreased, mitigating the impact of short charging times. B) The energy-buffering capability of the battery means that the charging station can draw a more constant power from the network.

3. Shore connection: the vessel is automatically connected to the charging station within 15 seconds of arrival. This is done without operator input. Capacity is 2400kW. An auto-mooring device can be used to reduce consumption in harbour, but this is not a requirement.

4. Multiple parallel batteries are used to reach the necessary battery size of 1000kWh. This gives the added benefit of redundancy should one system fail.

5. Auxiliary generator sets can be fitted to supplement battery power during fault situations.

The graphs below show how the onboard battery's charge develops through the course of the day. The early morning period of higher transit speeds and shorter charging duration is shown to start a little after 5am, continuing to around 7am.

The charging station on shore draws an average power of 200kW from the grid and peaks at around 350kW. When connected to the vessel, the charging station, utilising the buffered energy in the battery, can deliver up to 2.4MW worth of power to the ferry.

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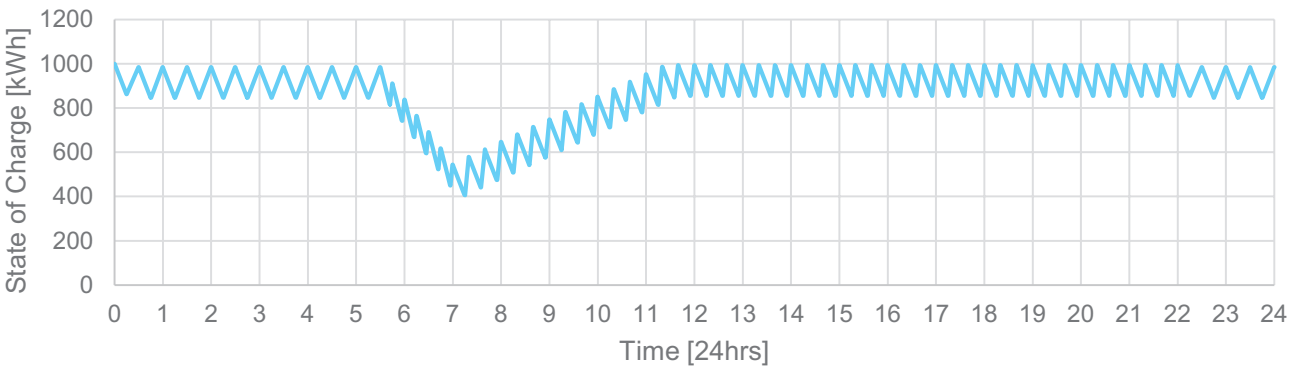

Figure 3: State of charge of the vessel's onboard battery

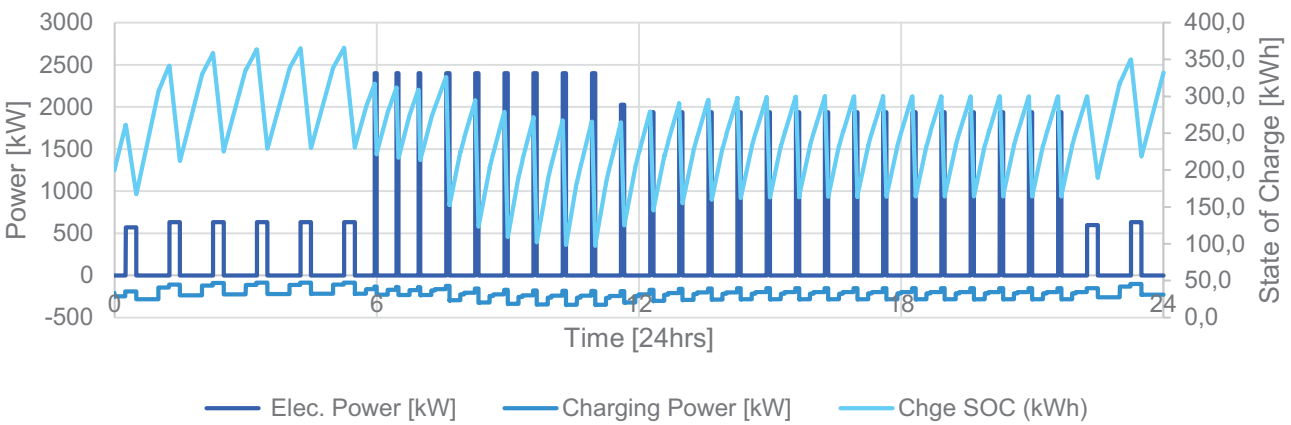

Figure 4: Key parameters of one of the two charging stations

Variable speed power generation in high voltage marine power systems

Dynamic AC

Variable speed power generation can provide significant fuel savings with diesel electric propulsion when the operational profile of the vessel has a high degree of variation in speed and power demand.

The Dynamic AC (DAC) concept by ABB enables optimising the total fuel consumption of the vessel by adjusting the rotational speed of the diesel generating sets and allowing the system frequency to vary within the specified range. Direct current (DC) solutions have also been considered, although the technology is challenging for high voltage power systems.

Fuel savings by variable speed power generation

When operating a vessel requires considerable variation in speed and power, diesel electric propulsion is a natural choice because of flexibility and fuel economy. The ability to freely connect generators online and offline according to power demand enables optimisation of the power plant for several operating points, though there is still ample room for improvement.

Specific fuel oil consumption (SFOC) of combustion engines varies according to load, which can cause significant differences in fuel economy between two operating points. Especially a load step, where a new engine needs to be called in, may increase the specific consumption dramatically. It is possible to overcome this issue by variable speed power generation, when the engine speed and efficiency can be adjusted with the loading.

The fuel saving potential in a vessel is based on operational profiles. Figures [PRSPEED] and [PRPOWER] present exemplary speed and power profiles for a cruise vessel with four generators in the power plant. In this example, variable speed power generation can provide 4 to 6 per cent annual fuel savings in comparison to conventional systems.

Dynamic AC concept

Variable speed power generation has been available from ABB since 2011, when the Onboard DC Grid concept was introduced for low voltage systems. The new Dynamic AC concept, introduced in 2016, is intended for larger vessels that require high voltage power systems.

Dynamic AC is based on variable system frequency in the main power systems. The main engines are running at adjustable speed in the 80 to 100 per cent range, generating electric

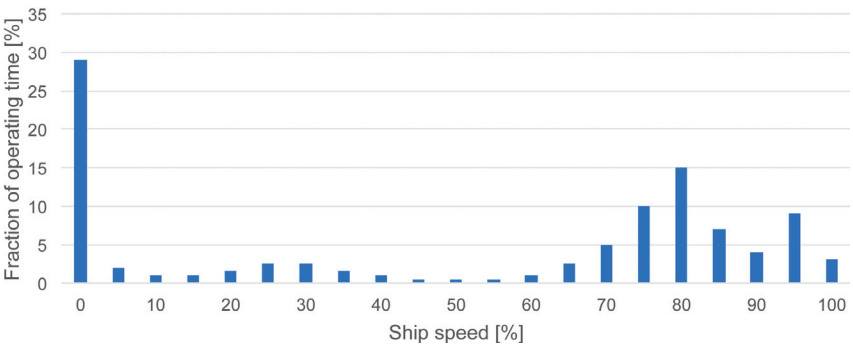

Figure [PRSPEED]: Example of a speed profile for a cruise vessel

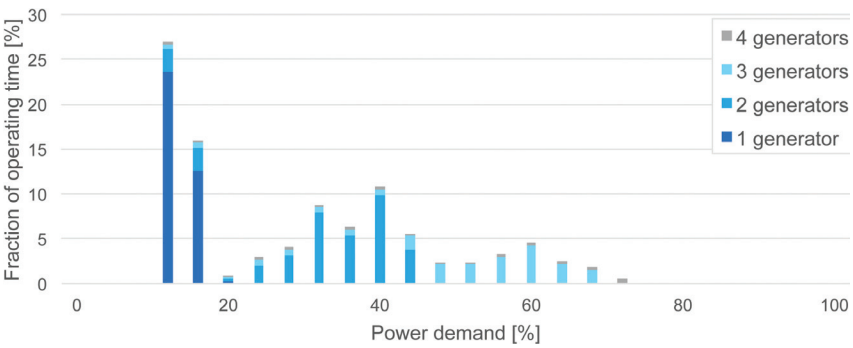

Figure [PRPOWER]: Example of a power profile for a cruise vessel

power with a corresponding frequency. As illustrated in Figure [DAC], the power system layout is similar to a conventional system, with the exception of being designed for variable frequency.

The Dynamic AC concept is based on proven technology, since it utilises only existing products that are dimensioned for variable frequency and integrated to operate together. The user experience is similar to conventional systems, because the control of speed and frequency are automated within the power management system. Any consumers sensitive to frequency are supplied by island converters that are configured to produce constant voltage at 50 or 60 Hz frequency.

Minimising power conversions

A key factor in optimising the investment cost and footprint of the system is the on board power distribution. There are numerous consumers on board that are supplied by power electronics and hence are insensitive to supply frequency. In some vessels, the auxiliary and hotel loads can be in the range of megawatts and have strict requirements for redundancy. It is therefore necessary to critically review all requirements and seek opportunities to minimise unnecessary power conversions.

The principle of optimising the on board power conversions is illustrated in Figure [CONV]. Instead of converting all electric power for auxiliaries and other consumers into constant frequency, it may be beneficial to supply the fire zone substations at variable frequency and utilise distributed island converters for selected consumers.

Most auxiliary equipment comprises motor drives supplied by frequency converters. These drives can be supplied directly from the variable frequency system, as well as most electronic devices and LED lighting power supplies. With careful analysis and purpose-driven design, it is possible to suppress the installed power of island converters into a fraction of the original plan.

Direct current technology

Onboard DC distribution provides several advantages over traditional AC systems, such as a more compact

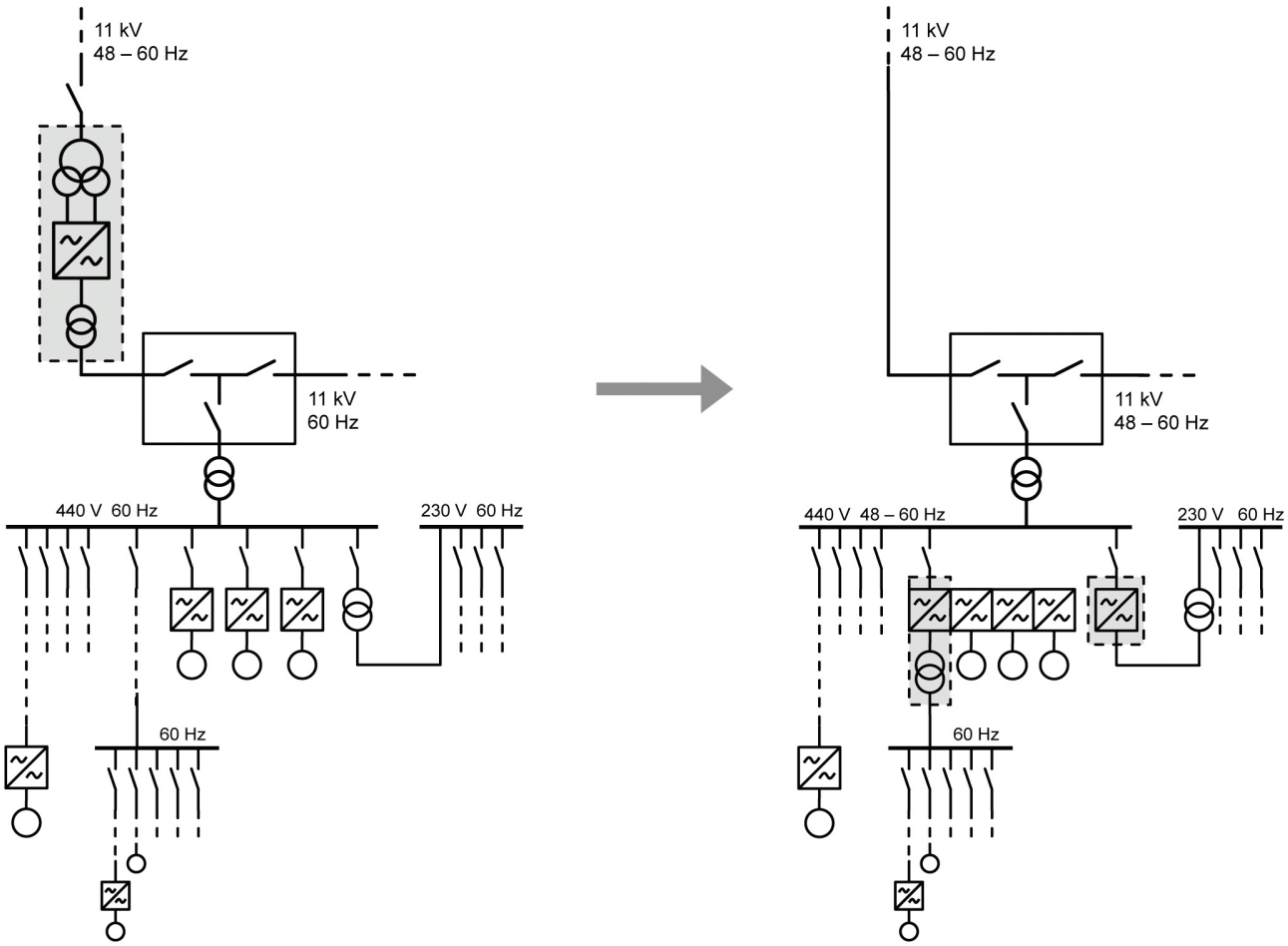

Figure [CONV]: Centralized power conversion replaced by distributed island converters

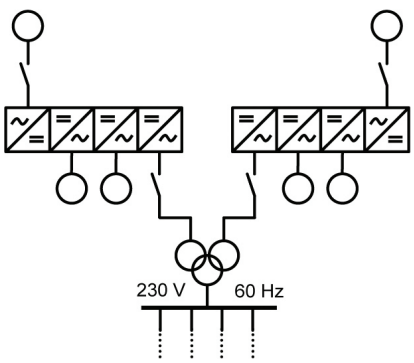

Figure [ALT]: An alternative configuration for variable speed power generation

footprint and flexible integration of energy storage and alternative power sources. However, technology for high voltage DC systems still requires development to cover all requirements on safety and reliability.

Figure [ALT] presents a principle of a compact high voltage system based on DC technology. While all consumers are supplied by power converters, either motor drives or island converters, it is possible to omit the main switchboard and connect the generators directly into the power converters. The DC capacitors of the multidrive converters may need to be detached from each other because of redundancy and reliability, but the power flow between converter lineups and power boards can be managed with the help of the three-winding transformers.

The way forward

There are naturally numerous variants available depending on the vessel type and purpose, as the solutions presented describe only the basic principles. Finding the optimum for each project requires careful analysis of different alternatives and an innovative attitude towards new solutions.

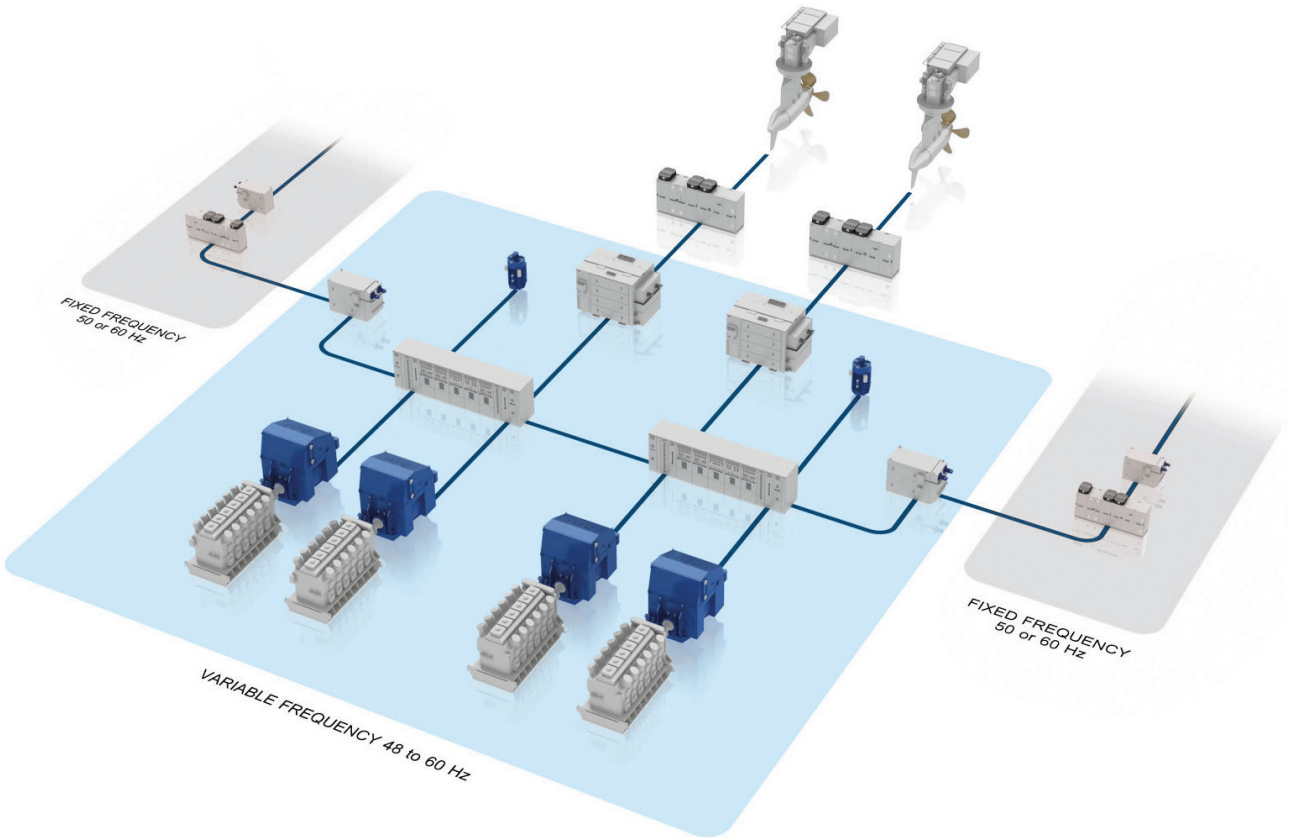

Figure [DAC]: Layout of the Dynamic AC concept

Energy efficiency is a sustaining trend, which still has much unexplored potential. On board power generation with variable speed engines is a major step forward, and is now available for the higher power range as well.

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Smart moves into the future

Bridge Systems

ABB is exploring the next generation of Bridge Systems, combining smart technology with intuitive user interfaces to deliver solutions that are customised, robust and highly efficient.

In early 2014, ABB China partnered with SaierNico, a local leader in the design and manufacturing of marine switchboards and automation systems, to develop ABB's Bridge Systems expertise. The team identified real market potential for a user-friendly solution capable of enhancing operational efficiency, and being flexible enough to be customised for a vessel type. They believed 'hundreds of console sets' could be supplied annually to vessels.

Three pilot projects were initiated to develop the Bridge Systems concept. ABB created the solution 'roadmap', detailed in this article, with the aim of both enhancing user experience, developing automation competence and supporting marine business development.

Concept

ABB delivers many consoles and subsystems, generating considerable customer feedback. Product reliability and efficiency are two areas where customers are seeking enhanced standards for their crews. With this in mind, the Vessel Information and Control product group teams from China and Finland began work on designing a bridge console especially for the demands of the Platform Supply Vessel (PSV) segment, where conditions are exacting and vibrations challenging. The usability and modularity of the console were key considerations.

To maximise operator space, the team utilised a c-shape design for the prototype. The console features three main modules: a 'basement' with horizontal operation side; a level for monitors; and an easy-to-open equipment box, which can be modified for different components, such as ABB's remote control system (RCS) levers.

Process improvements were developed to cut console manufacturing time and minimise human error. These included the use of new materials as metal alloy fixed by screws and changeable overlays. As a core enhancement, the width of the consoles can be easily modified for different needs. One design patent covers the three shapes (C, Y, T) illustrated in Figure 1.

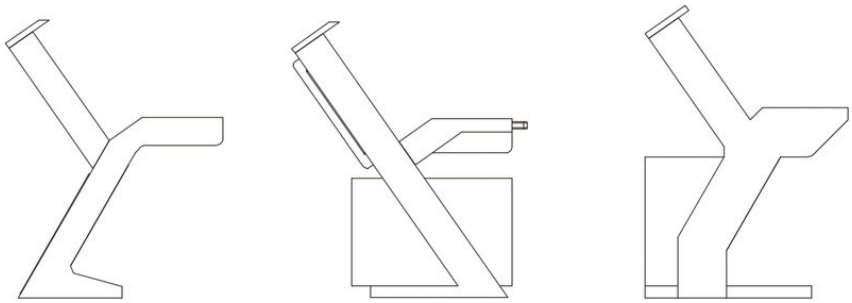


Figure 1: Three typical shapes (C, Y, T), Design patent (No. ZL 2014 3 0393789.2) and Utility model patent (No. ZL 2014 2 0603128.2)

Design that delivers

The overall design is described as simple, modular and clean with plain surfaces. Based on the ABB Marine global design guidelines, which emphasise safety and situational awareness, the design shows discipline and professionalism. The solution utilises black and white as the main colours, while other colours are used to highlight safety features and guide users. The products are provided with consistently high standards as 'assembly kits' for replacement.

Bridge Systems is designed as a communication bridge between ABB, shipyards and users. The platform reduces engineering work on planning, production, implementation and maintenance.

Customised service

The China Technology team redesigned the layout of the Marine New Lab in Shanghai, creating a virtual vessel for training and demonstration purposes.

This customisation process mirrors the approach that is required for the marketplace, where solutions and services must be tailored to meet customer needs and vessel types. Deliveries of ABB's Bridge Systems rarely share the same configurations.

Continuous optimisation

Demonstration consoles were set up in Marine New Lab's virtual vessel, allowing feedback to be collected and acted upon. Modifications were made to meet both vessel types and user preferences. Collected feedback was categorised according to factors such as appearance, operation, function, design and craft process, amongst others. ABB is working on the continuous optimisation.

Integrated Bridge Systems

Traditionally, the Integrated Bridge Systems (IBS) concept has evolved from integrated navigation systems (INS) in the first generation, auto-pilot in the second, ECDIS in the third, and integrated for the fourth generation. Most manufacturers have now reached a consensus on standards for MFWs (Multi Function Workstations) and smarter software for advisory systems.

IBS systems include ECDIS (Electronic Chart Display and Information), Conning, Radar (S-band & X-band), ARPA (Automated Radar Plotting Aid), AIS (Automated Identification System), Steering & Autopilot System, GPS & DGPS, Gyro Compass, Echo Sounder, Doppler Log, Wind Sensor, VDR (Voyage Data Recorder), Alarm System, and Communication Equipment, amongst other component parts and systems. This enables advanced concepts such as Voyage Management Systems.

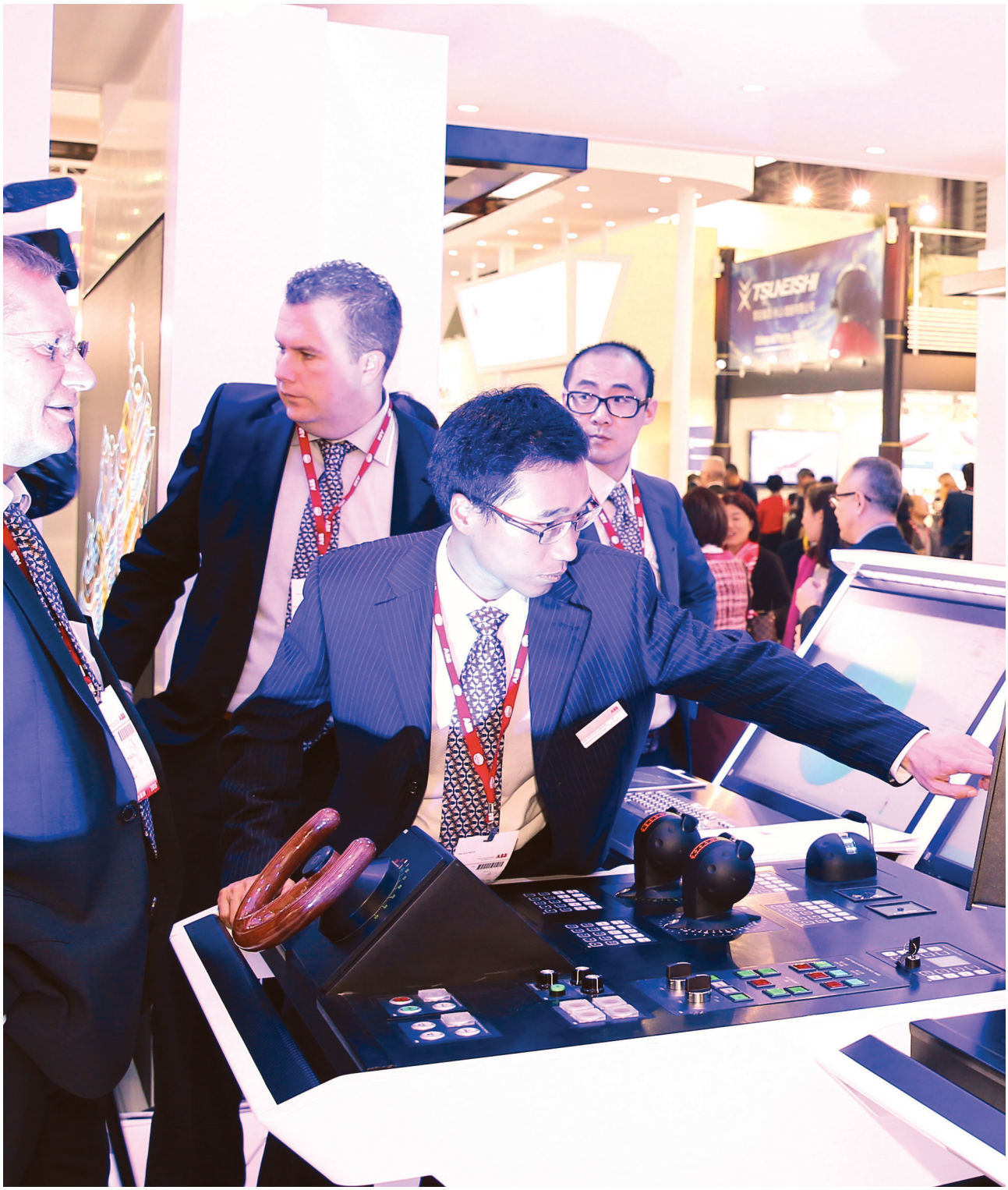
ABB's Bridge Systems

ABB's Bridge Systems include remote control system for propulsion, various advisory solutions (e.g. for motion, trim and speed advisory) and auxiliary control systems. ABB's marine automation and electrical propulsion expertise allows it to fully focus on propulsion remote control (PC), auxiliary navigation (AN), and miscellaneous engineering (ME) at the heart of the MFWs.

ABB's Bridge Systems cabinets and consoles also provide an integration enabler for larger IBS systems including third party solutions, and third party navigational communication (NC), internal communication (IC) and dynamic positioning (DP) can be integrated into the system.

ABB has a long history of working with specialist partners when creating optimal ergonomic and well-functioning working environments for operators. This helps minimise unwanted incidents and accidents.

The functions of ABB's Bridge Systems meet the unified interpretation from IACS (International Association Of Classification Societies). The BDEAP



ABB's Bridge Systems launch in China

ABB's Bridge Systems rendering

(Bridge Design, Equipment Arrangement, Process) standard summarises the applicable clauses of IMO MSC / Circ.982, SOLAS, ISM, STCW.

Hardware and software

ABB 800xA (Hardware & Software), MAPL (Marine Automation Platform Library) and Marine UI design guidance are the foundations of Bridge Systems created to satisfy a wide range of automation and control tasks on board a modern vessel. The unified hardware and software help eliminate human errors.

The system can be enhanced through the addition of ABB RCS Interface, Advisory System, IAS vessel management (VMS), and energy efficiency solutions.

The consoles contain subsystems and act as a bridge between operators and their vessels.

Feedback and the future

In response to demand, design and engineering work is now in progress to cover vessel types including service operation as subsea operation vessel (SOV), mercy hospital vessel (MHV) and pure car truck carriers (PCTC).

One of the pilot projects covers Auxiliary Navigation System and Engineering Equipment, including Hospital Call System, Refrigerator Call System, ER Light Colum, Remote Start/Stop Box, and Emergency Cut Off.

Another pilot project includes one set of Bow Thruster RCS and a New Drive Control Unit. All of these contain elements of Bridge Systems, while some have the full scope of consoles (ECR, FWD Bridge, AFT Bridge, DP Backup). Shipyards have reacted well to the new innovations, providing active feedback into the design process, while shipowners and classification societies see real potential for the future of ABB's Bridge Systems.

The 'Concept' phase of ABB's Bridge Systems has been completed, with the 'Core' stage now underway in which propulsion remote control (PC), auxiliary navigation (AN), and miscellaneous engineering (ME) subsystems are implemented. 'Complete' is the next and final stage of the roadmap "Concept, Core and Complete".

The result will be a customisable system that sets new standards by meeting demands and satisfying a wide range of user requirements.

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