

PUBLIC

HELPING STARTUPS TRANSFORM
THE PUBLIC SECTOR



TRADE 2.0

HOW STARTUPS ARE DRIVING THE
NEXT GENERATION OF MARITIME TRADE

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Inmarsat
Research
Programme





THE SHIPPING INDUSTRY IS AT THE BEGINNING OF A FUNDAMENTAL TRANSFORMATION. THE COMBINATION OF THE RISE OF CONNECTIVITY AND DIGITALISATION, AND THE NEED TO MOVE AWAY FROM TRADITIONAL FOSSIL FUELS, MEANS THAT EVERY ASPECT OF THE INDUSTRY'S OPERATING MODEL WILL CHANGE OVER THE NEXT THREE DECADES

PUBLIC

FOREWORD

We are delighted to be the key sponsor of this excellent report into maritime start-ups and host its launch event at London International Shipping Week as part of our Digitalisation Day. This year has been an exciting time for Inmarsat Maritime and our Digital Incubation team, with the launch of Fleet Data, the maritime industry's first IoT platform in January, the continued development of our Certified Application Provider programme and the successful completion of our first accelerator programmes with industry partners such as Wärtsilä and Cargotec and exciting new collaborations with some of the start-ups covered in this report to bring game-changing digital products to the maritime industry.

The Inmarsat community is overwhelmed with talented and expert individuals who work to deliver reliable satellite communications, creating value for our partners and end-users. But sometimes innovative ideas and niche knowledge or experience reside outside of our walls.

This is why we're championing open innovation, collaboration and partnership and why we're reaching out to, identifying, co-researching and co-creating new digital products with external innovators such as those mentioned in this report to both better serve our existing customers and open up new markets.

Happy reading!

Ronald Spithout
President, Inmarsat Maritime


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EXECUTIVE SUMMARY

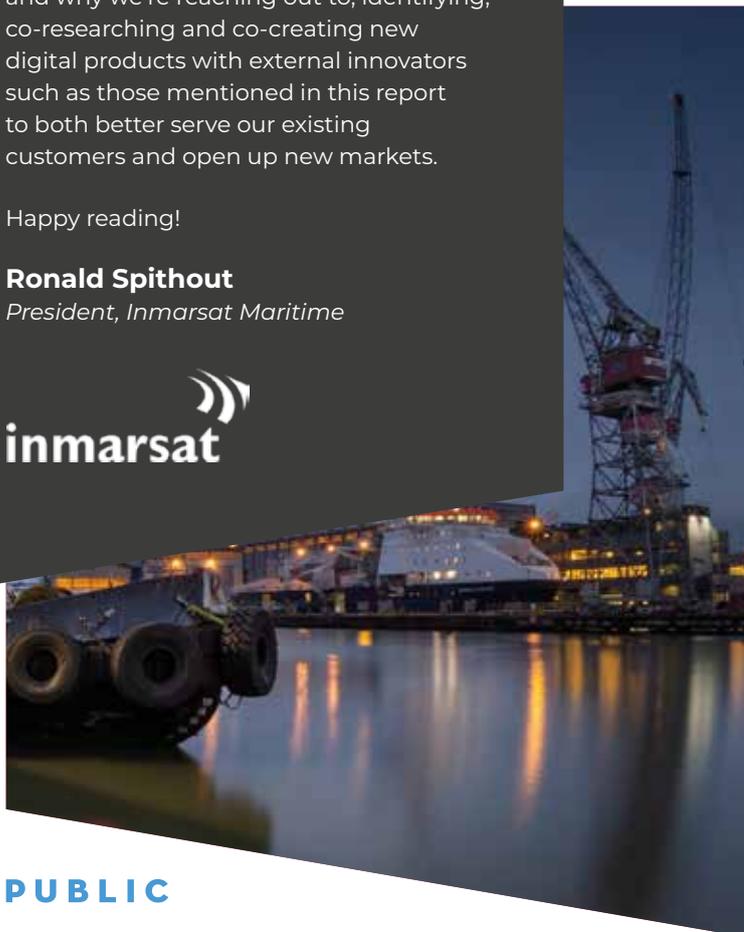
The shipping industry is at the beginning of a fundamental transformation. The combination of the rise of connectivity and digitalisation, and the need to move away from traditional fossil fuels, means that every aspect of the industry's operating model will change over the next three decades.

This report examines how startups, enabled by a new generation of connectivity at sea, and emerging technologies such as big data, AI, blockchain, and cloud computing, are driving this change to create a new ShipTech market. Having engaged with startup founders from around the world, we showcase some of the most encouraging case studies to-date of startups transforming the global maritime sector.

This report also provides a first-of-its-kind sizing of the global 'ShipTech' (shipping and maritime technology) market. Our analysis shows that the current value of the market is over \$100b dollars today, and is set to grow to be worth \$278b by 2030. Startups and investors should see the maritime sector as one of the greatest future market opportunities to develop over the next ten years.

The global maritime sector is at an inflection point. The International Maritime Organization (IMO) has committed to phasing out greenhouse gas emissions from the industry entirely by the end of the century and by at least 50% from the 2008 levels by 2050. This policy, coupled with a more immediate January 2020 deadline for banning sulphur emissions above 0.5%, will have a transformative effect on the shipping industry worldwide. Looking closer to home, the UK government has committed to strengthening the country's reputation for maritime innovation, maximising the benefits to the UK from new maritime technology through universities, maritime SMEs, and global companies as part of its Industrial Strategy.

It is more important than ever for startups, corporate suppliers, and ship operators to collaborate. The right combination of entrepreneurs, capital, and customers is required for startup driven innovation to work,



AS WE ENTER TRADE 2.0, THE GOAL FOR OUR INDUSTRY IS CLEAR: TO USE THIS OPPORTUNITY TO MAKE MARITIME TRADE SUSTAINABLE, SAFE, AND PROFITABLE

and these ingredients are increasingly being brought together by a growing number of maritime accelerators operating around the world. To date, the global maritime startup accelerator community has collectively graduated 226 startups.

Another key enabler of the digital transformation of shipping is connectivity. Ships have always been about making connections, and vessel connectivity has evolved from signal flags, to radio, to basic internet over hundreds of years. There is no 4G network at sea however, and much of the innovations we have seen in the last ten years have not yet made it onto ships. As the cost of transferring data between any two points on earth becomes negligible, we will see transformative technologies implemented on vessels around the world.

This report examines how new technology will impact four key operational aspects of the industry:

- ➔ **Ship Operations**
- ➔ **Port Operations**
- ➔ **Ship Management and Services**
- ➔ **Trade Facilitation**

Remote monitoring and autonomous operation is set to change how ships are currently operated. With operational decision support and potentially even decision making moving away from the ships and into shoreside monitoring centres. As well as navigation, technology is expected to have a major impact on how the engine rooms of ships are managed, moving away from reactive and scheduled maintenance to a data driven approach where maintenance decisions are made using data fed from IoT sensors.

In port, collaborative management, decision making, and scheduling platforms are beginning to see more widespread adoption, with some of the more advanced systems deploying artificial intelligence to aid decision making and solve port call optimisation problems. Blockchain technology is becoming viable as a way of processing and managing customs declarations and certificates of origin, paving the way for smart transactions and automated customs processing.

Augmented and mixed reality now make it possible for fleet management teams and specialist engineers ashore to assist engineers at sea with complex tasks that require specialist skills. This often vastly cuts down on cost and job completion time. Drones are also growing in popularity both as an inspection tool for service providers like class societies, and as a delivery mechanism for ships agents to transport supplies out to ships.

Cloud computing is also transforming trade facilitation, with a number of startups enabling shipbroking transactions and freight forwarding fully online. Further, blockchain technology is making the digitalisation of some traditional trade documents possible. Blockchain-based bills of lading and insurance transactions are becoming a reality as well as permission based trade platforms that make trade data accessible to any party that needs it.

Connectivity is also enabling better sustainability throughout the industry, with more data able to create better models and simulations to aid decisions like weather routing, or even efficiency improvements to a ship's hull. Further, alternative propulsion systems like sails are making use of weather data and autonomous technology to create solutions that can be deployed at sea with minimal retraining required for the crew.

As we move into the next phase of transformation, current pilots and proofs-of-concept will become full rollouts and the dynamics of the industry will shift to become more digitally focussed. Looking further ahead, nascent technologies like artificial intelligence and additive manufacturing could become a disruptive force in the industry by causing radical shifts in trade flows through decentralised manufacturing and changing the way humans consume goods. However you look at it, it is clear that a new era of global trade is beginning.

As we enter Trade 2.0, the goal for our industry is clear: to use this opportunity to make maritime trade sustainable, safe, and profitable.

INTRODUCTION

It is safe to say that the internet has fundamentally transformed all of our lives. No one could have known the impact the world wide web would have had when it was invented in 1990. In just 29 years, it has evolved from being a static repository of information accessible only to experts, to the fabric that enables modern society to function. It has changed not just how we communicate, but also how we consume: it is now common practice to watch TV, shop, order food, and book travel through the internet.

This, of course, has totally transformed the entire composition of some of our key markets and sectors. E-commerce has been stealing market share from traditional retail for years and shows no signs of slowing down, estimated to be worth more than £4 trillion and account for 14.6% of all retail sales worldwide by 2020.¹

As of 2017, there are more mobile phone subscriptions than people on earth, with 104 subscriptions for every 100 people. More important however, is that mobile phone usage in developing countries is now 98.7%, though not all of those phones are smartphones, there are more than 4.3 billion mobile broadband subscriptions worldwide.² Mobile broadband subscriptions are cheaper and more versatile than fixed broadband. We are now entering an era of cloud computing, internet enabled devices, big data, and artificial intelligence. As the developed world struggles to move away from legacy systems, developing countries that have until now had very limited digital services are able to leapfrog a generation of technological infrastructure, driving rapid adoption of digital services.

To-date, one major industry has been left out of the internet revolution: maritime. The trillion

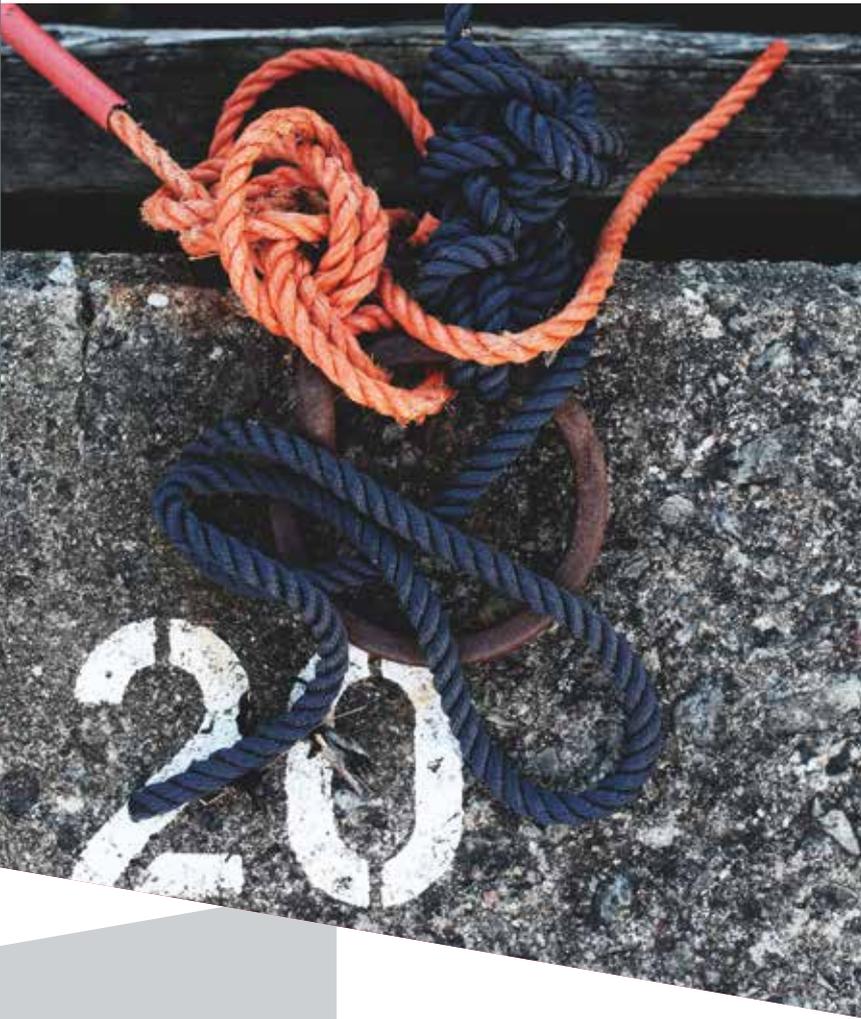
dollar industry that is the engine of the world's economy, has so far barely been touched by the rise of connectivity. The simple reason is that broadband as we know it has not been possible at sea. The underlying infrastructure that we rely on ashore cannot exist at sea, and currently, connecting a vessel to the internet requires expensive satellite infrastructure.

The maritime industry is steeped in history and tradition. The systems and processes that enable maritime trade have been developed over hundreds of years. Some key documents in use today, like bills of lading, would be largely recognisable to a Venetian trader operating 500 years ago. Similarly, many of the professional practices found onboard today's ships, like celestial navigation and signal flags, were developed hundreds of years ago in a time before computing existed and the internet could have even been conceived of. Because of this, shipping is often written off as a conservative industry, holding on to a past that no longer exists. This is not the case, from the first iron steam ships crossing the oceans, to the first container ships enabling globalisation, the industry has been at the forefront of pioneering innovation and exploration for centuries.

However, as we enter the 21st century, the rules of innovation have changed. Digitalisation and connectivity have enabled rapid iteration and made it possible to develop and adopt new ideas

¹ Forecast growth in percentage of online retail / Ecommerce sales, eMarketer, Chaffey, 2018.

² ITU releases 2017 global information and communication technology facts and figures, ITU, 2017.



TO-DATE, ONE MAJOR INDUSTRY HAS BEEN LEFT OUT OF THE INTERNET REVOLUTION: MARITIME

information is exchanged at sea, to transforming how the entire industry operates in much the same way that the internet has transformed how society and the economy functions.

This fundamental shift is ushering in a new era of trade. Maritime is considered one of the last great industries to be transformed by digitalisation. Trade 2.0 requires us to embrace change and rethink the systems and processes that allow shipping to function.

What has evolved slowly over the last 500 years, will transform rapidly in the next decade. This new 'ShipTech' industry is already worth \$105b worldwide, and is predicted to grow to \$278b by 2030. This fundamental shift will disrupt those businesses who do not change with it, and fuel the growth of those who do. This report explains some of the fundamentals of how maritime trade works today, and examines the ways in which, as we enter the Trade 2.0 era, the industry is being transformed by startups and innovators around the world. It is intended to bridge a culture and knowledge gap between the entrepreneurs and innovators who want to change the world, and the traditional maritime industry that made the world what it is today.

faster and cheaper than ever before. Startups and small businesses have become dominant as a force for change in many industries, disrupting the status quo and transforming the world economy. Constrained by limited connectivity, the maritime industry has missed much of the transformative innovation that wider society has seen in recent years.

As satellite technology advances, it is enabling a new generation of connectivity: with ships anywhere in the world able to achieve more bandwidth at lower costs than ever before. This makes it possible for the maritime industry to engage with digital innovation in a way that has not been possible until now. Just like the developing nations that are leapfrogging legacy internet infrastructure, the maritime industry will be able to leapfrog the last 20 years of internet innovation and rapidly take advantage of all that the connected economy has to offer. The rise of big data, artificial intelligence, blockchain, robotics, and other technological mega-trends we are seeing in wider society are now open to the industry. The maritime internet is moving from transforming how

POLICY OUTLOOK

THE IMO

Since 2005, the International Maritime Organisation (IMO) has been gradually tightening the rules on the sulphur content of marine fuels, known as bunkers. Most ships burn heavy fuel oil, a derivative of crude with a high sulphur content.

The current limit on the sulphur content of fuels is 3.5%*m/m*, but from January 1 2020, that limit will be reduced to 0.5% globally. There are already a number of special sea areas where sulphur content is limited to as little as 0.1%, but this cap, which will be enforced globally, represents the biggest change to the bunkering in a generation.

To comply with the new rules, ship owners will either have to fit machinery known as scrubbers to remove sulphur from exhaust gasses, or use low sulphur fuels in their operations. Partly due to the uncertainty of their efficacy, but also the capacity of yards to fit them, uptake of scrubbers has so far been low. It is estimated that just 1,700 ships will have fitted scrubbers by 2020 with a further 2,800 by 2025, representing just 7% of the world fleet.³ The vast majority of ships will need to operate on low sulphur fuel as of January 1st, with many large carriers introducing contractual mechanisms to pass the costs on to shippers.

At the time of writing, there are a number of question marks in place regarding the availability of low sulphur fuels, with little consensus from experts on whether the refining industry has the capacity to service the demand from the world fleet. Despite the uncertainty, the IMO is pushing ahead with the 2020 deadline, as it is estimated that delaying the sulphur to 2025 would contribute to 570,000 early deaths

³ IMO 2020: Ready or not?, Leitch, McManus, Wood Mackenzie, 2019.

globally.⁴ There is still little clarity on how the new laws will be enforced, with individual nation states left to conduct enforcement operations. For instance, the Indonesian government refused to enforce the rules on its domestic fleet, arguing that the high cost and lack of availability of low sulphur fuel oil makes complying with the rules impossible until supplies improve.⁵ They have since backed down, with state-run energy firm Pertamina committing to produce 380,000 cubic metres of low sulphur fuel each year to cover the requirements.⁶

Global marine bunkering is highly complex: it is a small cog, subject to market forces in a much larger fossil fuels industry, making it hard to accurately predict the impact of the sulphur cap on prices. It is possible that the cap could be maritime's Y2K bug, where the reality of the problems faced on January 1st do not live up to the anxiety and hype preceding it. Equally, it could have a very real impact on the industry; disrupting not just bunker prices but, where there is little fuel available, operations too. Only time will tell.

⁴ Health Impacts Associated with Delay of MARPOL Global Sulphur Standards, Corbett et alia, Finnish Meteorological Institute, 2016.

⁵ Indonesia will not enforce IMO low-sulphur fuel rules on domestic fleet, Christina, Khasawneh, Reuters, 2019.

⁶ Indonesia gets back in line with sulphur cap introduction, Jiang, Splash 247, 2019.



Looking past 2020, there is one single public policy commitment that is set to transform how the shipping industry operates more than any other. In April 2018, the IMO's Marine Environment Protection Committee set a strategy to reduce greenhouse gas emissions from shipping by 50% from 2008 levels by the year 2050, whilst at the same time pursuing efforts to phase them out entirely.⁷ For the entirety of the last century, commercial shipping has depended solely on fossil fuels as a method of propulsion. Phasing them out, even just reducing their emissions by 50% requires the industry to completely transform how it operates and invest in the development of technology which does not currently exist commercially.

The IMO has been working to improve the energy efficiency of ships worldwide, developing and mandating the use of the Energy Efficiency Design Index and Ship Energy Efficiency Management Plan in 2011. The resolution created base levels of energy efficiency that all new build ships need to meet. The efficiency requirements tighten every five years, meaning that by 2025, newbuild ships will be 30% more energy efficient than those launched before 2010.⁸ Taking this one step further, in its greenhouse gas strategy the IMO set out short, medium, and long term measures for reducing industry emissions by 50%. These include financial incentives for first movers in the short term, all the way through to investing in the development of alternative fuels in the long term.

Though it is still early days for the IMO's Greenhouse Gas strategy, with an in-depth set of short term measures not due to be agreed and published until 2023, it represents a recognition across nation states and industry itself that radical changes need to be made to reduce the maritime sector's ongoing damage to the environment.

IN THE YEAR FROM MAY
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VESSELS LEFT THE UK
FLAG, REPRESENTING
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REGISTERED TONNAGE

BREXIT AND THE UK GOVERNMENT

It is impossible to forecast the UK's domestic position on trade without considering the potential impact of Brexit. The potential disruption caused by a 'no-deal' exit from the EU could have a significant impact on the UK's short sea routes, potentially causing delays at ports on both sides of the channel. That said, it is unlikely that we will see any great impact on deep sea shipping including container shipping and bulk trades.

One unintended consequence of Brexit has been a mass exodus of ship registrations from the UK. The vast majority of short sea vessels trading around the UK need to comply with EU regulations. As the original Brexit date approached, a significant number of operators decided it would be more efficient to reflag their large ships to EU nations than risk the uncertainty of a regulatory divergence after Brexit. In the year from May 2018 to May 2019, 86 vessels left the UK flag, representing 39% of all UK registered tonnage.⁹

This year, the Department for Transport outlined their strategy for the next 30 years: 'Maritime 2050: Navigating the Future'. The strategy outlines the Department for Transport's vision for the UK maritime sector and sets out ten strategic aims for the industry including to strengthen the UK's 'reputation for maritime innovation, maximising benefits to the UK from new maritime technology through our world leading universities, maritime small and medium enterprises (SMEs) and global companies'.¹⁰

⁷ UN body adopts climate change strategy for shipping, IMO, 2018.

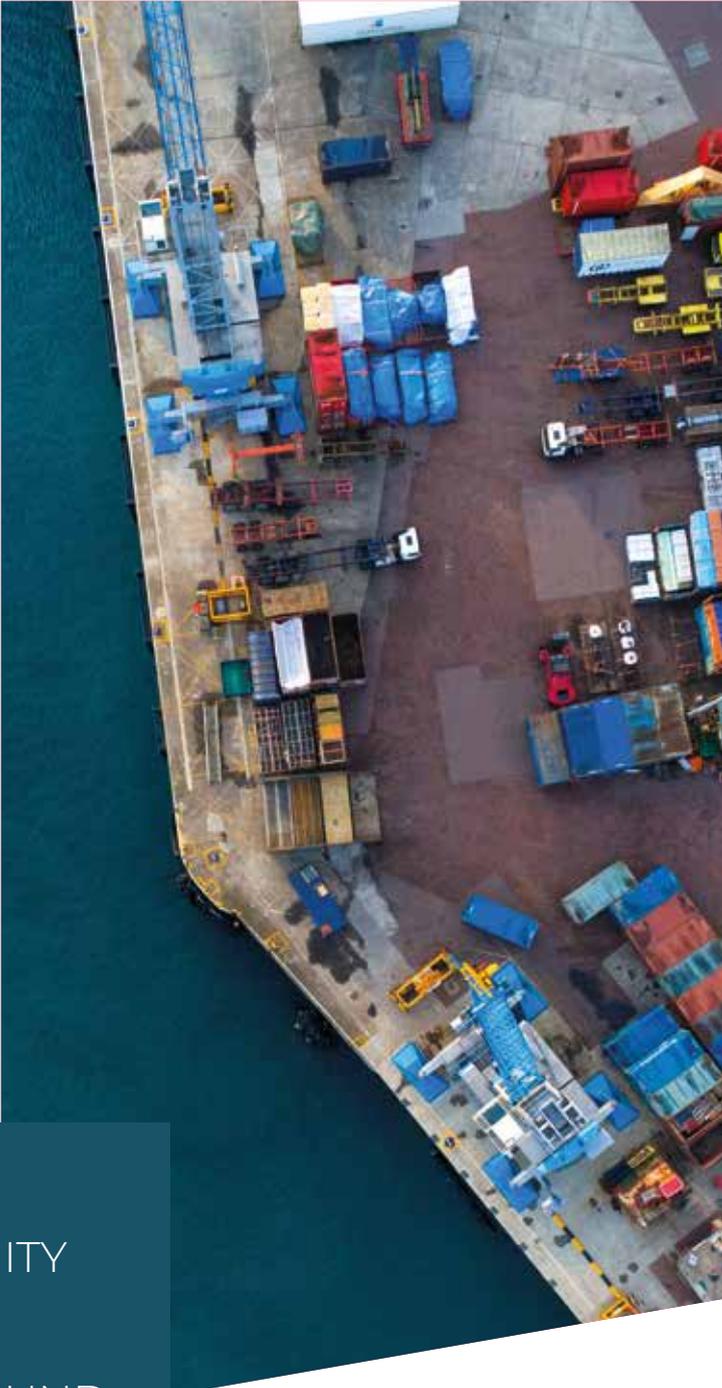
⁸ Energy Efficiency Measures, IMO, 2019.

⁹ Shipping firms drop British flag as Brexit risks loom, Terpilowski, Sea News, 2019.

¹⁰ Maritime 2050 - Navigating the Future, Department for Transport, 2019.

As the government works towards the goal of maximising the benefits of maritime technology to the UK, it has established a maritime autonomy regulation lab, committed £1.3m to fund a clean maritime challenge competition, and supported the Port of Tyne to open a '2050 Innovation Hub'. Looking to the next year and beyond, DfT plans to establish a centre for smart shipping, begin running hackathons, and legislate a domestic framework for autonomous shipping.¹¹ Since entering office, Boris Johnson's government has championed the concept of post-Brexit free ports as a way to stimulate growth and generate high value jobs in port towns around the country. The free port model creates an opportunity to create high tech innovation hubs, clustered in and around our ports, with the added benefit of creating a tax and regulatory environment that is friendly to startups and small businesses.

At this stage, whatever the outcome, the long term economic and political impact of Brexit is impossible to predict. It is possible that the continued uncertainty could cause as much economic damage as a disorderly exit from the trading bloc. If the UK does slide into a recession for whatever reason, the reduced trade flows that result would negatively impact the maritime sector and have a knock on impact on future investment in new technology.



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¹¹ Maritime Annual Report 2018-19, Department for Transport, 2019.

THE MARITIME STARTUP ECOSYSTEM

WHY ARE STARTUPS IMPORTANT TO MARITIME?

In 2018, startups in the maritime sector raised nearly \$200m in global venture investment.¹² It is impossible to deny that there is now a significant maritime startup ecosystem in development around the world. But, given that established maritime and logistics companies are now investing in new technologies and business processes, why are startups so important for driving innovation in the sector?

What is a startup?

A startup is a temporary organisation built to explore and identify a business model that is viable, repeatable, and scalable. Viable because it must be profitable and have a significant addressable market, repeatable because revenue should not come from one-off projects, and scalable because it must have the potential to grow into a large organisation. A startup works in a completely different way to an established organisation: indeed, the majority do not go on to become established businesses themselves. Most fail, many are acquired, and a small minority scale to become large organisations. The purpose of a startup is to rapidly experiment to discover a commercial application for a technology and a business model that can be financially viable in the long term.



As such, growth potential is the defining feature of a startup. For a company to be able to grow quickly, it must create something that a lot of people want, and be able to reach and serve all of those people. This is why traditional businesses, even when they are brand new, are not startups. Take the example of a new hairdressing salon. While hairdressing may be an in-demand service almost everywhere in the world (and so has a large market), it would be almost impossible for an individual hairdresser to serve everyone in that target market. On the other hand, a marketplace that allows people to book and pay for appointments with local hairdressers has the potential to scale very quickly and serve a significant portion of the market: therefore, it fits our definition of a startup.

A startup may fail or be acquired before it discovers a successful business model. If it gets as far as establishing a viable business model, the focus will switch from experimenting to find product-market fit, to scaling the business as quickly as possible. A company in this phase of growth is often referred to as a 'scaleup'. The management team of a scaleup has a very different set of priorities to that of a startup, with the principal focus being on executing the repeatable business model to rapidly grow the business.

¹² Analysis from Thetius, 2019.

INNOVATING FAST AND SLOW: WHY THE INDUSTRY NEEDS STARTUPS AND VICE VERSA

It took the aircraft 64 years to reach 50 million users: it took television 22 years, the internet seven years, and WeChat just one year. Incredibly, it took Pokemon Go just 19 days to reach 50 million users.¹³ Innovation and technology adoption have changed dramatically in the last hundred years. Both follow a law of accelerating returns. With each generation able to leverage the lessons of the generation before it, the speed of innovation continues to grow exponentially. By comparison, it took more than a century for the shipping industry to move from sail to steam, roughly in line with the adoption speed of other technologies introduced at the time. Not so for the recent digital technology boom: despite the first type approved ECDIS systems being launched in 1999, many ships still sail with paper charts today. Although shipping has traditionally been a highly innovative industry, at the cutting-edge of technological transformation for over 2,000 years, it has failed to keep up with the pace of innovation seen in the digital era.

Innovation projects in large industrial businesses traditionally follow a familiar process that consists of top-down research and development followed by testing applications in the real world. These projects often involve large teams and budgets and usually assume that in 18-36 months, the market will not have changed significantly. This assumption was valid throughout the 20th century: but today, when it is possible to launch a product and scale it to millions of users in a matter of days, this traditional approach is no longer appropriate.

There are a lot of buzzwords used to describe the process of innovation in a startup, but for the most part, it all stems from some combination of lean and agile methodologies. Lean methodology, which has its roots in manufacturing, focuses on the continuous improvement of processes to drive customer value. Agile methodology, which was specifically created for the development of software, is at its core about developing new products through constant iteration and testing, and responding to change rather than following a rigid plan.

Whatever terms are used to describe it, startup-driven innovation is based on using the smallest amount of resources possible to validate an idea, build it, test it, and continuously improve it. A traditional software project might have separate periods for designing, building, testing and implementing. A startup will attempt to do all of these things at the same time, continuously deploying updates to software and testing them against customer expectations. When updates add value to a customer they are further iterated on, when they do not they are killed off and used to learn what went wrong. This process is not just applied to software, but every aspect of the business, including the revenue model, distribution and sales channels, and advertising and marketing. Where a traditional innovation project might take months or even years to release a product or feature, a startup will attempt to do it in weeks or even days.

STARTUP INNOVATION IS BASED ON USING THE SMALLEST AMOUNT OF RESOURCES POSSIBLE TO VALIDATE AN IDEA, BUILD IT, TEST IT, AND CONTINUOUSLY IMPROVE IT

Why do traditional maritime businesses struggle to innovate?

Many large maritime businesses have tried to explore innovative new products or ways of working: the majority have failed. In 2009, Jeffery Immelt, CEO of General Electric, one of the world's largest and oldest heavy industry manufacturers, declared that he would transform the business into a startup. His plan was to build an operating system for heavy industry and turn GE into a top ten software business by 2020. In a 2016 interview with the New York Times, Immelt said that the future of GE depends on its transformation, describing the initiative as 'this or bust'.¹⁴ By the end of 2017, GE had run into financial trouble and made scores of layoffs. GE's stock price tanked, Immelt stepped down as CEO, and the business left the Dow Jones after 110 years.¹⁵

¹³ How Long Does It Take to Hit 50 Million Users?, Visual Capitalist, 2018.

¹⁴ G.E. the 124 year old software startup, New York Times, Lohr, 2016.

¹⁵ What the Hell Happened at GE?, Fortune, Colvin, 2018.





GE is an extreme example, and their problems ran deeper than a CEO's desire to be more like a startup but the barriers for large companies that want to become more like startups are significant. Simply put, a large corporation that has relied on a particular business or operating model for many years cannot transform itself overnight. This is particularly true in an industry like shipping where capital investments are made in ships and infrastructure that last upwards of 25 years. Further, the infrastructure that enables large businesses to operate at scale is at odds with rapid iteration. Startups can move at lightning speed because they do not have to deal with hierarchical decision-making, budgetary approvals, and legacy IT systems that allow their monolithic cousins to function.

Lastly and perhaps most importantly, startups are willing to fail. Jeffery Immelt's experience at GE exemplifies why it is far easier for a small team of entrepreneurs to 'bet the farm' on an idea than it is for a shipping company or a manufacturing giant. Most corporations are not built to incentivise risk: the potential downside of failing a project could be redundancies, whereas the potential upside of a spectacular success might be a promotion and a salary bonus. This puts the culture of large industrial corporations entirely at odds with the culture of embracing short-term failure as the path to long term success.

In shipping, these factors are compounded by the nature of the industry. The industry operates around 50,000 ships that serve the entire global economy. It is the ultimate legacy infrastructure which, with no obvious substitute, is almost impossible to move away from. Further, it is very difficult to differentiate cargo space, making it highly commoditised and dependent on global trade flows. This combination generates long cycles of 'boom and bust' with razor thin margins. Lastly, in safety-critical industries like maritime, failure is regarded as wholly negative, because it is not only businesses that are at stake, but also human lives.

That said, there is a misconception that large corporations cannot innovate. This is untrue: indeed, in some circumstances, large international corporations are the only ones who are capable of driving meaningful market changes. For precisely the reasons outlined above, failure and rapid iteration does not work when building ships or aircraft. You cannot split test and iterate on the hull of a ship, and at no point would it be desirable to pivot a tanker into the cruise market because of better customer demand. Some innovations also require specific testing phases. New composite materials for example, take a lot of time, capital and operational investment, and testing to get right: and companies are innovating with planes or ships, it is crucial that they do not fail.

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Large corporate organisations can innovate, and they are best suited to innovating in precisely the spaces where startups cannot. Once again, this dynamic is further compounded in the maritime sector. For the shipping industry to create any kind of value, heavy machinery needs to move heavy cargo from A to B. In maritime, digitalisation and software can only go so far, there will always be a need for mechanical processes. Startups can transform the business processes that allow the industry to function, but they cannot do this in isolation.



STARTUPS IN THE SECTOR EXPECTED TO BE RAISING AN ADDITIONAL 66% ON TOP OF FUNDS ALREADY RAISED FOR THE NEXT STAGE OF THEIR BUSINESS' DEVELOPMENT

ENTREPRENEURS, CAPITAL, CUSTOMERS

There are three base ingredients required for any successful startup ecosystem; entrepreneurs, capital, and customers. Entrepreneurship takes a specific set of character traits and skills. As well as the innate skills that all nascent entrepreneurs need, anyone starting a company in shipping needs specialist knowledge of the industry and its peculiarities. Most founders in maritime come from a shipping background, having either worked at sea or ashore in the industry for some time before venturing out on their own.

Investment capital in the industry has been growing rapidly in recent years. The maritime sector has historically been of little interest to the venture investment community, but the likes of [Flexport](#) have blazed a trail that has raised interest amongst institutional venture investors. Most investment capital comes from 'outside' of the industry, though a number of funds have been set up inside the shipping industry in recent years. Investment in maritime startups has grown from \$121m in 2017, to \$196m in 2018. Though the figures are skewed by [Flexport's](#) massive funding round, the 2019 total to date is \$1.143b. Even when [Flexport](#) is removed from the statistics as an outlier, funding in maritime startups looks set to achieve year on year growth of 60% for three years running.¹⁸ Funding demand is also growing, with startups in the sector expected to be raising an additional 66% on top of funds already raised for the next stage of their business' development and the significant majority of startups still being at the seed or pre-seed stage.¹⁹

DEVELOPING THE GLOBAL ECOSYSTEM

Recognising that neither startups nor corporates can solve problems in isolation, the maritime industry is now beginning to embrace startup driven innovation as a way to evolve. Since the 1970's Silicon Valley has been known as a mecca for high tech innovation and startups; giving birth to some of the world's most successful tech giants including Facebook, Google, and Uber. Indeed, in 2016 42% of all unicorns in the world were based in California, with 62% based in the USA¹⁶. Just three years later, however, that picture has changed dramatically. Today, just 49% of unicorns are based in the USA, with 25% based in China, 5% in the UK, and 4% in India.¹⁷ While Silicon Valley's reign as the world's premier hub for innovation may appear to be random, the rapid rise of hubs from other parts of the world prove that it is not. The truth is that to build leading centres of innovation you need a deliberate mix of the right people, capital, and policy. How is this model being replicated in maritime and what needs to be done to accelerate its growth?

¹⁶ The Unicorn list, Fortune, 2016.

¹⁷ The Complete List of Unicorn Companies, CB Insights, 2019.

¹⁸ Analysis from Thetius, 2019.

¹⁹ Data from Startup Wharf, 2019.



In consumer technology, customers can be anywhere, but in the shipping industry customers can be more difficult to find. The startup-driven model of innovating through iterations and feedback requires a close relationship between startups and customers. To be able to test and validate an idea, a startup may well need access to a fleet management team, a shipbroker, or even a ship itself. Over and above access, the founding team will need buy-in and regular feedback from their early users in a process that is often more intense and demanding for customers than a regular procurement process. Highly engaged and supportive customers are important for a business at any stage, but for a startup with limited resources, they are absolutely crucial.

The solution, then, is to develop the right partnerships for startups and large, established organisations to innovate together. There are many different models for these partnerships, some of which we outline below. In general, large organisations that work with startups are more likely to be successful than those who do not.²⁰ Moreover, high-performing large companies are twice as likely to report being risk-seeking with external partners when pursuing innovation.²¹ The evidence seems to suggest that, for large and highly complex organisations to be successful in the modern economy, they must embrace working with startups in some form. This idea is often referred to as 'open innovation' – 'the paradigm that assumes that firms should use external ideas as well as internal ideas, and internal and external paths to market'.²²



20 CIO. 2016. Startups and diversity driving innovation - 2017 CIO Agenda recommends new technology procurement strategy.

21 CB Insights. 2018. State of Innovation Report: Survey of 677 Corporate Strategy Executives.

22 Chesbrough, Henry. 2005. Open Innovation: A New Paradigm for Understanding Industrial Innovation

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FOR DRIVING
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DIFFICULT IN ANY
INDUSTRY

FINDING THE CATALYST FOR GROWTH

Bringing together the right ingredients for driving innovation is difficult in any industry, with the opaque and disparate nature of the shipping industry adding to the challenge. Until recently, aside from some limited initiatives by industry giants like Maersk and Wartsila, there were no dedicated programmes aiming to drive long-term startup-driven innovation in maritime. PortXL changed this dynamic when it launched in 2015, creating the world's first startup accelerator dedicated to the maritime and ports sector. In the years since, they have expanded into Antwerp and Singapore, accelerated 36 startups, and facilitated the signing of 81 pilot contracts.²³

Startup accelerators usually offer some combination of capital, access to customers, office space, and mentorship to help a startup to validate an idea and grow as quickly as possible. There are small, but significant, differences between incubators and accelerators. Incubators help very early stage ideas move to the prototype and validation stages of development. Accelerators are more focused on taking an idea that has achieved proof of concept and some level of customer validation, and providing the working capital and mentorship required to run the business, including helping it to acquire customers or raise further funding. To date, there have been two predominant models of funding accelerators; public and private. Public accelerators typically are funded by one or more public sector bodies, do not take any equity in the businesses that they accelerate and act as an independent conduit between

23 Vision, PortXL, 2019.

startups and the target corporate community. In privately funded accelerators, the initiatives are often started or funded by large commercial organisations with the aim of creating a profit centre in its own right. The funders of the programme provide a testing ground for new products and ideas developed by the startups and are usually given first refusal on commercial contracts. Typically, though not always, private accelerators will take an equity stake in the businesses that graduate from the programme.

ACCELERATORS PLAY AN IMPORTANT ROLE IN BRINGING STARTUPS, WHO MAY BE HIGHLY INNOVATIVE BUT LACK COMMERCIAL SKILLS

Since PortXL's launch, there has been an exponential growth in programmes around the world. There were ten programmes operating worldwide by 2017 and 25 operating worldwide by 2018. The most prominent programmes operating today are [PortXL](#), the publicly funded [PIER71](#) in Singapore, [CMA CGM's zeBox](#) in Marseille, [theDOCK](#) in Haifa, [Rainmaking's](#) Trade and Transport Impact programme in Hamburg (which includes [Inmarsat](#) as a partner), and the [Lloyd's Register](#) Safety Accelerator in London. To date, the global maritime startup accelerator community has collectively graduated 226 startups. Only one third of the accelerators in the sector are focused on incubation and happy to accept entrepreneurs with an idea that has no customers. The other two thirds are focused on the acceleration phase, requiring startups to have at least one or more clients. The majority of accelerators are privately funded from multiple sources. Just 26% of them receive some kind of public funding, and more than 50% of all accelerators receiving funding from more than three sources.²⁴

Accelerators play an important role in bringing startups, who may be highly innovative but lack commercial skills, with shipping companies, who



often have the opposite problem. Often, without the help of an accelerator, the expectations of both startups and corporates going into a partnership are unrealistic. Many startups expect a corporate partner to move at the same speed as them and to offer a continuous stream of feedback on their product. Equally, many corporates expect a startup to go through a normal 12-18 month procurement process and to present a finished working product. Further, the greatest challenges faced by many corporations are mismatched from the problems that startups are trying to solve.

Accelerators play an important role for corporates: sourcing startups that solve genuine problems, working with them to streamline or completely bypass the traditional procurement process, and put mechanisms in place for providing feedback on products and ideas. The value for the startup is equally high, helping them to refine their proposition to make it commercially viable, navigate a large organisation's procurement process, and providing practical and operational support, including office space and legal advice.

The current growth trend in new startups, accelerators, and funding is showing no signs of slowing down. By bringing those key ingredients of entrepreneurs, capital, and customers into one place and by bridging the cultural and expectation gaps that naturally crop up, accelerators of all stages are acting as catalysts, fuelling future growth in the market.

²⁴ Analysis from Startup Wharf, 2019.

THE CASE FOR GEOGRAPHIC HUBS

The most successful accelerators in any industry are positioned in geographic hubs. Clustering related businesses together is a well-established practice for enabling business growth: it is partly what has enabled Silicon Valley to dominate the tech space throughout the end of the last century. When businesses are clustered together, they benefit from sharing expertise, capital, and infrastructure. Clustered businesses grow on average 1.4% faster than non-clustered businesses.²⁵ In high-growth tech, the effects are compounded over decades, with successful entrepreneurs who have had large exits often reinvesting in the next generation of local startups and offering their expertise and experience. As well as benefiting from the proximity of capital, technology clusters can leverage local academic institutions to provide a steady stream of talented employees or new research which could be commercialised.

CLUSTERING RELATED BUSINESSES TOGETHER IS A WELL-ESTABLISHED PRACTICE FOR ENABLING BUSINESS GROWTH

The opportunity to leverage the world's ports as centres of technological innovation for maritime trade cannot be overstated. There is already a natural clustering effect in existence in the industry. Hamburg is known for ship owning and operating, London is known for maritime business services such as insurance and law, and Singapore is known as one of the world's great transshipment and ship services centres. There are many more, usually centred around a port, each with their own unique strengths and strategic advantages. It takes a combination of support from local corporates, investors, and local and national government to transform a maritime cluster into an innovation cluster.

In Singapore, for example, a combination of business-friendly regulation, public and private funding, and access to local businesses has created a rapidly growing ecosystem. As well as PIER71, there are more than 100 local incubators, accelerators, and venture builders across a broad range of specialisms and industry sectors. As of 2017, 4,000 startups employed 22,000 people across the city state, with investment funding growing from \$800m in 2012, to \$10.5b in 2018.²⁶ This is a model that could be replicated across other port cities, helping to build a global ecosystem of specialist maritime hubs.

25 Sizing the Clean Economy: A National and Regional Green Jobs Assessment, Brookings Institute, 2011.

26 Singapore strengthens its startup ecosystem to enhance position as a Global-Asia node for technology, innovation and enterprise, Enterprise Singapore, 2019.

THE CONNECTED SHIP

Shipping has always been about making connections. When the Phoenician merchants first set out in their ships over 3,000 years ago, it was to connect with foreign lands to trade, and not much has changed since. The number, size, and complexity of ships operating has grown over the following millennia but the 50,000 modern merchant vessels plying the world's oceans today exist to make the trade connections we all rely on.

In 2018, the UK conducted over \$1 trillion in seaborne trade with the rest of the world.²⁷ Everything we rely on day to day is carried by sea, but incredibly, up until very recently, it was almost impossible to know where a ship was once it had left port.

A BRIEF HISTORY OF VESSEL CONNECTIVITY

Up until the beginning of the 20th century, a merchant ship and its crew were an independent entity. Once out of sight of land, they were entirely cut off from the wider world unless they saw another ship. Even when they did see other ships, communication was difficult. To help ships to communicate when in-sight of each other, a system of signalling with flags was developed. Each flag represented a letter and a string of letters could be encoded to create a message. In 1857, the British Board of Trade published the first International Code of Signals. It contained 70,000 signals and 17,000 messages using a combination of just 18 flags.²⁸ Signal flags are still mandatory and in common use today, though the current International Code of Signals uses 36 flags and far fewer signals.

As we entered the 20th century, Italian engineer Guglielmo Marconi developed a system that made it possible to send and receive messages by radio telegraphy. The same system of signals and messages that previously relied on flags

could now be sent using morse code over radio. The Royal Navy implemented Marconi's system, and, after being successfully used in operations during the Boer War, it was quickly adopted by merchant ships on the Atlantic trade. After thousands of years of isolation at sea, a ship's range of communication was extended from line-of-sight to around 500 miles.²⁹ On the night that the Titanic sank in 1914, some of the nearby ships had switched off their radios for the night and missed the faltering ship's distress calls. The 700 lives that were saved were credited to the *Carpathia* picking up the radio distress signals and responding, even though it was further away than a number of other ships in the vicinity. In the aftermath of the disaster, it became mandatory for all ocean-going ships to not only carry radio equipment, but to have it manned 24 hours per day. Designated distress frequencies and radio silence periods were also introduced: these changes took radio from being a service used by passengers to send messages home, to becoming a critical part of maritime infrastructure.

As the 20th century progressed, high-frequency radio made it possible to communicate over ever greater distances, and the invention of radio telephony made it possible to communicate by voice. WWII provided the context for the next great leaps in innovation, with the invention of marine VHF, allowing bridge-to-bridge voice communication, and the invention of radar, making it possible to detect and track other nearby ships and aircraft.

²⁷ International trade in goods and services based on UN Comtrade data, Department for International Trade, 2019.

²⁸ Preface, International Code of Signals, IMO, 1969.

²⁹ The Technology That Allowed the Titanic Survivors to Survive, The Atlantic, 2012.



THE CONNECTED SHIP IN THE INTERNET AGE

Since the 1990s, computing and the internet has revolutionised every facet of our society. The generation entering the workforce now does not remember a time where they had to choose between being on the phone or being on the internet. Mobile technology has given every one of us a powerful, fully connected computer laden with sensors. Technology that was science fiction even two decades ago is now ubiquitous across every industry. Every industry except for shipping.

There is no 4G network at sea, and while they are far more connected than at any other time in history, ships are still isolated from the digital infrastructure and devices that are used in every other sector. In the past, the prohibitive cost and bandwidth limitations of satellite communication made it a tool to be used only for distress, safety, and very limited operational functions. Today, as we enter the fourth industrial revolution, the barriers to satellite communication are coming down.

Thanks to recent advances in the commercial space industry, the cost of connecting a vessel to the internet is reducing all the time, as is the bandwidth capacity of satellite networks. The shipping industry is on the cusp of realising some of the many digital advances that we have seen sweep across society over the last three decades.

In 1979, the International Maritime Organisation (IMO) created the Global Maritime Distress and Safety System (GMDSS), a standard set of equipment used by all ships operating at sea. The system, still in use today, was comprised of a combination of different radio installations, radar transponders, and satellite technology. In the same year, the IMO founded a non-profit intergovernmental agency to develop satellites to improve aeronautical communication and safety around the world. The International Maritime Satellite Organisation, the precursor to [Inmarsat](#), developed and launched the satellites that not only became the backbone of the maritime industry's global distress system, but also a key part of the sector's operational infrastructure.

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THE DAWN OF A TRANSFORMATION

In the coming years, as the cost of transferring data between any two points on earth becomes negligible, the same world of technological opportunities currently open to wider society will also become open to the global shipping fleet. Mobile technology, IoT, artificial intelligence, big data, augmented and virtual reality, and blockchain will all move from being concepts and pilot programmes discussed at conferences to commonplace tools and technologies that can be accessed by all. As well as giving ships access to technology, this shift will also give technologists access to ships. The tens of thousands of ships sailing the oceans currently collect billions of data points each year about our oceans, world trade, and the environment. This data mostly sits in silos aboard each individual vessel but liberating it will create entirely new tools, technologies, and methodologies with the potential to disrupt everything from environmental research to commodities trading. The global maritime sector now has a blossoming startup ecosystem which will grow exponentially as these new data feeds become a reality, and the communication barriers between ship and shore finally come down.

This transformation runs beyond just the ships themselves. Merchant shipping supports a global industrial ecosystem whose transformation is still in its infancy. From the insurers who underwrite marine risk, to the retailers who rely on an efficient supply chain, the connected vessel will affect everyone in the coming years. Some will be disrupted, some will disrupt, but everything will change. This is an opportunity to create a safer, more efficient and more sustainable maritime supply chain and the world's innovators, large and small, are only now coming close to realising the potential of a fully connected maritime ecosystem.



CASE STUDY



INMARSAT - BUILDING INNOVATIVE PARTNERSHIPS

Over the last year, Inmarsat has joined forces with leading startup programmes, including [Rainmaking Trade and Transport Impact \(T&TI\)](#) and [Bluetech Accelerator](#), to support new businesses such as [Geollect](#) and [ScanReach](#) focused on the Internet of Things and big data innovation in the maritime, ports and logistics supply chain.

These programmes have been designed to fund, support and mentor start-ups' developing applications that aim to harness the power of IoT and big data to enhance safety, efficiency and sustainability. Inmarsat will collaborate with these startups to find a route to market via its global, high-speed satellite communications infrastructure that connects over 160,000 ships and yachts, as well as ports, road and rail networks across the world.

From enhancing safety to improving operational efficiency, emerging digital technologies such as machine-learning and IoT are set to become increasingly important in the day-to-day running of shipping and logistics companies, and vital in improving throughput at the world's largest ports.

For Inmarsat, supporting companies in the global supply chain is not simply about deploying the most advanced communications infrastructure. It is also about supporting the creation of applications that directly address an organisation's challenges and help transform these into significant opportunities.



To fully explore the impact of connectivity and digitalisation on the maritime sector, the following chapters explore the impact of new technology on four key operational aspects of the industry:

- ➔ **Ship Operations** explores how ships are currently operated at the deck plate, including aspects of navigation, cargo and passenger operations, and marine engineering at sea and how autonomous technology, remote monitoring platforms and IoT are set to transform the status quo.
- ➔ **Port Operations** explores the impact of collaborative platforms, robotics, and artificial intelligence on aspects of port management including vessel traffic flows, cargo handling equipment, and customs and security.
- ➔ **Ship Management** and services examines how fleet management teams are leveraging technologies like cloud services, drones, and mixed reality to transform everything from spare parts procurement to crew training and familiarisation.
- ➔ **Trade Facilitation** covers how shipbroking, insurance, and the wider trade ecosystem is being transformed by marketplace technologies, blockchain, and big data.

THIS IS AN
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CREATE A SAFER,
MORE EFFICIENT
AND MORE
SUSTAINABLE
MARITIME SUPPLY
CHAIN

SHIP OPERATIONS

The world's oceans are not a place designed for humans to live or work. It is through thousands of years of trial and error that we have been able to build ships that, for the most part, are relatively safe.

That said, in 2017 alone, 94 large ships were lost without recovery.³⁰ The oceans are still an incredibly inhospitable environment, and it takes a great deal of experience, skill, and ingenuity to safely operate a ship at sea. It has been said that navigation is the world's most precise science. Moving a 300 metre-long piece of steel that is floating on water from Southampton to Sydney and parking it within a 1 metre degree of accuracy, while avoiding the myriad of dangers en route requires a degree of accuracy rarely seen outside of nano-technology. It is an incredible feat: but it is one that happens every day, without the majority of us even realising.

The team responsible for safely navigating a ship is collectively known as the deck team. This team is made up of the ship's captain, chief officer, a number of junior officers, and a number of ratings. Each member of the team is highly trained in their own specialist areas, with the captain taking overall responsibility for the ship. Working in shifts 24 hours a day, 365 days per year, at least one person will be on the bridge of every seagoing ship responsible for safely navigating it to the next port. Though the technology continuously evolves, the principles of navigation have remained unchanged for a thousand years. By knowing either the distance from or the direction of a number of known fixed points, it is possible to establish your own position. These known fixed points can be coastal landmarks (including lighthouses, etc.), celestial bodies (including the sun, moon, and stars, etc.), or man-made positioning satellites (including GPS, GLONASS, etc.).

³⁰ Safety and Shipping Review, Allianz Global Corporate & Specialty SE, 2018.



As long as you have the relevant charts, it is possible to navigate the oceans by hand with nothing but a compass, sextant, chronometer, and a book detailing the positions of the celestial bodies through the year (known as a 'Nautical Almanac'). Celestial navigation is a highly reliable (though, not particularly accurate) method of navigation: a competent navigator should be able to fix a ship's position to within a mile using the sun, moon, stars, and a chronometer. As well as the traditional methods, modern ships use a combination of tools including radar, satellite systems, and electronic charts to safely navigate the world's oceans. Partly due to the cost of fuel, and partly because the industry is becoming more conscious of its environmental impact, the practice of navigation increasingly includes finding not only a safe route of passage, but also the most efficient route to the next port.

As well as the safe navigation of a ship, the deck team is responsible for the maintenance of the ship's safety systems and for the safe delivery and care of cargo. The main purpose of almost every merchant ship is to carry cargo. That cargo

could be anything from coal carried in bulk to humans aboard a cruise ship. Cargo ships are generally split into two categories, bulk and unitised cargoes. Bulk cargo covers include everything carried in bulk quantities like oil, gas, chemicals, and raw materials like grain and ore. Unitised cargo covers everything that can be carried in units like containers, lorry trailers, and cars. Most consumer goods and food travels as unitised cargo, whereas most raw materials travel as bulk cargoes. The ship's deck officers and crew need to continuously monitor the status of the cargo: this could mean checking ten thousand containers are securely in position, or that 300,000 tonnes of oil is at a safe temperature.

Whatever the cargo, it needs expert care and attention: there are very real dangers that come with carrying cargo across the oceans. Liquefaction can cause bulk cargoes to behave as if they are fluid, reducing the stability of the vessel, potentially causing it to capsize and sink. Similarly, flammable goods packed into containers can cause fires which rip through the entire ship in a matter of minutes. Heavy weather can cause vehicles on ferries to flip on to one side. The crew onboard are ultimately responsible for ensuring the ship arrives safely with the cargo intact, a critical responsibility that requires a great deal of manual monitoring and intervention.

While the deck department is responsible for operating the ship, the engineering department is responsible for keeping it running. Everything from a ship's propulsion system, to the sewage system, must be looked after by a team made up of experts including a chief engineer, engineering officers, an electro-technical officer, and engine ratings. The largest ships' engines weigh more than 2,000 tonnes, are more than four storeys high, and are longer than three London buses placed end-to-end.³¹ These engines, which produce more than 100,000 horsepower, require constant monitoring and maintenance because they need to run continuously while the ship is at sea. If it breaks down, the ship, its cargo, and the lives of the crew onboard will all be put in jeopardy. All of the systems that support life onboard a ship also fall under the engineers' purview. Cargo ships can have as few as seven or eight crew members but for a large cruise ship, the systems need to support up to 9,000 people using 200 litres of water each everyday.³² It is not possible to call a plumber to fix the toilet, or an electrician to fix a light when a ship is at sea: so the engineering department

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needs a broad skillset to keep all of the systems running smoothly, safely and efficiently.

It is also not possible to call an ambulance or the fire brigade if there is an emergency. In the middle of the Atlantic or Pacific Oceans, a ship can be weeks from the nearest land and days from the nearest assistance. All seafarers are trained in varying levels of emergency response, including first aid and medical care, firefighting, sea survival, and search and rescue. When an incident happens at sea, a well-trained crew will quickly respond and take appropriate action to protect life and assets. This could be anything from fighting a fire onboard, to conducting damage control after a collision, or lowering a boat rescue a person overboard. Incidents like this can happen any time, day or night meaning the crew must constantly be ready to take action.

When not working or responding to emergencies, crew have down time to rest, eat, socialise and exercise. These activities are managed by a ship's onboard services team. Usually made up of at least a ship's cook and a steward, they are responsible for keeping the crew fed. Every ship is different, with different leisure facilities: some have swimming pools, some have cinemas, and most have some sort of exercise equipment. Crew members will be onboard for up to nine months at a time. In a 40 year career, it is quite possible for a seafarer to spend 30 years of that at sea, away from home. This makes the health and welfare of individual crew members a highly important aspect of safely operating a ship.

³¹ The world's most powerful engine enters service, Warstila, 2006.

³² What happens when you flush the loo on a cruise ship?, The Telegraph, 2017.

TECH INSIGHT

While the operation of a ship is in many ways highly traditional, there are a number of areas of life onboard that are being radically changed by digitalisation, particularly as more ships have become connected to the outside world through some level of internet connection. We are still at the early stages of realising the benefits of this shift, with the majority of vessels still only having a basic connection. As that changes, we will see the operation of ships move from being the sole responsibility of an isolated team, to becoming a collaborative process with seafarers onboard supported by technical and nautical teams ashore.

DUE TO PASSENGER DEMAND FOR BANDWIDTH, THE CRUISE INDUSTRY IS AHEAD OF OTHER SECTORS WHEN IT COMES TO INVESTING IN SATELLITE BROADBAND

Due to passenger demand for bandwidth, the cruise industry is ahead of other sectors when it comes to investing in satellite broadband. The ability for passengers to upload #sunsetselfies to Instagram has an obvious positive impact on the marketing efforts of cruise operators, but the benefits run deeper. [Carnival Corporation](#) capitalised on their high bandwidth by building a number of Fleet Operations Centres to support the ships at sea. The first one, which opened in Hamburg in 2015, was the first time ever in the commercial maritime industry that a remote monitoring centre of this nature had been opened. There are now three in total, with centres opened in Seattle and Miami in subsequent years. These centres make it possible to monitor the company's entire 102 ship fleet. An operational snapshot of each individual ship which includes everything from stability data to radar screenshots is beamed from around the world to the monitoring team in real time. At

least two highly experienced master mariners (usually senior captains) monitor the fleet 24 hours per day seven days per week. If any aspect of a ship's operation appears to fall outside normal parameters, they can contact the bridge team onboard to assist and consult with them.

The next logical step from remote monitoring is remote operation. In the last five years, there have been a number of 'firsts' in the space of remote vessel operations. In 2017, manufacturer [Rolls Royce Marine](#) and tug operator [Svitzer](#) collaborated to install and test the first remote control system for a tug in Copenhagen Harbour.³³ In 2018, tug operator [Kotug](#) claimed the world's first remote operation of a tug from a long distance, with the tug in Rotterdam and the operator in Marseille.³⁴ In May 2019, UK startup [Sea-Kit International](#) completed the world's first commercial crossing of the North Sea by an unmanned vessel. Sailing from the Essex coast, the 12m long *USV Maxlimer* (uncrewed surface vessel), carried a consignment of oysters caught around Mersea Island to Oostende, Belgium. Upon receiving the oysters, customs officers loaded *Maxlimer* with Belgian beer for the return voyage.³⁵ The voyage was a collaborative effort supported by a number of UK government agencies, including the Maritime and Coastguard Agency, the Department for Transport, the Foreign and Commonwealth Office, and counterparts on the Belgian side.³⁶

Despite the advances in remote monitoring and operations, there are yet to be any unmanned vessels launched of any great size. The project to build the first autonomous full-size ship is currently under construction. [Kongsberg](#) and [Yara](#) launched the plans for the *Yara Birkeland* to much fanfare in 2017,³⁷ but the launch date has been pushed back from 2018 to 2020, with autonomous operations now not due to start until 2022.³⁸

33 Rolls-Royce demonstrates world's first remotely operated commercial vessel, Rolls Royce, 2017.

34 KOTUG demonstrates remote controlled tugboat sailing over a long distance, Kotug, 2018.

35 SEA-KIT docks in Belgium to complete first ever international commercial uncrewed transit, Sea-Kit International, 2019.

36 Autonomous boat makes oyster run, BBC News, 2019.

37 The world's first crewless cargo ship will launch next year, The Verge, 2017.

38 Yara Birkeland press kit, Yara, 2019.

CASE STUDY



WIND+WING TECHNOLOGIES - AUTONOMOUS WIND SAILING

The shipping industry has been using wind power as propulsion for thousands of years. In the last two centuries however, wind has been sidelined in favour of propulsion systems driven by internal combustion engines. On the shores of San Francisco Bay, Wing+Wing Technologies is working to bring wind power back to the commercial shipping industry. Rather than traditional sails, Wind+Wing has developed composite wings which generate thrust through a pressure differential in the same way that a plane's wing generates lift. They have developed and tested full size wings fitted to a demonstration boat.

The skill of using the wind to sail has been lost by the shipping industry. There is no requirement for merchant seafarers operating commercial ships to know how to sail. To combat this, Wind+Wing has developed an entirely autonomous sailing system that works in tandem with a ship's engine. A ship's navigator can switch on the system and using a combination of GPS data, wind data, and the ship's desired course the wing will automatically adjust itself to provide maximum thrust. Using this system to create hybrid propulsion it is possible to reduce fuel consumption by up to 40%.³⁹

Recognising that fitting wings to commercial ships could be expensive, the company has also developed the Container Wings concept. Multiple wings are stowed in and deployed from a standard 40ft container that can be loaded on any ship's deck. The system functions completely autonomously to provide additional thrust on demand with the modular nature of the system making a broad range of applications viable.



Due to the complexity of the equipment involved, the large scale commercial uptake of full sized unmanned ships will not happen for some decades, if at all. But autonomous doesn't mean unmanned, and there are a number of startups working to build autonomous navigation systems to act as decision support tools for manned ships. San Francisco and Paris based Shone are working with CMA-CGM, the world's third largest container ship operator, to develop a system that pulls in data from onboard cameras, radar, AIS, and GPS systems and applies AI to try and predict the behaviour of other vessels in the vicinity.⁴⁰ Sea Machines Robotics, who recently closed a \$10m series A round, signed a contract with Maersk in April last year to trial their AI powered decision support system aboard the new Winter Palace ice class container ships.⁴¹

It is not just on the bridge where new technology is having an impact. In recent decades, as crew numbers have diminished, there has been an increasing administrative burden placed on the seafarers onboard. A watchkeeping officer onboard a merchant ship would ordinarily expect to do an additional two hours of administrative work and safety checks in addition to the eight hours they spend on watch. German startup Nautilus Log recently launched a mobile-based logbook that helps crew to reduce their time spent on record keeping. The app can record information on vessel position, speed, weather, hull and machinery condition, and safety equipment status. Much of this logging is automatic, requiring no crew input, and ensuring accuracy. Once the data is logged, it can be parsed directly into systems ashore, reducing admin work in the office.⁴²

⁴⁰ Shone, 2019.

⁴¹ Maersk Selects Sea Machines for World's First AI-Powered Situational Awareness System Aboard a Container Ship, Sea Machines, 2018.

⁴² Nautilus Log App, Nautilus Log, 2019.

CASE STUDY



- A SMARTER SOLUTION FOR LOGGING REST HOURS

Despite advances in digital technologies in recent years, a number of ship board processes are still managed on paper. The logging of crew work and rest hours is one of them. There are legally binding minimum rest hours that all crew members need to adhere to while at sea. On the vast majority of ships, these records are recorded on paper by crew members themselves. At the end of the month, the crew hand in the records to the chief officer who checks them and files them in case of inspection by a port state authority. If the records are lost or the ship is found to be non-compliant, the vessel could be detained by authorities.

Workrest believe that monitoring something as important as rest hours should not be as time-consuming or difficult as it currently is. Their platform allows crew to log their rest hours each day on any device through a mobile app or browser, even when offline. At any time, the chief officer, captain, or management team ashore can check the crew's work and rest hours through a cloud platform. As well as logging, Workrest automatically checks for compliance against international legislation, sending alerts or email notifications when non-compliant entries are made.



A ship's main purpose is to carry cargo, and taking care of that cargo is one of the principal responsibilities of the crew. There are millions of containers currently in circulation, usually once a client's cargo is packed into a container, they will receive no information on its location, progress, or status. Fitting IoT sensors to containers is expensive, and until recently the cost has outweighed the potential benefits. To bring down the cost of container IoT, Israeli startup Loginno has developed an IoT device that fits inside a regular container vent. This means that it is possible to fit the devices at any container depot around the world without any specialist skills, drastically reducing the cost of the operation. Though smart containers are still in their infancy, they have the potential to give teams a wealth of information on the status and position of cargo. As well as keeping the cargo owner informed, this will also reduce the number of manual checks required by the crew and minimise the risk of container fires, a surprisingly common and often deadly occurrence on modern container ships.

CASE STUDY

GREEN SEA GUARD - USING IOT SENSORS TO MEASURE ENVIRONMENTAL IMPACT

As the industry comes under increasing pressure to better measure and reduce its environmental impact, IoT is being hailed as a potential solution. UK-based Green Sea Guard has developed an emission monitoring system that uses a sensor installed directly into the ship's exhaust funnel to measure the precise composition of exhaust gases at any one time.

Data collected by Green Sea Guard can be transmitted to the cloud in real-time by satellite, or integrated into existing ship onboard systems. Using advanced data analytics, the solution can verify a ship's emissions with enough accuracy to satisfy the EU's emission monitoring and reporting regulations (EU MRV).

As well as verifying and reporting emissions, Green Sea Guard can also monitor engine health. By monitoring the exhaust makeup of any engine it is possible to diagnose the efficiency of the engine and diagnose problems like timing errors before they develop in to catastrophic failures.





Beyond container fires, there are multiple hazards that face anyone living and working onboard a ship: from engine room fires and lifeboat accidents, to enclosed space entry and falling overboard. Accidents at sea are still too common, and are almost always preventable. The key to preventing accidents is understanding the multiple causal factors that lead to an incident. UK startup [HiLo](#) collects data on the 'high frequency, low impact' incidents that often lead to major incidents. By digitalising the collection of near-miss reports and data from safety reporting systems across thousands of ships, the HiLo team are able to model the risks from those leading indicators back to the ships. Through their work, HiLo has been able to reduce the risk of lifeboat accidents 72% across 900 ships operated by 10 companies, and reduce the risk of engine room fire by 65% across a fleet of 1,800 ships.⁴³

Many accidents at sea are attributed to human error, and Danish startup [Scoutbase](#) believes that rather than being a root cause in its own right, human error is a symptom of the ever changing interactions between humans, technology, and organisations. Their safety tools allow seafarers across a fleet to anonymously share their experiences at work from their smartphones, the data is gathered in real time and processed to create real-time leading indicators, helping crews and fleet management to address issues before they become accidents.

We are just at the beginning of scratching the surface of the potential of the transformation of ship operations. While some level of internet is now available on most ships, it is still far slower than we are used to ashore. Just as we are only beginning to understand the implications of 5G ashore, the implications of the next generation of satellite connectivity at sea will only be fully realised in the coming years. The principal barrier to digitalisation at sea has been the lack of connectivity, many innovative solutions have been developed that work around this by functioning without any or with a limited connection. The real power of the connected vessel comes in its ability to allow innovators such as [Sea-Kit](#), [Loggino](#), and [Nautilus Log](#) to revolutionise the way ships around the world are operated.

CASE STUDY



ORCA AI - USING AI TO ELIMINATE COLLISIONS

There is a set of rules known as the collision regulations that govern all ships and boats sailing on the high seas. Their purpose is to ensure that no two vessels ever collide at sea or in port. Despite the size of the oceans, collisions at sea are relatively common. Global trade patterns and geographical restrictions in coastal areas like Singapore or Dover mean that large numbers of ships have to share narrow stretches of water. 90% of collisions occur in crowded waterways, and the 3,000 collisions that occur annually cost the industry \$20b.⁴⁴

75% of collisions at sea are caused by human error.⁴⁵ Israeli startup [Orca AI](#) is working to eliminate collisions at sea by creating intelligent decision support tools to help a ship's captain and officers better navigate crowded waters. By combining artificial intelligence with data feeds from positioning, AIS, weather, and radar, the system is able to recognise distant vessels, even in poor conditions. Data about nearby vessels is aggregated and the most crucial information is displayed to the ship's navigation team.

⁴³ Our Services, HiLo Maritime Risk Management, 2019

⁴⁴ Orca AI, Orca AI, 2019

⁴⁵ Orca AI, Orca AI, 2019

PORT OPERATIONS

Ocean ports are the world's logistics centres. Everything we consume in some way depends on the ability of goods to transit the oceans, a journey which must start and end in a port.

UK ports handled 483.3 million tonnes of goods in 2018,⁴⁶ and our dependence on these critical pieces of infrastructure is often underestimated. Even when manufacturing is based in the UK, raw materials still need to be imported. Food grown on a farm five miles away from your home will likely have been processed by machinery that arrived by sea, transiting a number of ports en route. The objective of every port is to move goods through them as efficiently as possible, from discharging cargo from a seagoing vessel to loading goods onto a truck or train for delivery to the next destination.

The first challenge is getting the ship safely alongside the quay. As a ship is approaching port, its crew will submit the paperwork required to gain entry between 24 and 48 hours ahead of its scheduled arrival. Most ports are controlled by specialist teams known as Vessel Traffic Services (VTS) who monitor the waters in and around the port. Currently, many ships have to wait on arrival for a berth to come available and to be granted entry, often requiring the ship to anchor in a safe space near the port limits. Once a berth is available the ship can begin its voyage into the port, guided by a pilot with specialist knowledge who boards before entry. These large floating warehouses can carry anything from oil to oranges and, with the exception of specialist vessels and ferries, are mostly built for efficiency, rather than manoeuvrability. To help to guide the ship in safely, small but powerful boats called tugs will push and pull the ship into the right position.

Once safely alongside, the ship can begin loading or discharging its cargo. Depending on the ship type, this could take from a few minutes to a

few days. Most RoRo ferries are able to discharge in a matter of minutes, while the biggest bulk carriers and tankers can take a few days to fully load or discharge their cargo. Responsibility for the safety of the ship during cargo operations lies in the hands of its officers and crew. As well as monitoring that the right cargo is being loaded in the right place, the crew also need to monitor the status of the ship's position alongside the quay. As weight is moved on and off a ship, its height and angle in the water will change: if a ship is loaded too quickly or with unbalanced weight, it could cause the ship to capsize or even break in pieces. As well as the stability of the vessel, each ship type has unique safety considerations. In a process known as liquefaction, some bulk cargoes can behave as if they are liquid when their moisture content gets too high, causing the ship to lose stability. Some others like coal and tapioca can spontaneously combust in port or at sea. The gasses emitted from oil cargoes can create a dangerously flammable atmosphere, making the fire and explosion risk high. Though it does not come with the same safety risks, loading a container ship is highly complex: on the largest ships, thousands of containers will be moved on and off the ship in a tight time window. On the shore side, there is a wide array of equipment used to move cargo on and off a ship. From giant gantry cranes used to lift containers, to enormous pumps used to fill oil tankers. The UK's largest gantry cranes stand at 130 metres, which is roughly the same height as the London Eye. They were installed at DP World's London Gateway terminal to help them service ever increasing ship sizes.⁴⁷

While the ship is alongside, there are a number of important services that may need to be carried



⁴⁶ UK Port Freight Statistics 2018, Department for Transport, 2019

⁴⁷ Pair of 130m cranes, the tallest in UK, are moved into position at DP World container terminal, Daily Echo, 2018.



out. As well as inspections by customs and immigration officials, there may be changes to the ship's crew, restocking of provisions, repairs to equipment, and refuelling (known as bunkering), all of which needs to be completed before the ship sails. All of these inputs add complexity to the port operation and can make it difficult to judge the amount of time that will be needed for the ship to stay alongside. Coordinating services provided by a number of different companies is challenging, particularly as each company has its own aims and objectives, and the communication between all of those stakeholders is conducted mostly by email, phone, and even fax. This makes scheduling a challenge, as it is often difficult to know when a berth will become available, which has a knock-on effect that ships who are approaching the port.

For any port or terminal, planning the yard space where cargo is stored is key to their productivity. This problem exists across every terminal type, but is particularly prominent in container terminals. In a container terminal, minimising the number of times that boxes are moved during their time in the port has a direct impact on both the costs and environmental impact of the terminal. Minimising the distance travelled for each of those moves compounds any potential savings. Considering that some ships are over 400 metres in length, if a container is stored in the wrong place in the

yard, it can add significantly to the distance that it needs to travel to be loaded onboard.

Yard planning is like finding the best way to build a giant jigsaw puzzle that has an infinite number of possible solutions. Shanghai, the world's largest container port had a throughput of 37 million containers in 2016: just a 1% improvement to their yard planning would have a multimillion pound impact on their bottom line.⁴⁸ The same is true for optimising the gates for trucks transiting in and out of the terminal. Every time that a container is delivered to the terminal by road, the truck will be directed through a series of gates and to a specific drop off point. The same optimisation problem exists here too, particularly when you consider that the trucking companies are interested in the shortest possible turnaround times.

Before cargo can leave a port, usually while it is in the yard (but potentially even before it arrives), it also needs to be cleared by customs.

UK PORTS HANDLED
482 MILLION TONNES
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Customs is as much about ensuring that goods entering a country are of sufficient quality and are legally allowed as it is about collecting fees. In the UK, customs is managed by Her Majesty's Revenue and Customs (HMRC) and enforced by the UK Border Force. In addition, nearly 30 UK government departments feed into customs policy and enforcement: from the Department for the Environment and Rural Affairs, to Arts Council England.⁴⁹ Customs is a highly collaborative process that relies on partnerships between a number of actors, including public

⁴⁸ Top 50 World Container Ports, World Shipping Council, 2019.

⁴⁹ The Customs Declaration Service, National Audit Office, 2017.

authorities, port community system providers, chambers of commerce and traders.

It is impossible for every shipment of cargo to be physically checked as it enters or leaves the UK, and so current customs methodology is heavily intelligence-led. Traders must submit a customs declaration before importing or exporting any goods, and controlled substances (such as medicine) can only be moved across borders by companies who have the requisite licenses and authorisation. Using a combination of trading pattern data, declarations, and customs checks, HMRC conduct risk assessments on goods being moved and use the results to decide which shipments to inspect in more detail. Currently, just 3% of UK imports are subject to documentation checks, with an even smaller number receiving a physical inspection.⁵⁰ This approach keeps a level of scrutiny over high-risk trade, while allowing the vast majority to transit the border unhindered.

As well as controlling the movement of legitimate goods across borders, ports have a key role to play in national security: protecting unauthorised people and goods from crossing the border. Further, these critical infrastructural assets need to protect themselves against potential acts of terrorism, or other malicious attacks. Maritime security is governed by the International Ship and Port Security Code (ISPS Code). This code dictates that ports must have a dedicated security fence, and that entry in and out of the port area must be controlled in the same way as it is in an airport. On top of this, national authorities have the power to set the security level for ports and ships operating in them. In the UK, the Department for Transport sets the national ISPS level, which ranges from level one, where operations can run normally, to level three where all traffic in and out of the port is stopped. Any port must have a security level at least as high as the national level, and any ship must have a security level at least as high as the port it is visiting. Each ship and port has its own procedures in place for each security level.

AS WELL AS CONTROLLING
THE MOVEMENT OF
LEGITIMATE GOODS
ACROSS BORDERS, PORTS
HAVE A KEY ROLE TO PLAY
IN NATIONAL SECURITY

TECH INSIGHT

In the days before ships had any connection, they would arrive as close as possible to a pre-agreed planned time. There was no way to tell ahead of time whether the port would be able to accept the ship on arrival, and it was also impossible for the port to know with any accuracy when a ship would arrive. Today, ships can be tracked using AIS, so arrival times are generally much better communicated.

Even so, the majority of ocean going ships still receive no indication of the optimum time to arrive and many can spend hours, if not days, waiting at anchor just outside the port area. The shipping industry is under increasing pressure to reduce its emission footprint and that fact is no more prevalent than in the world's ports. All of the time that a ship spends in port will require fuel consumption, either for propulsion or to keep the ship's electrical systems running.

Further, the link between ship traffic and respiratory problems in the local population is well-documented. This is particularly important given that many ports are close to major towns and cities in the UK. Indeed, up to 3,000 premature deaths in the UK can be attributed to emissions from ships in port or coastal waters.⁵¹ Currently, the best way to minimise a ship's environmental impact in port is to minimise the length of time it needs to spend there.

As the global fleet becomes connected, better data sharing becomes possible: this includes updating vessel schedules and routes on demand. Managed by the [Swedish Maritime Authority](#), the

⁵⁰ Implementing Brexit: Customs, Institute for Government, 2017.

⁵¹ Toxic fumes from ships linked to thousands of UK deaths, The Independent, Gabbatiss, 2019



EU-funded Sea Traffic Management Validation project aimed to introduce a system similar to Air Traffic Control to the maritime sector. The project has already successfully developed and trialled the concept of Port Collaborative Decision Making, allowing ships and port actors to collaborate on the schedule for a port call.

The systems in development rely on a common set of data standards which, when integrated into existing systems, can be used to share accurate information between stakeholders. As well as collaborative decision making coming into port, the STM Validation project has pioneered the concept of route sharing while at sea. It is now possible for two ships sailing in the same sea area to share their planned routes to aid decision-making and collision avoidance. STM-enabled ships are able to share routes with each other directly between two ECDIS (electronic chart) machines. Further, pilots and VTS operators are able to share recommended routes with approaching ships. While still in the early phases of testing and implementation, STM has so much potential that the world's largest cruise operator [Carnival Corporation](#) recently committed to enable their entire fleet of more than 100 vessels with the technology.⁵²

⁵² Carnival connects entire fleet to STM, Hellenic Shipping News, 2019.

CASE STUDY

shipx
mastering a sea of data

SHIPX - USING DATA TO OPTIMISE DISPATCH PROCESSES

Port assets such as tug boats and pilot boats are expensive to run and only make money when they are in use, safely bringing a large ship in or out of port. It is therefore in the interests of any operator to maximise their utilisation. This is one of the problems that Dutch startup [Shipx](#) is trying to solve. The maritime big data specialist teamed up with global tug operator [Kotug](#) to develop a platform to help port operators to dispatch tug boats, pilots, linesmen, and bunker barges in the most efficient way possible.

The 'OptiPort Dispatch' platform, now a joint venture owned by ShipX and [Kotug](#), pulls in data from various sources, including AIS and weather feeds. It uses proprietary algorithms to calculate the optimum use of port resources, taking into account crew scheduling, port restrictions, and individual vessel operation expenses. It can react suddenly to changes in conditions that influence the operating of the port like estimated times of arrival and departure, or bad weather.

Aside from OptiPort, ShipX has been gathering data on vessel movements around the world for five years. This gives them insight into everything from individual vessel characteristics to global trade flows and even port performance.

DIGITALISING THE FLOW OF INFORMATION ALSO CREATES NEW OPPORTUNITIES TO FURTHER OPTIMISE OPERATIONS USING ANALYTICS AND AI.

A number of startups are working on the problem of vessel scheduling too. USA based startup [Portcall](#) has developed a cloud-based scheduling platform that makes it possible for any port stakeholder to view a vessel's planned schedule and instantly make updates to it when required. In the time that they have been operating, Portcall have eliminated more than 42,000 phone calls by coordinating over 35,000 port calls.⁵³ In London, [Intelligent Cargo Systems](#) has developed 'CargoMate', a port call optimisation platform for ship operators. CargoMate collects port performance data wherever a ship goes and uses it to predict the optimum departure time. Vessel crews and fleet management teams are kept up to date with the progress of cargo operations and are notified when the system predicts delays or early sailing opportunities. Because the system does not require any input from the port, it works wherever the ship sails.

While still not perfect, these collaborative platforms significantly reduce the amount of manual communication required between ship and shore. Digitalising the flow of information also creates new opportunities to further optimise operations using analytics and AI. Danish startup [PortChain](#) uses artificial intelligence to aid port call planning. Their 'Berth Optimisation Engine' runs multiple planning scenarios concurrently as soon as a vessel's ETA is known to find the optimum schedule for the vessel to maximise berth usage while avoiding potential clashes and congestion. Port call planning usually takes hours, but the application is capable of planning an entire week's schedule in less than 90 seconds, freeing up time for planners to spend on more strategic decision-making.⁵⁴ On the land side too, the vast amounts of data generated by terminal operating systems can be used to help artificial intelligence algorithms to optimise the yard planning, minimising the number of moves required for the cargo handling equipment.

⁵³ Portcall Port Partners, Portcall, 2019.

⁵⁴ Berth Optimisation Engine, Portchain, 2019.

CASE STUDY



- SMARTER SURVEYING OF WATERWAYS

The depths of world's port waterways are constantly changing. Silt deposits can build up at the mouths of rivers and particularly strong tides can physically move deposits into major waterways, reducing the depth of the water. To combat this, ports need to regularly survey their waterways and, if appropriate, dredge them to maintain a minimum depth that is safe for shipping. Survey and dredging vessels are expensive to hire and are a major contributor to the cost base of many ports.

Docktech, a startup from Tel-Aviv, is drastically cutting the costs of surveying and dredging in ports. By connecting the standard echo sounders of a port's service boats (tugs and pilot boats) to the cloud, they have been able to build accurate survey pictures of water depth in port. This crowdsourced data eliminates the need for a dedicated survey vessel to operate in the port, cutting expenses and emissions.

As well as measuring current depths, there is enough regular data for the DockTech platform to predict future depths too, allowing port authorities to better plan dredging activities. The potential for this technology is enormous, with a better understanding of a port's safe depth, ships can load more cargo, increasing profitability and efficiency. Further, surveying open sea areas for depth is currently a costly endeavor and there are still coastal areas that have not been surveyed since Victorian times. Crowdsourcing depth data like this could have an enormous impact on maritime safety, allowing every ship to contribute and benefit from a better understanding of our oceans.



Automating cargo handling equipment has been a goal of port and terminal operators for decades. Currently, automated cargo cranes and trucks are significantly slower than human-operated equipment. Leading cargo handling equipment provider [Kalmar](#) has developed autonomous gantry cranes that can move load or discharge roughly one container every two minutes.⁵⁵ This is about half the speed of a competent human operator, but the consistency of the operation makes it an investment worth making. In an automated crane there is no need for breaks and shift changes: the operation can run 24 hours per day, 365 days per year.

Even when cargo handling equipment has been automated, it still needs monitoring. IoT sensors in cargo holds can help the ship's officers to monitor the progress of the cargo loading and discharge operation. Sensors in cargo holds have existed for some time, but short of rudimentary displays in the cargo control room, they are not usually networked. Sensors that measure heat, moisture content, and gaseous mixtures make it possible for crews to get an early warning on liquefaction or spontaneous combustion, and allow for deeper analysis into how cargo operations on the vessel might be affecting the stability or structural integrity of the ship. On the rare occasions when dangerous incidents do occur, this sort of data is invaluable when it comes to establishing cause and helping investigators to understand how to prevent the same thing happening in the future.

IoT also has a number of potential applications in port security. Belgian startup [Xetal](#), has developed a microprocessor that uses the same sensor as a regular digital thermometer to detect the presence of humans. The system can detect the location and number of people in a room with high accuracy, using only a single temperature sensor that is about the size of a €1 coin.⁵⁶ Because the system only detects the presence of humans and not their identity, it is a GDPR-compliant way to monitor entry and exit into sensitive areas of ports or ships with implications that go beyond security into safety and compliance.

While it is important to stop unauthorised people entering a port from the land side, it is equally important to intercept suspicious vessels operating nearby, or entering port from the open sea. All ships carry transmitting devices such as automatic identification systems (AIS) which broadcast the vessel's position to those

nearby, but malicious actors can simply switch off this equipment to avoid detection. US-based startup [HawkEye 360](#) uses a constellation of micro satellites to listen to radio signals from all vessels, even those that want to avoid detection. Each satellite is about the size of a wine bottle, and is able to pick up even the faintest of radio signals from earth. Even when a ship tries to avoid detection, it will still transmit signals from navigation and communication equipment such as radar and handheld VHF radios. These signals are picked up by multiple satellites, processed algorithmically and used to triangulate a position for a vessel, when this data is overlaid against public AIS data it is possible to validate a vessels position and track it even after it has switched off its identification equipment.⁵⁷

Intercepting smuggled goods is a key part of a port's role, but its main function is to let legitimate goods pass freely through. The full digitalisation of customs processing across the EU has created a multitude of opportunities to apply new technologies to improve the process. With the input of so many different actors and a high level of trust required, customs is a clear use case for blockchain technology. Using blockchain for the creation and authentication of certificates of origin or the authentication of goods has the potential to drastically reduce the likelihood of counterfeit goods making it across a border. In May 2018, blockchain-based certificates of origin were used for the first time in Singapore. Launched as part of a collaboration between local startup [VCargo Cloud](#) and the [Singapore International Chamber of Commerce](#), the new certificates are far more secure and more cost efficient than their paper based counterparts.⁵⁸

The digitalisation of customs documentation also aids the intelligence-based approach that customs authorities increasingly need to take to successfully intercept illegitimate goods. In the UK, HMRC's new digital customs platform, CDS, processes millions of declarations each year. The data created in this process can be used to train AI models of normal trading patterns so that customs and border force officials can be alerted when a particular shipment or trader is behaving unusually. This could drastically cut down the number of inspections on goods required, while at the same time improving the hit rate of those that are carried out.

⁵⁷ HawkEye 360 and Windward Partner to Provide Deeper Insights and Better Visibility on Vessel Behavior, HawkEye 360, 2019.

⁵⁸ Singapore International Chamber of Commerce and vCargo Cloud Launch World's First Blockchain-Based eCertificate of Origin, VCargo Cloud, 2019.

⁵⁵ Kalmar Automated Terminals, Kalmar, 2017.

⁵⁶ How small is a sensor?, Xetal, 2019.

SHIP MANAGEMENT AND SERVICES

To be commercially successful, ships need to be operational for as long as possible: ideally 24 hours per day, 365 days per year. Keeping a large piece of industrial machinery running in an environment as unforgiving as the world's oceans is a feat of engineering that requires not just the crew's input, but the input of multiple support teams ashore too. Every commercial ship has a management team that is responsible for all aspects of the vessel's operations, from creating the sailing schedule, to ordering spare parts.

It is a common practice in the industry for ships to be owned and managed by separate companies, and then leased to a third party who has cargo to move. For example, an oil tanker's owner may be a financial institution with no interest in the day-to-day operations of the vessel. They will pass this responsibility on to a third party ship management company. Once under management, the tanker can be chartered out to cargo owners like [BP](#), [Shell](#), or [ConocoPhillips](#), who want to move oil around the world. A ship can be chartered for the duration of a voyage or for a fixed period of time, with different levels of service included depending on the agreement. Equally, it is possible for a single company or group of companies to own, operate, and charter a vessel, but this is usually the preserve of the very largest shipping companies who will likely still charter vessels according to demand.

Whether managed by a third party company or not, the first step to getting a ship ready to sail is receiving approval by the flag state and classification society. A ship's flag state is the country the ship is registered too, which is not necessarily the country the ship is owned or operated in. Each country sets their own regulations for safety, environment, and taxation and shipowners can choose which country to register their vessels to fit their needs. While the flag state sets the rules, the classification society is responsible for ensuring



ships adhere to them, sending surveyors to inspect the ships and, if appropriate, issue them a certificate allowing them to sail.

Once ready to sail, a ship needs a crew. Crewing is a logistics operation in its own right. Every day, thousands of crew members around the world will join or leave a ship, they will need flights, visas, accommodation, and onward travel arranged for them. The world's largest cruise ship has a crew of 2,200 crew from 77 different countries.⁵⁹ Most cargo ships have a crew of 10 to 30 people, and seafarers will spend anywhere between six and nine months of the year at sea onboard a ship and the rest at home on leave. While onboard, crew members live and work together, sharing the accommodation spaces and leisure facilities onboard. Each crew member also needs to be trained appropriately for their role, including mandatory basic health and safety training. The majority of crew education and training is conducted in colleges and training centres around the world.

⁵⁹ Symphony of the Seas is now the world's largest cruise ship, Crew Center, 2018.



In addition to getting people on and off a ship, feeding them represents another logistical challenge. The Royal Caribbean cruise ship 'Symphony of the Seas' needs up to 60,000 eggs and 6 million coffee beans per week to keep its passengers properly fed.⁶⁰ Food is not the only consumable required during the normal course of operations: bunker fuel oil is needed to power the ship, and lubricating oil is needed to keep its engines running smoothly. Further, there are countless pieces of equipment that need to be replaced over time, including fire fighting equipment, safety gear and mooring lines. Usually a ship's chief officer and chief engineer are responsible for requesting new equipment or spare parts. Once they submit what is required to the fleet management team, all food, equipment, and fuel needs to be procured and delivered safely to the ship during the limited time it is in port. Procured stores will be sent to the ship's agent in the port, who will arrange all of the logistics for having them finally delivered to the vessel.

Like any asset, a ship needs to be insured. A ship's hull and machinery is insured through traditional insurance, while everything else including crew, cargo, and environmental liability is insured through a type of mutual assurance known as Protection and Indemnity (P&I). Shipowners join not-for-profit P&I clubs and pay into a pool of funds based on the amount of tonnage that they operate. These funds are used to cover the cost of any incidents and accidents, and the shipowner becomes a member of the club.

When accidents do happen at sea, it again falls on the ship management team to coordinate a response along with international search and rescue bodies. Every ship must have a designated person ashore (DPA) to act as the main point of contact between ship and shore in case of emergencies. Beyond the coordination of a search and rescue response, which will be handled by one of several government-run Maritime Rescue Coordination Centres worldwide, the DPA and the ship management team is responsible for arranging salvage operations, pollution control efforts, and repatriation of seafarers who may be stranded.

FURTHER,
AUGMENTED REALITY
HEADSETS ALLOW
ENGINEERS TO
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TECH INSIGHT

Making it possible for ships to operate continuously requires a regular programme of maintenance on the ship. Much of this can be carried out by the ship's crew without the need for input from ashore, but there are often times when specialist knowledge or skills are required to do the work. Currently, this involves flying specialist engineers out to visit a ship to either conduct work while the vessel is alongside, or to temporarily live and work onboard the ship while it is sailing between ports.

Of course, flying engineers out to visit ships is a significant cost, as is delaying a ship for conducting work or installing equipment. As such, remote engineering and maintenance represents a highly promising use case for emerging augmented and virtual reality technology. Connecting engineers onboard to specialists ashore and allowing them to see and hear the situation through the crew's eyes and ears when carrying out particularly complex work can drastically reduce the amount of time and money it takes to fix problems or conduct maintenance. Further, augmented reality headsets allow engineers to access all of the information they need to perform a job while keeping their hands free.

⁶⁰ How Much Food is Consumed Each Week on the World's Largest Cruise Ship?, Cruise Fever, 2018.

In a recent trial by energy giant [Equinor](#), an engineer was tasked with locating a specific tube in one of the modules onboard an offshore platform under construction in South Korea. Without the VR headset it took a full hour to locate the part: with the headset, it took just three minutes.⁶¹ Norwegian startup [Fostech](#) develops holographic solutions for the maritime industry. Their work includes a range of applications to assist workers in their roles including games for training and system guides for operational use. A Norwegian shipyard is currently using their technology to allow construction supervisors to see blueprints in real time as they inspect work being carried out onboard the ship. If there are any discrepancies in the work, the supervisor can communicate directly with engineers through the headset for further discussion⁶²

Up until very recently, maintenance has relied heavily on the crew's eyes and ears and a regular schedule. Thanks to advances in the Internet of Things (IoT), that is changing. It is now possible to deploy connected sensors to almost every piece of equipment onboard a vessel, enabling remote monitoring of everything from sound and temperature, to humidity and movement. Seattle-based startup [ioCurrents](#), who recently raised a \$5m Series A, use a combination of IoT-enabled sensors and data input from equipment to transmit data to their MarineInsight analytics platform. The platform helps ship operators to reduce fuel consumption and maintenance costs by predicting breakdowns and problems before they become critical. It can also be used to monitor the status of cargo on the ship. Data is stored locally onboard and is accessible to crew members at any time and, whenever there is a connection, it is also transmitted to the cloud to give fleet managers ashore insight into the ship's operational health and efficiency.

61 Augmented reality could be the vision of maritime's future, Riviera Maritime Media, Martin, 2018.

62 Ibid.

CASE STUDY



NAUTILUS LABS - FLEET MANAGEMENT AT SCALE

Even without IoT, ships already produce vast amounts of data, but it often is not accessible in a way that is useful to fleet management teams, or it requires huge amounts of manual work to make it meaningful. New York startup [Nautilus Labs](#) is making maritime data useful through their fleet intelligence platform. The business, founded in 2016, raised an \$11m Series A in April 2019 from investors led by Microsoft's venture arm [M12](#).⁶³

Nautilus Labs claim that 30% of the \$100b of bunkers burned each year can be saved through data-driven decision making. Their platform automates data collection across a fleet, entering it to a single cloud application that eliminates data silos and allows for better decision making in real-time. Monitored vessels can be benchmarked against fleet KPIs, charter party terms, and voyage instructions, with automatic alerts for anomalies or exceptions.

As well as getting data off ships, the platform allows for better collaboration across a company. Any user can tag and alert other users to specific events logged to the platform, giving ship operators, captains, and superintendents a unified view of performance across departments and offices around the world. Further, Nautilus uses machine learning to predict future vessel performance taking in external factors like weather and dynamically adjusts sailing instructions to reduce fuel consumption and maximise profitability.

63 Announcing Nautilus' Series A, Nautilus Labs, 2019.

UP UNTIL VERY RECENTLY, MAINTENANCE HAS RELIED HEAVILY ON THE CREW'S EYES AND EARS AND A REGULAR SCHEDULE

Another way of safely extending the eyes and ears of humans is through drone technology. Dutch startup [RIMS BV](#) specialises in using advanced robotics for inspection and maintenance in the maritime and offshore industries. They have now been approved by nine classification societies to carry out remote inspection work to ensure that ships are complying with class and flag state regulations.⁶⁴ Drones come into their own when conducting inspections that would otherwise be dangerous to humans. Humans entering enclosed spaces such as ballast and cargo tanks is one of the leading causes of death at sea. The spaces are often void of oxygen or contain poisonous gases. Using drones to conduct those inspections minimises the risk to humans and the time and costs involved.

Drones are also being trialled as a way of delivering supplies to ships. In ports with large anchorages like Singapore and Fujairah, UAE, ship's agents have to use boats to make deliveries to ships who may be anchored several miles offshore. Everything from food to spare parts is carried out by barge and manually craned onto the waiting ship. In March 2019, a drone lifted off from Marina South Pier in Singapore and flew out to a waiting ship in the Eastern Working Anchorage. The drone was carrying parts 3D-printed in [Wilhelmsen's](#) onshore micro-factory. It dropped off its 1.5kg payload on the deck of the MV Pacific Centurion and returned to base. This was the first commercial drone delivery to a vessel at anchor and it was conducted as part of a collaborative project

⁶⁴ Full steam ahead for RIMS in certification as Remote Inspection Specialist using drones, RIMS, Knukkel, 2019.



between aviation giant [Airbus](#) and [Wilhelmsen](#), a leading ships agency service provider. The entire operation took just 10 minutes, less than half the time it would have taken by boat. [Wilhelmsen](#) predicts that the delivery of light, time critical packages like spare parts, medical supplies, and cash by drone could reduce costs by up to 90% when compared to launch boat.

Another company working on making heavier payloads viable is Singaporean [F-Drones](#). This early-stage startup recently graduated from [Entrepreneur First's](#) accelerator with a mission to build a transition drone that can make deliveries of up to 100kg to ships and oil rigs. Their drone design is capable of taking off and landing vertically but transiting to fixed wing flight to travel long distances. It will be able to carry a 50kg payload up to 250km and land on a moving target making it a viable replacement for transporting stores to offshore rigs by helicopter or to passing ships by launch boat.

It is not just the final delivery of stores to ships that is being transformed. The entire procurement process is being disrupted by digital platforms that combine an improved user experience with access to a broad range of suppliers. Currently, most shipping companies

use a system of paper forms and email conversations to manage procurement. Indian startup [ShipsKart](#)'s maritime procurement platform allows captains and chief engineers to order spare parts and stores from their phone. Users can browse a catalogue of over 25,000 products and submit requisition orders on an app that works without a connection. Once the device connects to the internet, the orders are synced with a cloud-based procurement platform where they can be checked and approved by the fleet management team ashore. The fleet management team can view prices from more than 100 vendors and spend analytics across their entire fleet. If the requisition is approved, Shipskart completes the order and handles the logistics for delivery at the next port. ShipsKart claim to be able to reduce procurement man-hours by 30% and costs by 20%.⁶⁵

Crewing is another area that relies heavily on email to get the job done. Moving the 1.5 million registered seafarers around to join and leave the world's 50,000 ships is a serious undertaking. Most crew flights are booked manually, with entire departments having to email crew details to travel agents. Dutch startup [C Teleport](#) is automating the process of crew travel. Their application syncs automatically with crewing software to book flights without the need for data entry. Further, if the ship is delayed into port, the manning team can cancel and rebook flights for the entire crew in just a few minutes instead of the hours it usually takes to manually amend a booking with a traditional travel agent. As well as handling travel, every time a seafarer joins ship, paperwork including training certificates, licenses, visas, and even vaccination documents need to be checked and verified. Further, a crew member's competencies need to be matched to the ship's current requirements.

Cyprus-based [RadiantFleet](#) has been working to organise all of these requirements into a single cloud platform. Started as a side-project in 2012, the [RadiantFleet](#) platform gained its first customers and investment in 2017 after taking part in Port of Rotterdam's [PortXL](#) accelerator. [RadiantFleet](#) allows users to manage all crew documents, competencies, schedules, and even payroll in one place. They have also introduced a crew portal mobile app to give seafarers access to everything they need to know for their time onboard ship. In 2019, they launched a procurement module and plan to have a full suite of modules for ship management within the next few years.⁶⁶

All of the technologies discussed in this chapter so far have one thing in common: they produce vast amounts of structured data on everything from crew competence and diet, to engine oil levels, to wear-and-tear of parts. While there are immediate benefits that can be realised by these systems, we are barely scratching the surface of what can be done when the data generated is properly utilised. Fed by petabytes of data, insurers will be able to use artificial intelligence to accurately predict risk and dynamically adjust premiums, a concept that London-based [Concirus](#) is already successfully implementing in multiple maritime settings.

Further, it will soon be possible for IoT sensors in marine engines to feed platforms that not only make it possible to predict when parts need replacing, but that also automatically procure those parts so that they arrive in the next port, or at the next available delivery time. Those spare parts could be installed by an engineer wearing an AR-enabled headset to ensure the job is done quickly and accurately. Their training data could have uploaded directly to a crewing platform that handles their schedule, books their travel, and perhaps even pays them through a digital currency like the one being developed by [NYK Line](#).⁶⁷

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⁶⁵ up Grows in Rotterdam, Port of Rotterdam, 2017.

⁶⁷ Japanese Shipping Line Develops Digital Cash for Crew, Bloomberg, Matsuda, 2018.

⁶⁵ ShipsKart, ShipsKart, 2019.

⁶⁶ Crewing and Ship-Management Software Start-



CASE STUDY

BUNKEREX

BUNKEREX - BUILDING A MARKETPLACE FOR BUNKERING

Fuel, in the maritime industry known as bunkers, makes up the single largest cost of running a merchant ship. As well as being a significant operating expense, it is also volatile; rising and falling with market conditions and local availability. A fluctuation in bunker prices can wipe out a shipping company's operating margin overnight, yet ship operators often use brokers to buy bunkers who rely on personal relationships rather than objective data to choose a fuel supplier. The bunker market is completely unregulated and the opaque nature of bunker procurement means that ship operators often overpay for fuel.

BunkerEx, the London-based startup who raised a £400k Pre-Seed round two years ago, set about bringing transparency to the industry by pulling in thousands of fluctuating bunker prices worldwide to a single platform. Their online portal updates with new prices every 15 minutes, and takes into account vessel deviation costs, charter party terms, and port fees to help ship operators to pick the cheapest bunker option throughout a voyage.

Shipping companies miss the cheapest bunker port in 30% of voyages, adding an average of \$200/day to the ships operating costs.⁶⁸ As well as making bunker data available through the online portal, BunkerEx have an API, allowing other developers and service providers to pull data into their own platforms. BunkerEx data is now being successfully deployed to Kongsberg Digital's Vessel Insight platform, giving ship operators a quick way to accurately evaluate bunker information inside their existing systems.⁶⁹

⁶⁸ Why BunkerEx, BunkerEx 2019.

⁶⁹ BunkerEx join the Kognifai partner program, Kongsberg Digital, 2019.

TRADE FACILITATION

As mentioned previously, it is common practice in commercial shipping for a ship to be owned and operated by separate parties. Shipbrokers sit between those parties, helping shipowners to buy and sell vessels, or to find cargo for vessels to move.

There are different types of shipbroking, each requiring their own specialist knowledge, skills, and contract types. Sale and purchase brokers help shipowners to buy and sell ships on the second-hand market or manage the contracts for building new ships. Dry cargo and tanker brokers match shipowners to cargo that needs moving. If a cargo owner wants to move 10,000 tons of grain across the Atlantic, it will be a dry cargo broker that helps them to find a ship capable of carrying it. Shipbroking has traditionally relied heavily on personal relationships and trust built up over many years. As technology has evolved and data on the world's shipping fleet is becoming more widely available, most modern shipbrokers have begun acting as trusted advisors to their shipowner clients, helping them to maximise profit from the vessel and advising them on market conditions.

Similar to shipbrokers are freight forwarders, who handle the movement of freight around the world. A freight forwarder may be responsible for anything from moving a single container of goods from China to the UK, to managing the logistics operation for a German auto-manufacturer. While shipbrokers will usually help to charter an entire ship to move goods, a freight forwarder will usually book part of a ship for a particular voyage like some containers across the Atlantic or lorries across the English Channel. Usually, freight forwarders help their clients to manage the shipment of goods from door to door, negotiating multiple modes of transport, and any potential hurdles thrown up in the import and export process. This makes freight forwarding another discipline reliant on personal relationships and expertise gained over many years.

When cargo is moved at sea, whether with the aid of a shipbroker or a freight forwarder, one document is crucial to the entire operation: a bill of lading. When goods are delivered from a factory in China to a warehouse in the UK, when do they legally change hands? Who owns the goods when they are on the ship? Who is legally responsible for them if something goes wrong? A bill of lading serves three functions: it acts as a receipt that the goods have been successfully loaded on to the ship and what condition they are in; as a contract of carriage for the goods; and, most importantly, a deed of title proving ownership of the goods. When goods are loaded onto a ship, the carrier issues a bill of lading to the shipper. Once the consignee, the party receiving the goods, has paid the shipper, the bill of lading is released so that they can use it as proof of ownership when the goods arrive. In most circumstances, to receive the goods the

BUYING AND SELLING GOODS INTERNATIONALLY CAN BE A COMPLICATED BUSINESS, WITH MONEY NEEDING TO CHANGE HANDS ACROSS MULTIPLE JURISDICTIONS AS GOODS WORK THEIR WAY THROUGH THE SUPPLY CHAIN





consignee needs the original bill of lading, which upon successful payment, is usually couriered to wherever they are in the world. If the bill of lading is lost, damaged, stolen, or compromised in some way the goods can only be released by a court order, which can take some time.

Running alongside the flow of goods around the world is the flow of money. Buying and selling goods internationally is complex, with money needing to change hands across multiple jurisdictions as goods work their way through the supply chain. Alongside a bill of lading, a shipment of goods will be accompanied by a commercial invoice. The invoice is a requirement for customs clearance into a country and documents basic details of the financial transaction, as well as the value of the goods. Large amounts of cash get tied up in international trade, and moving money and paperwork across borders takes time, often making it impossible for small businesses and even small countries to successfully export goods. 3% of global trade worth roughly \$3 trillion is supported by trade finance, where banks and financial institutions facilitate the cash flow needs of importers and exporters.⁷⁰

Where this happens, a bank will issue a letter of credit alongside the shipment guaranteeing payment to the shipper for the goods. Other trade finance services include export and invoice factoring, where a shipper is paid upfront against an invoice or shipment of goods. These financial instruments help to bridge a cash flow gap and greases the wheels of international trade for SMEs and developing countries.

In an industry full of paperwork, complex financial instruments, high levels of risk, and large sums of money, it is unsurprising that legal disputes are common. There is an entire branch of law that has evolved over nearly two millennia that governs disputes in maritime: Admiralty Law. Though much of Admiralty Law was created over centuries through common law, a number of international conventions throughout the 20th Century have enshrined key aspects in statute, including conventions on the law of the sea, maritime pollution, avoiding collisions, the carriage of goods by sea, and mortgages for ships. In England and Wales, maritime disputes are heard in a special Admiralty Court and it is a field of law that requires deep specialist knowledge and experience.

Closely tied into maritime law is insurance. As discussed previously, ships are insured through two mechanisms: hull and machinery, and protection and indemnity (P&I). P&I Clubs are responsible for underwriting risk to cargo carried at sea. Because they are not-for-profit mutual assurance associations, their interests are closely aligned to those of shipowners and cargo owners, and they work extensively to help improve safety and reduce risk at sea. As well as handling and investigating claims, most P&I Clubs have loss-prevention departments that work closely with ship operators to develop and deploy best practices for the carriage of cargo and safety of crew onboard ship. Claims investigations and the ensuing data is used to shape best practice policy, reducing the risk of the claim recurring on another ship.

⁷⁰ 2019 Trade Finance Guide, Trade Finance Global, 2019.

TECH INSIGHT

The concept of shipbroking, and the very existence of intermediaries in general, is threatened by digitalisation. Indeed, this is not a trend unique to the maritime sector. As the distribution of information between different parties improves, the arbitrage that any traditional broker relies on to sustain its business model is effectively removed. Shipping is no exception, and though it lags behind other industries in removing information asymmetries, the role of a shipbroker is being changed by startups entering the space and using technology to connect different stakeholders across the supply chain.

Chartering platform [Opensea.Pro](#) is one such startup. Their platform connects shipowners looking for cargo, with cargo owners looking for ships. Users can upload vessel positions and be matched to cargo that needs moving, negotiate terms through online chat, and sign contracts all within the platform. Afterwards, users can rate each other, building trust and reputation into the platform itself. Similarly, Greek startup [Vesselbot](#) has developed a platform that brings the entire chartering process into one place, from matching ships to cargo to the signing of agreements.

Indeed, innovation in this space is not just the preserve of startups. Recognising that the role of a broker is changing from matchmaker to advisor, leading shipbroker [Clarksons](#) is attempting to disrupt itself by spinning off its own startup. [Maritech](#) is a wholly owned subsidiary of Clarksons but is kept completely separate from its main business. Since its inception in 2016, it has developed and launched [Sea/](#), an end-to-end shipbroking platform that ties market intelligence, document management, and performance monitoring, with the ability to manage a chartering contract from start to finish. The success of broking platforms like these are dependent on adoption: [Sea/](#) combines the mindset and execution ability of a startup with the reach and brand cachet of a leading established brokerage, giving it a distinct advantage over the competition.

CASE STUDY




SHIPAMAX - EXTRACTING INFORMATION FROM UNSTRUCTURED DOCUMENTS

International trade generates millions of documents, certificates, and email exchanges each year. The current process is messy, relying on a lot of manual data entry, but it works. Moving away from email and onto new digital platforms requires embracing risks and process changes that many are uncomfortable with. Recognising that email is here to stay, London startup [Shipamax](#) has developed a machine learning-based method to extract and process important information from unstructured documents like emails, bills of lading, and invoices.

Shipamax has leveraged the technology to create products for shipbrokers, chartering teams, and freight forwarders. The cloud-based service syncs with a user's email provider and intelligently extracts data to automatically create position lists, enter data into ERP systems, or provide market insight.

Currently, the Y Combinator graduates are processing 15 million emails a year for clients in 10 countries and claim to be able to reduce administration costs by up to 85%. They claim to be able to free up two hours per day of manual data entry time for shipbrokers and charterers.⁷¹

71 Shipamax for Shipbrokers, Shipamax, 2019.

AS WELL AS BILLS OF LADING,
BLOCKCHAIN IS BEING
DEPLOYED TO CREATE A
SINGLE SOURCE OF TRUTH
FOR TRACK AND TRACE OF
CARGO IN THE SUPPLY CHAIN



Traditional freight forwarding is facing a similar shift after the recent rise of [Flexport](#). Arguably the maritime industry's first tech 'unicorn', [Flexport](#) raised an enormous \$1b round in early 2019. The investment, led by [Softbank's](#) Vision Fund, valued the business at \$3.2b and set a new precedent for investments in the sector. The volume of freight moved by Flexport does not currently come close to justifying its valuation, but its vision to be the operating system for global trade was clearly enough to explain the size of Softbank's investment. [Flexport](#) uses a combination of their own cloud based platform, analytics, infrastructure, and logistics expertise to create what they describe as a 'modern, dramatically better, freight forwarding experience'.⁷² Despite their current small size, their focus on user experience and customer centricity has put them on a remarkable growth trajectory. What started as a pure software company, has since evolved into a full service freight forwarder, offering some credence to the idea that the complexities of freight forwarding cannot be solved by software alone.

72 About Flexport, Flexport, 2019.

CASE STUDY



Kontainers

KONTAINERS - MODERNISING TRADITIONAL FREIGHT FORWARDING PROCESSES

While Flexport is trying to use technology to disrupt the freight forwarding industry, [Kontainers](#) is using technology to help the existing players to keep pace. Software is not only changing internal trade processes but is fundamentally transforming how companies interact with their customers. Recognising this, their enterprise software allows traditional freight forwarders to create their own cloud-based forwarding platform far more quickly and cheaply than building an in-house solution.

[Kontainers](#), whose clients include Maersk Line and Toll Group, aim to democratise the digitalisation of logistics by making it possible for even the smallest forwarders to offer instant quotations, booking, customs, trucking, and bills of lading through a digital platform. The platform is hosted in the cloud, offering reliability and a fast implementation while requiring no maintenance.

By improving the user experience, [Kontainers](#) have been able to increase their clients' quote to book ratio by 20% while at the same time reducing sales costs by up to 33% through automated rate quoting.⁷³

73 Kontainers Pricing, Kontainers 2019.

Electronic bills of lading have been around for some time, with the first ones issued in the late 1990s after being pioneered by [Bolero](#) a joint venture between P&I provider [TT Club](#) and payments processor [SWIFT](#). Despite their obvious advantages, they still have not achieved widespread adoption. That said, the promise of blockchain has prompted a new wave of innovation in the space. A blockchain is just a record of events recorded on a distributed digital ledger. Those events could be just about anything: financial transactions, vessel movements, or cargo movements. The fact that they are recorded on a distributed ledger makes blockchain important: because the ledger is maintained and hosted in multiple instances by multiple machines, it is very difficult to edit an entry once it has been submitted. This is what makes it possible for blockchain to support cryptocurrencies like Bitcoin: once a transaction has taken place it is recorded in a way that makes it almost impossible to edit, minimising the risk of fraud. Blockchain technology can be implemented to create records of ownership and statements of fact that are far more secure than traditional methods, making it an ideal technology for replacing paper bills of lading. One startup making that leap is Slovenian startup [CargoX](#), whose smart bill of lading uses blockchain to securely transfer the ownership of cargo from a shipper to a consignee instantly, saving days of waiting time and 90% of the costs.⁷⁴ In a 2019 trial of their system, bulk carrier [G2 Ocean](#) and emerging markets specialist [Manuchar](#) were able to transfer ownership of cargo within a few minutes instead of the usual days to weeks it can take to send the same information by courier.⁷⁵

As well as bills of lading, blockchain is being deployed to create a 'single source of truth' for tracking cargo across the supply chain. [Tradelens](#), the collaboration between [Maersk](#) and [IBM](#), has created what it describes as a single, secure source of shipping data across the supply chain. The platform records and publishes over 120 unique events directly from the source, making the data available to all of the parties in the supply chain that need it. The platform, which processes over 10 million events per week,⁷⁶ uses blockchain-enabled sharing to allow cargo owners to share information with third parties like customs authorities seamlessly and automatically. With five of the top ocean carriers, who between

them control 52% of the market, now signed onto the platform, it seems that digitally connected trade platforms are here to stay.

Financial transactions are often held up by trade documents being delayed. Being able to instantly transact trade documents through blockchain also makes it possible to exponentially increase the speed of financial transactions in the global trade ecosystem. Further, it may well be possible for those financial transactions to be run through blockchain enabled platforms too. There have been a number of attempts to create blockchain tokens for transacting shipping services, though none have achieved high levels of adoption. In the short term, the digitalisation of trade finance documentation reduces a huge amount of the friction ordinarily involved in the process. London-based [Tradetiq](#) has capitalised on this shift by creating tools to connect banks offering trade finance to institutional investors who want to provide capital. Their platform uses machine learning to predict risk and determine credit scores and allows banks and investors seamlessly share data, negotiate terms and transact. This approach not only increases the amount of working capital available for traders to access, but is also turning trade finance into an easily asset class in its own right, offering reliable returns and a low default rate. 'Big-tech' is also getting in on trade finance, with both [Amazon](#) and [Alibaba](#) starting financial services divisions in the last few years to help entrepreneurs selling through their platforms to access credit. Both companies have access to the full trading history of the sellers on their respective platforms, putting them in a much better position to make an informed decision on credit risk than any bank.

As well as being useful in predicting credit risk, this data is useful when it comes to predicting other types of risk. Using data to accurately predict the risks to cargo moved on the oceans is highly desirable in marine insurance. Israeli scale-up [Windward](#) is pursuing precisely that goal. Founded in 2010, the company was one of the first to attempt to model maritime risk. Their proprietary 'Vessel Operational Profile' uses a combination of behavioural data and vessel characteristics to benchmark every vessel in the world against hundreds of risk factors, giving insurers a far deeper understanding of risk than they would otherwise be able to attain. The solution scales to entire fleets, making it possible for insurers to better understand and refine their own risk portfolio and has since been applied by governments and other commercial interests for intelligence and compliance monitoring purposes.

⁷⁴ CargoX Smart B/L Solution, CargoX, 2019.

⁷⁵ G2 and Manuchar Hail CargoX's Blockchain B/L, Port Technology, 2019.

⁷⁶ TradeLens, Digitizing the global supply chain and transforming trade, Tradelens, 2019.

CASE STUDY



GEOLLECT - MAKING SENSE OF GEOSPATIAL DATA

There is now a wealth of data available in the maritime industry, from ships, satellite imagery, and even national governments, much of it is tied geographical positions. Displaying that data in a way that is actionable and relevant can be challenging. UK startup Geollect brings disparate location data together to help clients understand the connection between assets and activities and generate insights for improved decision making.

By layering together satellite imagery, infrastructure data, news, social media, and other geo-referenced data such as incident reports, it is possible to build up a real-time picture of what is happening on the ground in a particular area. This makes it easier to evaluate risk, or gather intelligence before making decisions.

Geollect works in sectors including defence, international development and insurance as well as maritime. In collaboration the UK P&I Club, they have developed an online geospatial map that is capable of detailing port infrastructure including assessment of state of equipment repair, flows of bulk cargos, and incident reports from governments or users on the ground through a mobile app. In addition, they are currently working with Inmarsat through Rainmaking's Trade and Transport Impact programme to explore potential uses of Inmarsat's data in the marine insurance market.

Despite the vast amounts of data collected by the likes of Windward, they still have no visibility inside an individual container or pallet of goods. However, with IoT devices about the size of a thumb drive, US IoT startup Parsyl does. Their sensors can be packed in to individual packages, pallets or containers and measure light, temperature, humidity, impact, and position. Upon arrival at the package's destination, the device can be scanned to upload all of its data to the cloud giving users a full profile of the conditions en route. If cargo has spoiled during its journey, it will be possible to know for sure. More importantly though, Parsyl will be able to show exactly when it happened and where in the world the package was. From there, an insurer can determine who is responsible for damage and process a claim accordingly.

In June 2018, as part of a collaboration between EY, Maersk, and Guardtime, the world's first blockchain-enabled marine insurance platform was launched: Insurwave. The spinoff, now a startup in its own right, takes data directly from shipping companies, before verifying it, recording it as an automated ledger transaction, and then feeding it to insurers. This pipeline of trusted, immutable data has the potential to allow marine insurers to pay claims out in hours rather than years and agree premiums in seconds. Maersk has already signed up their fleet of 350 owned vessels to the platform to help them to reduce the amount of resources they have to put in to handling insurance and automate the manual processes they currently employ.

Transacting insurance through blockchain is just the beginning. Blockchain has the power to transform everything from shipbroking and freight forwarding, to Admiralty Law. The entire trade lifecycle could be conducted through smart contracts that automatically pay out when certain conditions are met. Fed by a network of IoT devices, cargo will be monitored on its journey around the world. Whether it arrives on time, late, or not at all, the contract will execute automatically, paying each party in the value chain what they are owed. Contracts and their execution will no longer be based on English language and good faith, but rules built into code and data.

HOW CONNECTIVITY IS ENABLING SUSTAINABILITY

Maersk has set the standard when it comes to reducing the shipping industry's carbon footprint by committing to a net zero carbon footprint by 2050. Due to the lifespan of a modern ship, they will need to be building carbon neutral ships by 2030 to achieve this ambitious goal.

They have already made great strides however: since 2008, [Maersk](#) has achieved a 41% relative reduction in CO2 emissions from its activities and have successfully decoupled CO2 emission growth from trade volume growth. They aim to increase this reduction to 60% by 2030 which, despite the progress, represents a number of significant challenges.

Although there is no doubt that the fuels used by the industry will need to change in order to eliminate carbon emissions, there is also a significant amount of work that needs to be done to improve both the operational and design efficiency of the world's shipping fleet. As well as a number of others mentioned throughout this report, one startup trying to help improve the operational efficiency of ships at sea is [Vento Maritime](#). Established in 2017, their on demand strategic weather routing service helps ship masters to plan long ocean voyages. Their service combines accurate long-term weather information with advice from meteorologists provided directly to the ship's captain on how best to route the ship to arrive safely, with the lowest possible fuel consumption.

Beyond this, Dutch startup [We4Sea](#) uses a combination of meteorological, sea state, and vessel particular data to calculate the fuel efficiency of any ship wherever it is in the world with no need for measuring equipment onboard. Combined with a direct link to the

vessel, the data can give ship captains insight into how to reduce their fuel consumption in real time. The technology is also being used to virtually test new fuel saving equipment or ship designs before it is installed to a ship and to calculate the impact of biofouling.

Biofouling is a major problem for the industry. As ships sail through the water, organisms attach themselves to the hull, creating drag and increasing fuel consumption. Traditionally, ships go into drydock after a fixed period of time, usually around five years, for hull cleaning and essential maintenance. Using [We4Sea's](#) technology it is possible to measure biofouling levels and drydock ships at the optimum time, reducing fuel consumption and unnecessary drydock time, saving on costs. Another Italian-Dutch startup wants to eliminate the need for ships to go into drydock for biofouling altogether. [WhaleWashing](#) has designed a fully autonomous semi-submersible, power-driven hull that is able to sink below the water line to inspect and clean the hull of a large vessel. Currently in the design phase, they will begin cleaning operations at the end of 2020. Able to clean a ship in just two to four hours,⁷⁷ this system eliminates the need for dry docking and manual hull cleaning. Also looking to hardware to reduce fuel consumption is Norwegian startup [Wavefoil](#), who have developed a modular hydrofoil that can be installed to any ship's bow.

77 WhaleWashing News, WhaleWashing, 2019.

In periods of rough weather, officers onboard can deploy a retractable hydrofoil which reduces the vessel's pitching movement and reduces average fuel consumption by as much as 20%.⁷⁸

In 1926, German aviation engineer Anton Flettner set sail across the Atlantic. Instead of using traditional sails, his ship was powered by large rotating cylinders on deck. The cylinders made use of the 'Magnus effect' which applies a force to rotating balls and cylinders perpendicular to the spin. It is the same reason backspin on tennis ball will lift the ball, making it harder to hit. The rotors, now commonly known as 'Flettner rotors', were more efficient than sails, able to function closer into the wind and producing more thrust, they also required less crew to operate. They were, however, never commercially deployed at sea because they could not compete with price and reliability of fossil fuels.



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source of propulsion can be highly unreliable, but thankfully this new breed of wind power can rely on other emerging technologies to make it viable. By making use of cloud processing power, weather datasets, and artificial intelligence, it will become possible to predict power requirements, choose the most efficient route, and autonomously run wind propulsion systems in the most effective way possible. Used in combination with renewable fuel sources it may be possible for ships to cross the oceans quickly and reliably with minimal or zero emissions.

While there is no doubt that for the industry to become completely carbon-neutral it will need to shift fundamentally away from fossil fuels and onto other renewable energy sources. In the meantime, it is the implementation of digitally connected technology and improvements in vessel design that is changing the operational efficiency of the world's fleet. These innovations are reducing the current carbon footprint of the industry, and by reducing the total energy consumption of ships, they are also making future alternative fuels like electricity and hydrogen viable.

As the industry moves away from fossil fuels, Flettner rotors are making a comeback. US-based startup Magnuss has developed a Flettner rotor system that can be retracted back into a ship's hull when the ship is in port. Another entrant into the space is Finnish company Norsepower. Their rotors have now been fitted to three vessels and have been operated for 45,000 hours. On one of their installations they have been able to reduce fuel consumption for the tanker Maersk Pelican by 7-10%.⁷⁹ Beyond environmental impact, ship operators are still principally concerned with reliability. Wind as a

⁷⁸ Exploiting the potential of wave energy, Wavefoil 2019.

⁷⁹ Flettner Rotor Exceeds Expectations, Maritime Executive, 2018.

THE CONNECTED SHIP OPPORTUNITY

This report has showcased a number of key technology developments across the maritime supply chain. As these initial use cases demonstrate, the global ShipTech market has made significant strides over the past few years, with startups slowly becoming a more mainstream part of the sector.

Below, we outline how the ShipTech market is set to grow substantially over the next decade, as the industry gradually begins to adopt digital technologies that are already well-established in other sectors. As we have argued throughout this report, widespread adoption of maritime technologies will rely on proper connectivity and information access across the entire supply chain. And for the ShipTech market to reach its full potential, it will be crucial for startups and established corporates to build the right kinds of partnerships. The early success stories featured in this report give reasons to be hopeful on both counts.

THE GLOBAL SHIPTECH MARKET IS WORTH OVER \$100B

There is strong growth ahead for digital in the worldwide maritime sector. We conducted a first-of-its-kind assessment of the size and growth potential of the global ShipTech market. Having analysed existing industry spend on technology products and services, we project that in a total global market worth over \$1.1 trillion (£900b), spend on ShipTech was estimated to be \$106b (£87b) in 2018.



THE GLOBAL SHIPTECH MARKET WILL BE WORTH AN ESTIMATED \$278B ANNUALLY BY 2030

THIS WILL GROW TO ALMOST \$280B BY 2030

Projecting ahead, we predict the global ShipTech market to be worth an estimated \$278b (£228) annually by 2030. This represents a compound annual growth rate of 8.4%, which is slower than many other high growth technology sectors, largely due to the complexities of delivering digital services at sea.

STARTUPS SET TO INCREASE MARKET SHARE

More interesting than the gross spend on digital technology is the shift in procurement away from large corporate technology providers to startups and SMEs. In 2018, just \$4.2b (£3.4b) of digital spending went to startups and small innovators, with the rest going to large corporations that also sell operational technology and hardware.

As the barriers to the consumption of digital services come down, thanks in part to improved connectivity at sea, total spending on digital services provided by startups and SMEs is predicted to be a little over \$111b by 2030, representing a compound annual growth rate of 120%.

MORE INTERESTING THAN THE GROSS SPEND ON DIGITAL TECHNOLOGY IS THE SHIFT IN PROCUREMENT AWAY FROM LARGE CORPORATE TECHNOLOGY PROVIDERS TO STARTUPS AND SMES

ShipTech Market Size - Corporate and Startup Market Share (\$b). 2018-2030



CONCLUSIONS: LOOKING TO THE FUTURE

There are few industries where the paradigm shift towards digitalisation is being more keenly felt than the trillion dollar maritime sector.



Through this report we have examined many facets of the industry that are in the early stages of transformation and development. From data platforms that are improving vessel traffic flows, to blockchain-based insurance and trade documents, we are still only just scratching the surface of what digitalisation will enable in the next decade. This early-stage market is already worth more than \$100b today but will nearly triple in size, to \$278b by 2030.

Where catalysts like [PortXL](#) have so far proliferated technology trials and pilots around the world, the next stage of growth will come when those pilots, once proved successful, lead to full-scale technology implementations across entire fleets, ports, and service teams ashore. We are now witnessing the beginning of this trend, with leading ships agency provider [Wallem](#) rolling out the collaborative inbox provided by Canadian startup [SEDNA](#),⁸⁰ and freight forwarding platform provider [Kontainers](#) signing multiple seven figure multi-year contracts in the last 18 months.^{81 82}

Looking at macro-level trends, there are a number of potential disruptors on the horizon, even for an industry as economically ingrained as maritime. We still do not yet know the full impact that artificial intelligence will have on the sector, or, indeed in almost every other adjacent sector. While AI is unlikely to affect the physical operation of ships in the short term, it could well have a great impact on the systems and processes that enable the industry. Certainly, all of the administration-heavy aspects of maritime trade, such as freight forwarding, customs, and insurance are at risk of disruption.

THIS EARLY-STAGE
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⁸⁰ Wallem turns to collaborative inboxes to deliver swifter ship agency services, SEDNA, 2019.

⁸¹ Maersk taps Kontainers for e-booking, Johnson, JOC, 2018.

⁸² Toll signs \$1.15 million contract with Kontainers, Shumake, Freightwaves, 2019.



More likely to impact the physical operation of ships is additive manufacturing. More commonly known as 3D printing, the technique makes it possible to decentralise manufacturing away from the current hubs like China. With raw materials delivered to additive manufacturing plants that are operated close to the consumer, the length of the supply chain can be significantly reduced. This is still a nascent industry (the technique is rarely used in full scale manufacturing), but the future potential of the technology to reduce the need for goods to be shipped around the world should not be underestimated.

Of course, the most fundamental shift maritime will see in the next few decades is how it manages energy in a world without fossil fuels. This is a problem that requires solutions going beyond digitalisation, with entirely new methods of capturing, storing, and using energy that need to be developed. As discussed throughout this report, the shipping industry already requires close collaboration between startups and incumbents to implement digital innovation. As we move into the development, testing, and rollout of future fuels that collaboration will need to be even stronger. New models for innovation will need to be developed that not only incentivise shipowners and operators to invest in new technology, but to also make renewing wider maritime infrastructure viable.

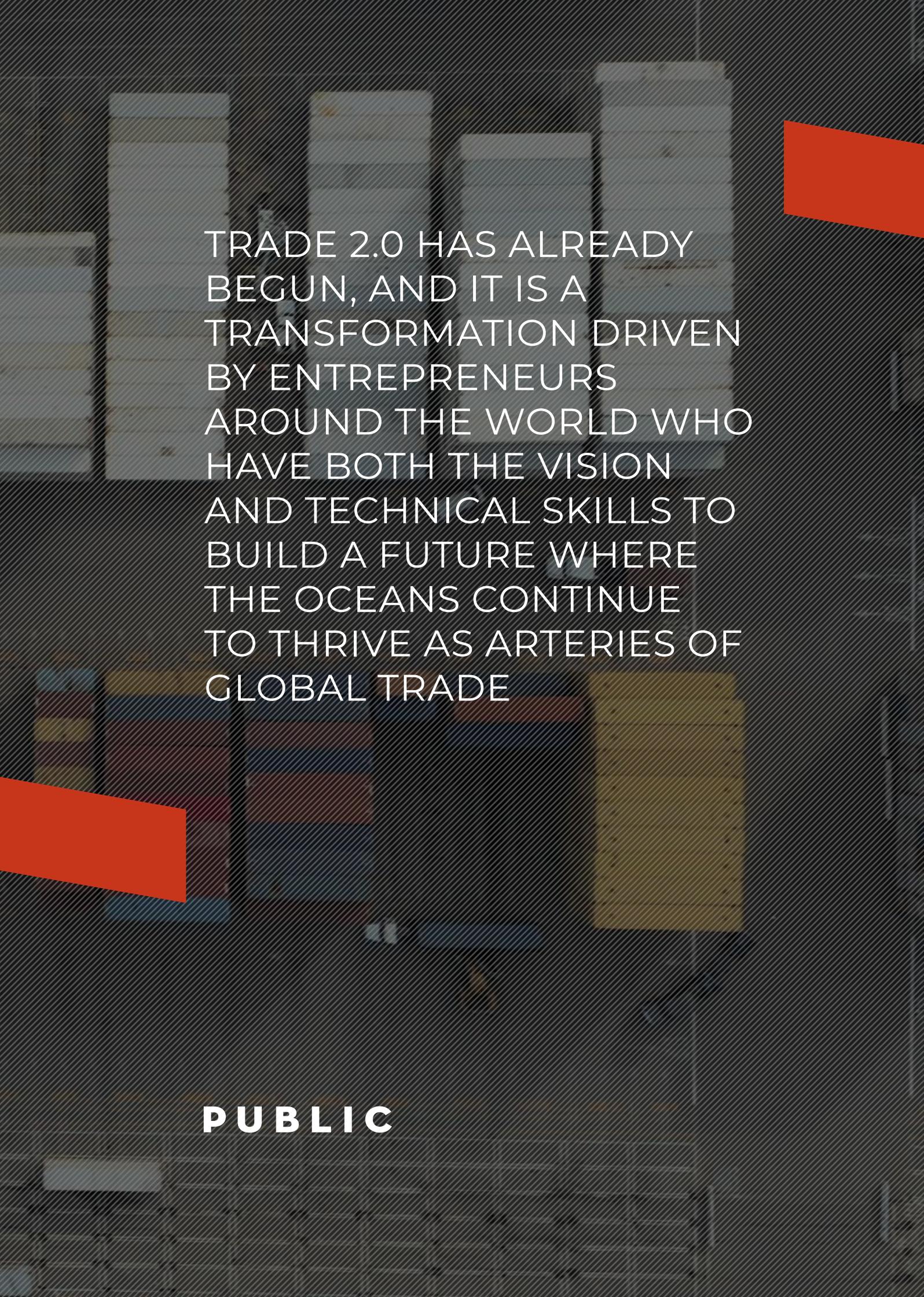
THE SHIPPING INDUSTRY HAS A PIONEERING HERITAGE AND SPIRIT, AND AS DIGITALISATION TRANSFORMS EVERYTHING FROM HOW WE WORK TO WHAT WE CONSUME, A NEW ERA IN GLOBAL TRADE IS EMERGING

The road ahead is not a clear one, with many countries around the world becoming more inwardly focused. As the engine of the world's economy, the maritime industry remains a beacon for global collaboration and cooperation. Though deemed conservative by many, the shipping industry has a pioneering heritage and spirit, and as digitalisation transforms everything from how we work to what we consume, a new era in global trade is emerging.

Trade 2.0 has already begun, and it is a transformation driven by entrepreneurs around the world who have both the vision and technical skills to build a future where the oceans continue to thrive as arteries of global trade.

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METHODOLOGY

This analysis in this report is constructed through a combination of primary research, (including telephone interviews, face to-face meetings and discussion groups), and secondary research, which includes data collected from Startup Wharf's continuous state-of-the-market research programme, as well as proprietary analysis conducted by PUBLIC and Thetius.

For the purposes of this report, information was gathered directly from more than 100 startups in the sector, with over fifty interviews conducted with startup founders. In addition, Startup Wharf has been tracking maritime startups and publishing a quarterly map of the state of Maritime Startup Ecosystem (MSE) since 2017. The list currently includes 240 active startups and scaleups, with an estimated 70% coverage of the global ecosystem. Lastly, the research made use of data from Thetius Insight, a database of innovation activity in the maritime sector. Data is gathered through desk research combining multiple published sources of information to profile startups, scaleups, and large innovators in the ocean supply chain.

While this report is certainly the most comprehensive and accurate of its type to-date, it is still by no means complete. The maritime sector is particularly fractured, and suffers from a lack of visibility at every level. Even with the resources put into this research project, the scope and granularity of our analysis was limited by lack of public market information.

Methodology For Sizing The Global Shiptech Market

For the purposes of this report, the maritime sector includes all spending related to the movement of passengers and goods by sea. The market sizing includes freight rates and all spending on ancillary services, and assumes a total market spend multiple of 2.88. For every \$1 spend in freight rates worldwide, \$2.88 are spent on ancillary goods and services.⁸³ In 2016, global freight rates were \$380b,⁸⁴ a figure which can be projected out to \$393.8b by 2018 using World Trade Organisation data on world merchandise trade.⁸⁵ This gives a total market value of \$1,134.3b in 2018.

Technology spend estimations as a proportion of turnover are based on primary research conducted in 2018 which, after telephone interviews with a number of industry leaders, was able to establish a baseline spend of 9.3% of industry turnover. This figure was cross-referenced against recent estimates on the size of the digital economy as a whole.⁸⁶

Projected ahead to 2030, we can use the (conservative) World Trade Organisations figures predicting a compound annual growth rate of 1.8% per annum.⁸⁷ This is highly conservative when compared with the United Nations Conference on Trade and Development's Review of Maritime Transport, which projects compound annual growth in seaborne trade to be 3.8% until 2023.⁸⁸ Using the conservative growth rates, we can estimate the maritime industry to be worth \$1,405.1b in 2030.

⁸³ Analysis drawn from The economic contribution of the UK Maritime sector, CEBR, 2017.

⁸⁴ Shipping Indispensable to the World, IMO, 2016.

⁸⁵ Statistics on merchandise trade, WTO, accessed 2019.

⁸⁶ Frictionless Trade, Chubb, Zangrando, PUBLIC, 2018.

⁸⁷ Statistics on merchandise trade, WTO, accessed 2019.

⁸⁸ 2018, UNCTAD, 2019.

For technology spend, we can project ahead to 2030 using research from Boston Consulting Group that estimates technology spend as a proportion of productivity to achieve CAGR by 6% per year.⁸⁹ This is again conservative, with many digital sub sectors like AI and cloud computing predicted to achieve much higher growth rates, 36%⁹⁰ and 29%⁹¹ CAGR to 2025 respectively. This puts technology spend at 19.84% of industry turnover in 2030. It is important to realise that due to the nature of moving physical goods, there will be a ceiling to spend on digital technology that is not a restriction in other industries. The predicted technology spend can be applied to the predicted industry turnover, giving an estimated market size of \$278.2b.

Due to the fractured nature of the industry, it is difficult to analyse the market split between large incumbents and startups and SMEs. To make a projection of the market shift, similar industries which are further ahead in their transformation were assessed, including FinTech (financial services technology) and GovTech (government technology).^{92 93}

Next, for companies to qualify as startups, we use the same criteria for company size as PUBLIC's other flagship reports. That is the European definition of SME (i.e. less than 250 employees, annual turnover not exceeding €50m, annual balance sheet not exceeding €43m). It is worth noting that almost none of the companies included in our index came close to these thresholds: and that almost all of them are venture or incubator-backed small companies that have been founded in the past 5-10 years. Using this data we were able to predict that the startup market will grow from 4% of the total technology market in 2018 to 40% of the total technology market in 2030. This is again a conservative estimate, with startups in some other technology sectors all but completely wiping out traditional incumbents,⁹⁴ but it is an estimate the we believe accurately reflects the integrated nature of the ShipTech industry, where startups and large corporates need to work together to innovate rather than attempt to disrupt one and other.

89 eGDP Summary of Forecasts, Boston Consulting Group, 2015.

90 Artificial Intelligence Market Growing at a CAGR of 36.6% and Expected to Reach \$190.61 Billion by 2025, MarketsandMarkets, Yahoo Finance, 2019.

91 At 29.2% CAGR, Cloud Computing Market Size will reach 285300 million USD by 2025, Marketwatch, 2019.

92 A hard sell - why does less than 3% of government procurement spend go to startups?, Nesta / Symons, 2015.

93 UK financial services firms fear up to 40% of revenue at risk from FinTech, PWC / Raven, 2017.

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ACKNOWLEDGEMENTS

The authors would like to thank the many people from the shipping industry who gave up their time and expertise to help shape this report. This report is the result of the collective ideas, experience, and input from countless people at all levels of our industry. That said, particular mention must go to the founders of the startups we interviewed: startup founders are often the busiest people in the world, yet so many of them took part in interviews and discussions that we cannot name them all here.

To all of the team at Inmarsat for continuing to support innovation across the industry, particularly Mark Warner, for believing in and supporting this project from the beginning. To all of the team members at PUBLIC who played an invaluable role in developing this report from concept to what we have today: special mention goes to Johnny Hugill who took the author's thoughts and edited them into a coherent and impactful narrative, and Davide Veronese for his early guidance on assessing and quantifying the size of the ShipTech market.

We are proud and grateful to Inmarsat for their support in sponsoring this report, and for showing a consistent commitment to championing startup-driven innovation in the maritime sector.



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Startup Wharf is the Independent, Global, Virtual Hub of Startup-driven Maritime Innovation. It is independent insofar as it treats startups, accelerators, industry and investors equally and fairly. It is global as it supports startups and ecosystems from all over the world, to create a truly global ecosystem of startups and maritime innovation. It is virtual to allow it to be truly global, without being linked to any specific geographic region. Startup Wharf supports startups and entrepreneurs to create innovation through their personal effort; industry to innovate and benefit from the startups effort; corporates as beneficiaries of the innovation coming from startups. Startup Wharf has been publishing the quarterly Maritime Startup Ecosystem infographic since 2017.

Thetius



Thetius is an innovation consultancy that brings together people, insight, and technology to solve challenging problems for clients in shipping. Digitalisation is rapidly changing the maritime industry. Knowing what to do to stay ahead and having the capability to do it is a major challenge. Founded in 2019, Thetius helps established business involved in the ocean supply chain to better understand and leverage emerging technology through market research, software development, and talent management services.

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