Digital Ships Project

Supporting Business Finland to Drive Faster Export Success By Improving Insight On Trends

team FINLAND MARKET OPPORTUNITIES Future Watch

FROST & SULLIVAN

Contents

1.0 Prioritization

Prioritized Countries

Countries across the world have made efforts to modernize their shipping infrastructure. Public private partnerships has been a prevalent model to accelerate marine digitalization.

Country	Inclination Towards R&D Spending	IP *(CY 2016-2018)*	Technology Adoption Status	Technology Readiness Level	Degree of Focus on Emerging Applications	Final Score
Ranking	*Low - 1 Medium - 2 High - 3*	*<1000 - 1 1001-5000 - 2 >5000 - 3*	*Low - 1 Medium - 2 High - 3*	*TRL 1,2,3,4 - 1 TRL 5,6,7,8 - 2 TRL 8,9 - 3*	*Low - 1 Medium - 2 High - 3*	
Weightage	10%	10%	40%	30%	10%	
Japan	3	3	2	2	3	**2.3**
USA	2	3	2	2	3	**2.2**
Germany	2	2	2	2	2	**2**
Norway	3	1	2	2	3	**2.1**
Singapore	3	1	2	2	3	**2.1**
Holland	1	1	2	1	2	**1.5**
Finland	2	1	2	2	2	**1.9**

2.0 Attractiveness Mapping

Technology Attractiveness Mapping

AI, Bid Data and Blockchain are the technologies with the highest traction globally.

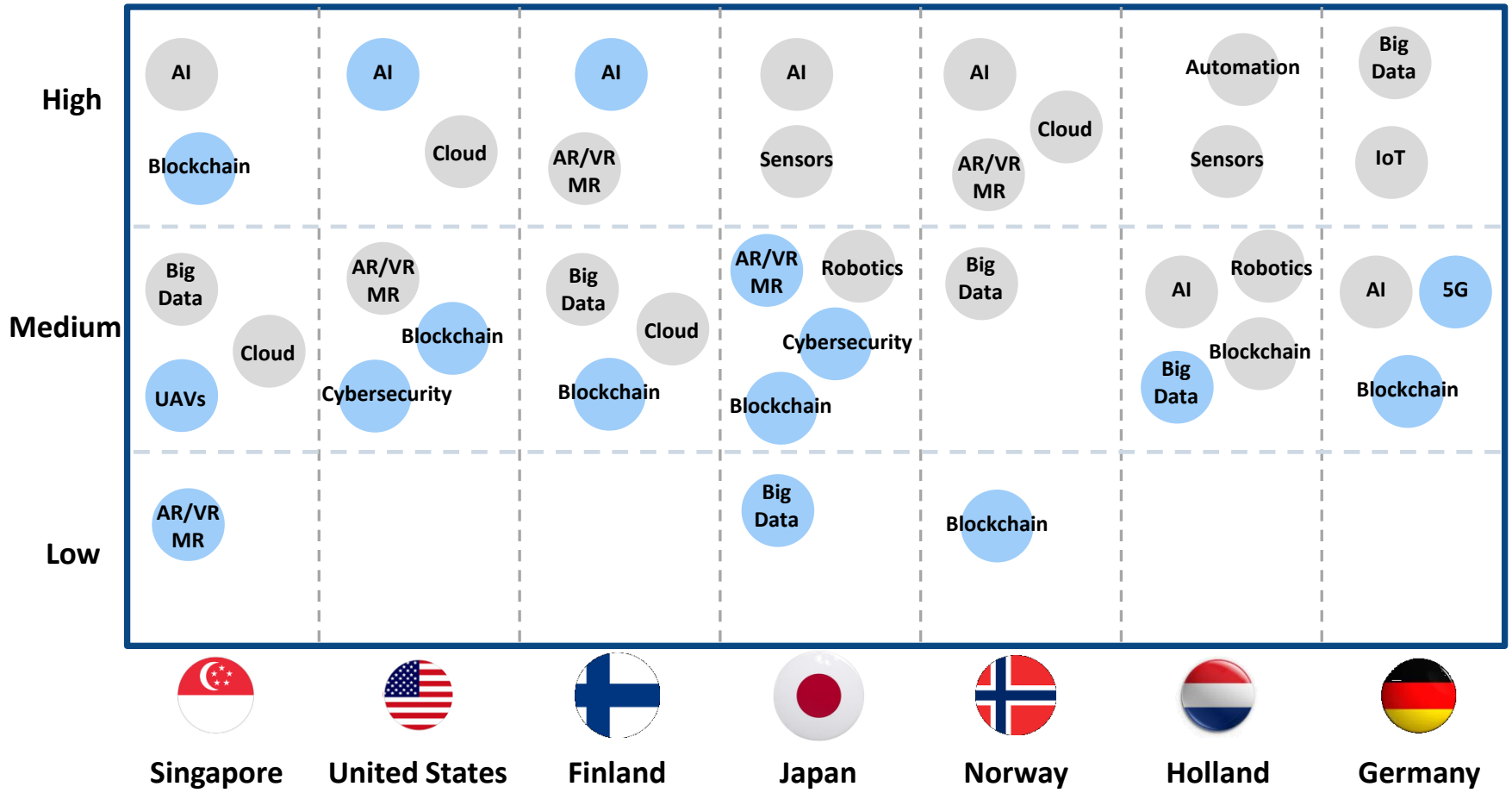
Technology Attractiveness Matrix

	Singapore	United States	Finland	Japan	Norway	Holland	Germany
AI	High	High	High	High	High	Medium	Medium
Big Data	Medium		Medium	Low	Medium	Medium	High
AR/VR/MR	Low	Medium	High	Medium	High		
Blockchain	High	Medium	Medium	Medium	Low	Medium	Medium
UAVs	Medium						
Cloud	Medium	High	Medium		High		
Cybersecurity		Medium		Medium			
Sensors				High		High	
5G							Medium
IoT							High
Robotics				Medium		Medium	
Automation						High	

High *Medium* *Low*

Country Attractiveness Mapping

While AI projects are matured with high attractiveness, blockchain based use cases are still in the emerging stage.



Technology Readiness Level

- Basic Technology Research
- Research to prove Feasibility
- Technology Development
- Technology Demonstration
- System/ Subsystem Development
- System Test, Launch & Operations

3.0 Summary Findings And Conclusion

Key Competency by Countries (1/2)

Maritime Industries across the Countries reviewed are Accelerating the Adoption of Technologies Such as Artificial Intelligence, Big Data and Blockchain to achieve Higher Efficiency and Performance

Singapore

- Singapore is one of the major tech hubs in Asia Pacific and is one of the global leaders in terms of maritime connectivity. Convenient connectivity, a stable and encouraging political regulatory environment coupled with the fact that the country is one of the major tech hubs in the Asia Pacific makes Singapore one of the better positioned countries to be a leader in marine digitization.
- The Maritime Port Authority of Singapore(MPA) has launched multiple initiatives and has fostered partnerships and collaborations among national and international partners in the areas of AI, blockchain and UAVs among others

United States

- Big data explosion and increasing number of connected devices is driving the digitization of the US shipping sector. A Government push for research in technologies like AI and Cognitive security is a critical factor driving the automation of shipping operations.
- Initiatives by the Department of Defense to move into cloud to maintain military's technological advantage, especially in the US naval sector is enabling successful integration of emerging technologies into US shipping.

Japan

- Japan shows high interest in developing novel marine applications by leveraging technologies such as sensors, AI and robotics. From 2025, Japan is planning to commercialize unmanned vessels on a larger scale.
- With large corporations involved in multiple aspects of R&D, there are more opportunities to explore frontier sciences for researchers within these well-funded organizations.
- A significant number of companies conduct R&D in domains non-core to their existing business. Fujitsu, Yamaha and NTT are a few of the traditional manufacturers venturing into the digital ship domain in order to extend their product portfolios.

Key Competency by Countries (2/2)

Autonomous Ships are Gaining Traction and Countries are Making Efforts to Design and Develop Autonomous Vessels as they Improve and bring New Business Opportunities

Norway

- Norway is forefront in the adoption and implementation of new technologies. Norwegian maritime industry stakeholders are using technologies such as AI, blockchain, big data, AR/VR and cloud computing for use cases such as eliminating paperwork, smart contracts, optimize route planning, vessel management and predictive maintenance.
- Norway is leading in the development of autonomous ships by launching several test sites, a forum (Norwegian Forum for Autonomous Ships) and various projects involved in research and development of autonomous vessels. Norway's interest in development of autonomous ships is growing as autonomous ships could provide new business opportunities for shipbuilders, equipment supplier, and ship-owners.

Holland

- Holland has been a stronghold of the marine industry with the presence of The Port of Rotterdam, which is the largest port in Europe and has established a global foothold for testing vessels from all over the world. Strategic alliances have played an important part in developing novel technologies for formulating digital ship concept. Forming an alliance enables all stakeholders within the supply chain of marine market to collaborate under a single platform.
- The increase in the development activities in the system segment indicates companies are increasingly involved in R&D activities, indicating the potential of integrating emerging technologies such as sensors, blockchain, AI and automation into marine products.

Germany

- The Maritime industry in Germany is major contributor to the economy as it drives competitiveness and helps safeguard growth and development. The maritime industry in Germany is undergoing rapid transformation due to digitalization in the areas of development, production and port services to achieve greater efficiency. Technologies such as 5G, big data, AI and blockchain are gaining traction due to their ability to improve both off and onshore operations and performance.
- Digitization is key focus of the "Maritime Agenda 2025" approved by the Federal Cabinet. Government initiatives and funding efforts are providing targeted support for research and development of innovative real time technologies bringing safety and security.

Finland's Competency (1/3)

Finland's dedication towards developing a sustainable shipping ecosystem is motivating companies to develop and test globally competitive green technologies.

> *"In the wake of the recent decision by the IMO to reduce CO2 emissions from shipping by 50% by 2050, we need to implement ways for the industry to decarbonize quickly. Optimizing operations of existing vessels is the fastest way to do this in the short term."*
>
> ***Pekka Pakkanen, Director of Development, NAPA Shipping Solutions***

Sustainable Shipping

- Finland has been one of the leading countries when it comes to framing and implementing environment protection initiatives. These initiatives have been spearheaded by private and public stakeholders and a notable amount of funding and efforts have been diverted towards green shipping initiatives in the country.
    - INTENS, a Finnish research-industry collaborative consortium has committed over €13 million in the next three years towards energy efficiency improvement and emissions reduction of ship energy systems. [1] Meyer Turku, a Finnish shipbuilding company has achieved a reduction 30% of yearly shipping CO2 emissions under this initiative. [2]
    - In August 2018, Finland along with Russia highlighted the need of the move to cleaner ship fuels in the Arctic ocean. [3] International Maritime Organization's (IMO) proposal to ban HFO (Heavy Fuel Oil) was also co-sponsored by Finland. [4]
- Many such examples have highlighted Finland's focus on clean shipping initiatives. Being a leader in sustainable shipping initiatives, Finnish companies are also gaining experience and expertise in developing energy efficient shipping technologies.
- The push from regulatory authorities in the country has also resulted in tangible research and commercial implementations.
    - A Finnish cruise ship, Viking Grace, which entered in service in 2013 is one of the most energy efficient ships in the Baltic region and is fueled entirely by Liquefied Natural Gas (LNG). [5]
    - In 2017, FinFerries unveiled a battery powered ferry, operating between Parainen and Nauvo. [6]

Finland's Competency (2/3)

Finland is the leader in the design and building of icebreakers. While Finland can reap benefits out of the icebreakers in the near future, the country also has an opportunity to host increased traffic in the Arctic with melting ice caps

> *"Going into the Arctic requires something extraordinary. It is a balancing act, where risks should be managed in close cooperation between stakeholders."*
>
> ***Henrik O. Madsen, Group Chief Executive, DNV***

Arctic Shipping

- Finland is uniquely positioned, geographically, to design, develop and deploy technologies for ships specialized for icy waters. Winter navigation expertise and skill has evolved in Finnish sailors and shipping companies by experience as Finland is the only country globally where at times, all the ports can be blocked by ice in the water. [7]
    - More than 50% of the icebreakers in the world are built in Finland and the demand for new icebreakers is only increasing, firstly due to the aging of old icebreakers and also due to the increase in cargo volumes flowing through arctic routes coupled with the pressure of keeping arctic shipping routes open throughout the year. [8] Countries such as Canada, United States, China and Germany have planned to expand their fleet of icebreakers in the future. [9]
    - Moreover, due to global warming the ice cap in Arctic ocean is melting and arctic waters are becoming easier to plough. Increased shipping activity in the region would result in opportunity for Finland.
- While in short term Finland can benefit from icebreaker business, it can also look forward to developing infrastructure to handle high volumes of cargo on its ports. It is predicted that by mid-century common open-water ships will be able to cross the arctic during summer without the need of ice-breakers .

Finland's Competency (3/3)

Finland is one of world's foremost countries with regards to autonomous shipping.

> *"Finferries wants to actively take part in ventures where cutting-edge technology is utilised to increase the safety of maritime operations. We believe this cooperation will benefit both our customers and the environment as the focus is on increasing reliability of marine traffic"*
>
> **Mats Rosin, CEO, Finferries**

Edge in Digitization

- Finland has been focusing on design and development of Autonomous ships. Finnish and international companies involved in the projects related to design and development of Autonomous ships and related technologies have made Finland their base of operations for testing and development.
    - Under the project SVAN (Safer Vessel with Autonomous Navigation) Kongsberg and Finferries have tested the world's first autonomous ferry.
    - VTT is also working with Kongsberg on a concept for command and control center for cargo ships.
- Finland's plan of imparting AI education to its citizens has also been met with a positive response and the country is likely to have a skilled workforce to accelerate AI adoption among all sectors of its economy, including shipping.
- Finland and especially the Greater Helsinki area is home to many companies in marine digitization. These companies include Wartsila, ABB, Cargotech and Konecranes.
- Finnish ports have also made an effort to be early adopters of 5G technologies and set up infrastructure for more connected operations of the ports.

Marine Digitization - Strategic Imperatives (1/2)

The Marine Ecosystem is set to experience to technology shift from Automated to Autonomous Vessels

1

Replacing automated devices with autonomous devices is set to transform the field of marine systems. Unlike a conventional automated device, an autonomous device leverages self-learning capabilities through data storage control systems.

2

Autonomous devices carrying out long deep-sea operations for months without human intervention are set to become a key trend.

3

In the future, underwater stationary power stations can be replaced by a mobile elevation station (which can ascend/ descend in water as per requirements) which can transfer power to the robots without cables through electromagnetic induction.

Marine Digitization - Strategic Imperatives (2/2)

Emergence of IoUT will enable Digitization in the maritime industry

4

Unlike traditional docking stations, the function of stations will not be limited to charging batteries; they will carry out reprogramming and complete maintenance of the robots.

5

Additional measures to mitigate buoyancy drift of Unmanned underwater vehicles (UUVs) will be taken in order to allow the vehicles to carry out long deep sea missions. For example, UUVs can be integrated with a variable buoyancy control system.

6

Advancements in Internet-of-Things (IoT) and underwater marine technologies as well as Internet of Underwater Things (IoUT), defined as a network of interconnected smart underwater objects, have enabled a wide range of applications, including environmental monitoring, underwater observations, disaster warning systems, and military applications.

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4.0 Project Objectives and Approach

Project Context, Objectives and Approach

Context

- Business Finland aspires to **strengthen Finland's position** as an exporter of products, solutions and services for a range of sectors and segments.
- Modern ships are noted to be highly automated and are increasingly dependant on software-based control systems. A significant shift is expected in the way in which the maritime industry manages information.
- In this regard, Business Finland has sought assistance from Frost & Sullivan in gathering market intelligence on the topic of '**Digital ships**'.
- Digital ships refers to the application of digital technologies to the shipping industry.

Objectives

- To conduct research on the topic of Digital Ships, to gather specific intelligence on
  - Technology development
  - Technology adoption, and
  - Benchmarking of countries

Approach

The objectives were achieved in 3 steps,

- **Step 1 – Tech Scouting**, which involves selecting and shortlisting countries based on preliminary analysis
- **Step 2 – Country Benchmarking**, which involves benchmarking Finland versus other countries based on technology development, adoption status, stakeholder ecosystem, amongst others
- **Step 3 – Prioritization** based on mapping country attractiveness to understand which countries are competent in marine digitization vis-à-vis Finland

5.0 Summary Profile of Shortlisted Countries

Singapore Profile

Singapore is emerging as a hub of maritime technology innovation owing to a strong tech ecosystem and a mature shipping industry

Singapore	
Fleet Value *(in million dollars - (US$)), CY 2017*	39,193
Fleet Size *CY 2017*	2599
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	77
IP *CY 2016 - 2018*	224
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	5

2.7

Country Index Score

Key Takeaways:

- Singapore is one of the most prominent hubs of global maritime trade and maritime contributes around 7% to the country's economy. [29]
- Singapore has hosted multiple pilot projects from leading companies such as IBM, Maersk and Airbus into a range of emerging technologies.
- A mature tech industry and a conducive business environment has helped the country gain an early edge in adoption of technologies.
- Singapore is faced with skill shortages and has taken initiatives to tackle the issue so as to keep the momentum of the industry going.

Norway Profile

Norway has a full Maritime Cluster including Ship Building

Norway	
Fleet Value *(in million dollars - (US$)), CY 2017*	58,445
Fleet Size *CY 2017*	1842
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	99.3
IP *CY 2016 - 2018*	120
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	5

2.7

Country Index Score

Key Takeaways:

- Norway is one of a few countries with a complete maritime cluster consisting of international shipping companies, shipyards, OEM's, and ship designers employing ~90k people.[1]
- Norway has become a popular destination for development and implementation of various advanced technologies with an above average technology readiness level.
- Formation of various consortiums and initiatives by government and other local bodies have accelerated the rate of technology adoption in the Norwegian Maritime industry.

Germany Profile

Maritime Industry in Germany is highly Competitive due to its strong interest in Research and Innovation

Germany	
Fleet Value *(in million dollars - (US$)), CY 2017*	38,142
Fleet Size *CY 2017*	3090
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	147.27
IP *CY 2016 - 2018*	1407
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	6

3.1

Country Index Score

Key Takeaways:

- Maritime industry is one of the key sectors for the German economy with an annual turnover of up to €50 billion and providing employment for 400,000 people directly or indirectly. [1]
- R&D and innovation initiatives by government and maritime companies in Germany has strengthened the industry.
- Germany's Hamburg sea port has implemented many projects using advanced technologies such as 5G, IoT and Big Data.
- Germany's maritime industry is experiencing a transformation due to increased digitalization aiming to achieve Maritime 4.0

USA Profile

US Navy is leading the front for adoption of emerging technologies in countries maritime arena

USA	
Fleet Value *(in million dollars - (US$)), CY 2017*	96182
Fleet Size *CY 2017*	2104
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	NA
IP *CY 2016 - 2018*	746598
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	5

3.4

Country Index Score

- US continues to drive its maritime development and procurement for a variety of applications including security, consumer experience, shipbuilding, operation and maintenance, fleet management, supply chain amongst others.
- US government and shipping companies will continue to invest emerging technologies such as AI, Augmented reality, Cloud to maintain its technological lead in the market for both political and economic purposes.
- Cyber security is expected to be a major developing trend for US. Shipping companies are seeking tailored security solutions and expertise to address advanced threat.

Finland Profile

Finland, leveraging its geographic location has emerged as a leader in designing icebreakers and polar ships.

Finland	
Fleet Value *(in million dollars - (US$)), CY 2017*	N/A
Fleet Size *CY 2017*	145
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	N/A
IP *CY 2016 - 2018*	509
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	3

2.0

Country Index Score

- Finland has started investing the digitalization of its maritime industry and has made efforts to foster stronger relations between public and private players.
- The geographic location of the country has helped the country gain an edge in designing and building icebreakers and polar ships.
- Finland has seen trails of autonomous ships for passenger transport and has established a test area to test further innovations to accelerate the commercialization of the technology.

Holland Profile

Holland has been a pioneer in the global marine sector and with the impact of digital technologies, the country is ready to maintain its position

Holland	
Fleet Value *(in million dollars - (US$)), CY 2017*	19,970
Fleet Size *CY 2017*	1256
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	NA
IP *CY 2016 - 2018*	60
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	3

2.0

Country Index Score

Key Takeaways:

- Holland has been a strong historical maritime country. The Holland shipping and marine sector contributes to the attractiveness of Mainport Rotterdam. Each year, the port attracts more than 400 million tonnes in cargo flow.
- Holland has hosted multiple pilot projects from leading companies such as IBM, Libellium and Samsung into a range of emerging technologies.
- The Dutch government supports extensive R&D focus on developing the marine infrastructures which is driving the growth for Holland's marine sector.

Japan Profile

Japan has been a pioneer in the global marine sector and with the impact of digital technologies, the country is ready to maintain its position

Japan	
Fleet Value *(in million dollars - (US$)), CY 2017*	77,898
Fleet Size *CY 2017*	3901
Spending on Research & Development *(in million dollars - (US$)), CY 2017*	152.79
IP *CY 2016 - 2018*	7930
Technology Adoption Status	Medium
Technology Readiness Level - Marine Digitization	6

3.6

Country Index Score

Key Takeaways:

- From 1960, Japan has been strong in the maritime sector by researching projects on autonomous ships. The Japan shipping and marine sector contributes to the attractiveness of adoption of emerging technologies for developing IoT based marine ecosystem.
- Japan has hosted multiple pilot projects from leading companies such as Fujitsu, Yamaha and Microsoft into a range of emerging technologies.
- The Japanese government supports extensive R&D focus on developing innovative technologies that aids in building autonomous ships.

team FINLAND MARKET OPPORTUNITIES

Future Watch

6.1 Country Benchmarking - Singapore

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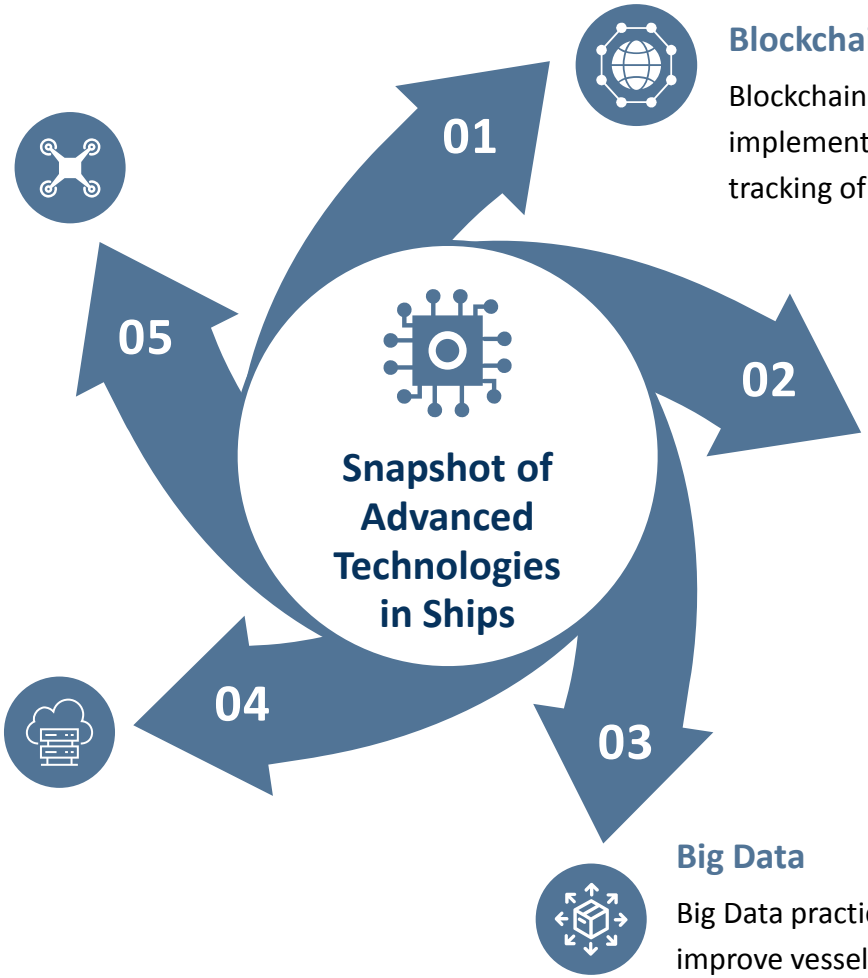
Key Technologies Assessment

Testing emerging technologies in the form of pilot projects has given Singapore based companies an edge over their global competitors



Blockchain

Blockchain has been tested and implemented to enable real-time tracking of documents and cargo.

AI

AI has been used to leverage vast amounts of data in order to enable autonomy and safety functions.

Big Data

Big Data practices are helping fleet owners monitor and improve vessel performance and make sense of swaths of data collected from a web of deployed sensors.

Cloud

Shipping Industry can rely on cloud technologies to address their concerns around standardization and data transmission.

UAV

Novel usages of UAVs are being explored into off-shore and on-shore operations by maritime companies to enable use cases into expanded visibility and maneuverability .

Technology Development Status: Significance (1/3)

Blockchain based applications are still in the testing phase and might not be implemented commercially in the short term while AI is currently being integrated into business applications

Blockchain

- Shipping companies in Singapore are looking at Blockchain to bring improvements in the documentation process and the larger supply chain management infrastructure.
- Multiple pilot projects have been initiated and implemented to test the viability of blockchain based solutions for addressing the existing challenges on the industry.
- Leading tech as well as shipping companies have formed collaborations to accelerate the commercialization of blockchain technologies.
- Apart from private companies, the Government of Singapore has also shown interest in leveraging blockchain to enable cross-border trade.

1 2 3 4 5 6 7 8 9

Technology Development

AI

- AI has been adopted by a wide range of industries and has started making inroads in the shipping industry.
- Multiple government agencies and private companies have either started pilot projects or have integrated the technology into their operations
- AI is being used in conjunction with analytics practices to aid subtle optimizations into the vessel's functioning which can collectively result in time/cost saving and safety enhancements.
- In addition to managing the operations on-board ships, AI has also been touted to revamp port management and operations where AI is helping ports analyze real-time data to predict congestion and identify risk hotspots.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (2/3)

Big Data & Cloud are being implemented in tandem with each other to transform the data management practices in the maritime industry

Big Data

- As the shipping business gets more digitized and competitive, fleet owners are in need for reliable and accurate insights generated from real-time data.
- These insights make it possible for fleet owners to take informed decisions on voyage management, vessel operations and manning, as well as chartering and third-party risk assessment.
- The Singapore government has formed partnerships with private players and universities to accelerate the development and commercialization of Big data and related technologies.
- Upwards of 12% fleet maritime businesses have currently adopted and deployed big data practices. [16]

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

Cloud

- Shipping businesses are inherently global and rely heavily on communication between different parties globally. However, many shipping companies still maintain their data in silos across continents, leaving employees with a limited visibly into information across the company and across geographies.
- Having centralized databases can help shipping companies avoid problems related to outages, latency and can reduce time taken by IT teams on unproductive and repetitive tasks.
- Processes such as ship building and monitoring of ship performance in real-time during voyage are being transformed using cloud based applications where multiple parties across the globe are accessing and working on a single program.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (3/3)

While the technology behind UAVs is already mature, UAV related use cases in maritime industry have to be tested and refined for their commercial deployment

UAVs

- Multiple use cases centered on UAV applications at sea and at ports are emerging globally which compliment the capabilities of a ship, making them more agile and help port officials reduce congestion on port.
- Major companies in avionics and shipping such as Airbus and Maersk have shown interest in adoption of drones as a part of their workflows.
- Singapore is one of the few countries leading the adoption of UAVs for marine use cases and has piloted multiple projects using the technology.

1 2 3 4 5 6 7 8 9

Technology Demonstration

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Blockchain Application Landscape and Case Studies (1/2)

Blockchain will enable companies to eliminate paperwork and reduce processing times

Digitization and Elimination of Paperwork

Shipping transactions involve significant amount of documentation effort from multiple parties which pass through a long chain of network. Leveraging blockchain based Smart Contracts, a large part of the paperwork can be eliminated and contractual obligations can be automated to reduce processing times.

Container Registry and Shipment Tracking

The shipping industry accounts for 60% of the world's trade and is battling with container tracking issues. [28] Up to 20% of all the containers are unaccounted for. [27] A blockchain based registry system could help companies develop trading platform upon a shared container inventory resulting in drastic cost reductions.

Cargo Management

Many Marine accidents have emerged from mishandled cargo and lack of precautions while transporting sensitive goods. Blockchain enabled interfaces can be used to ensure accurate communication of weight and vital freight related data to all parties involved in the shipping process.

Pacific International Lines & IBM

Pacific International Lines (PIL), a Singapore based shipping company has collaborated with IBM to improve documentation and supply chain processes using blockchain. The project has been supported by the Maritime and Port Authority of Singapore.

The partnership aims at using blockchain to create an electronic bill of landing (BL) instead of hard copies and duplicating the paper trail of BL with a blockchain ledger. [1]

BlocBox & Zeaborn

BlocBox and Zeaborn Ship Management have signed an MoU to collaborate on a blockchain based project to ensure the safety of ships at sea. Under the partnership BlocBox will build an immutable distributed ledger to solve the challenges of retrieval of black box data. The company is testing a prototype of the system. Under the proposed terms BlocBox will collect and store VDR data using blockchain for a test ship provided by Zeaborn, who will be responsible for the data analysis. [2]

Blockchain Application Landscape and Case Studies (2/2)

IBM is one of the pioneers of blockchain in maritime and is involved in multiple trials for the same

IBM, PSA International & PIL

A blockchain trial was conducted by PIL & PSA International leveraging IBM's blockchain platform to track and trace cargo movement. The core objectives of the trial were to enable real-time tracking, transparent capacity booking and permission access control.

After a successful trail of the system, PIL is planning to expand the scope and include more participants from the supply chain network. [3]

IBM & Maersk

IBM and Maersk have teamed up to launch a blockchain based electronic ledger named TradeLens. The ledger will record details of cargo shipments and track them in their journey and can allow the involved supply chain parties to view the tracking and documentation information which is updated in real time.

The platform has captured data for more than 160 million shipping events. PSA Singapore is using the system as a part of the pilot deployment. [4]

CrimsonLogic

CrimsonLogic, a Singapore based e-government service provider has launched a blockchain platform focused on cross-border trade. The platform named GeTS Open Trade Blockchain can allow multiple stakeholders in the supply chain to view and transact trade-related documents in a distributed way to improve supply chain efficiency and transparency. [5]

AI Application Landscape and Case Studies (1/2)

Adoption of AI will make it possible for ships to attain a greater level of autonomy and for sailors to have a better understanding of their vessels

Ship Safety

Human errors have been at responsible for multiple marine accidents. Aiding operators in controlling a vessel and ensuring safe operations is one of the areas where AI is being used. AI algorithms are being employed in ships to detect anomalies in actions of human operators and to enable remote diagnostics.

Autonomous Ships

Companies across the globe are working towards enabling partial or total autonomous functioning of ships. In the near future, vessels such as tugboats and small ferries will be automated and gradually the technology will be expanded to larger and more complex vessels.

Simulation and Training

AI also finds applicability in training sailors in the shipping industry. AI can be applied for facilitating realistic training scenarios during simulator training sessions. Complex AI based engines can be designed to replicate the environments found at sea and can mimic variables such as weather and ocean currents.

Fujitsu, SMU & IHPC

Fujitsu, Singapore Management University and Institute of High Performance Computing have collaborated to develop vessel traffic management at the port of Singapore with the support of the Maritime and Port Authority of Singapore (MPA).

The project aims to leverage AI and big data analytics to improve congestion prediction and collision detection techniques. [6]

Singapore Navy and Defence Science and Technology Agency (DSTA)

DSTA uses AI in conducting predictive maintenance on navy ships. The agency also leverages AI algorithms to keep a track of maintenance logs and to suggest when ships need to be serviced and repaired or to predict failures.

The Singapore Navy uses AI in their training facilities to prepare sailors for operating warships. The training center facilitates full range of training from operator component training to mission-based training, helping sailors gain operational readiness. [7]

AI Application Landscape and Case Studies (2/2)

Besides enabling autonomy, AI based solutions will also be able to assist sailors in operating and navigating their ships

CMA CGM & Shone

CMA CGM, the parent company to APL has collaborated with Shone, to embed AI on board its ships. Under the collaboration Shone will extract onboard data and will analyze it to provide crews with decision support on maritime safety and piloting. Shone also makes use of data from multiple sensors to increase detection accuracy and to prevent collisions. [8]

MPA & IBM

MPA and IBM have collaborated on a project named SAFER (Sense-making Analytics For maritime Event Recognition), aimed at automating critical tasks and increasing their efficiency.

The project is to be rolled out in multiple modules and pilot has been completed for modules including automated movement detection, infringement analytics and pilot boarding detection. [9]

Big Data Application Landscape and Case Studies

Infusion of sensors and connected systems will result in the generation of vast amounts of data which can help in optimization of vessel operation

Predictive & Prescriptive Analytics

Data collected from multiple sensors can give unique visibility into a ship's operations. The data generated from a ship can help uncover patterns in its operations which can be used to predict failures and avoid them pre-emptively. Data analytics practices can help in maintaining prediction and prioritization.

Regulatory Compliance

Ships involved in international business are subject to a wide range of regulations and disclosures. Big data practices can help companies in managing historical as well as real-time operational data which can be readily furnished and utilized for accelerating the process of record keeping and disclosures.

Enabling Sensor Technologies

The shipping industry is adopting sensor technologies rapidly and data collected from these sensors is emerging to be the most valuable type of data. Big data tools enable businesses to make sense of the data that is collected from theses sensors, helping decision makers spot signals from mountains of data made available.

Ascenz

Ascenz, a company based in Singapore provides solutions for real-time ship performance and monitoring. The company's Shipulse solution provides insights for better decision making, fuel savings and optimized vessel performance. To enable this, the solution analyzes data related to fuel consumption, bunkering activity, engine, hull and propeller performance.

The company has been acquired by France based GTT. [10]

Maritime and Port Authority of Singapore

The MPA has launched MPA Living Lab, an initiative to help companies adopt technologies to improve business processes. The labs are focused on driving innovations across multiple technologies. A dedicated hub has been set up under the initiative for technology partners to collaborate and co-develop data analytics applications such as just-in-time vessel arrivals or predictive analytics to forecast traffic conditions and potential collision for the next-generation vessel traffic management system. [11]

Cloud Application Landscape and Case Studies

Centralized storage of operational data can help shipping industry in maintaining a globally coordinated workflow and avoid issues related to standardization

Sourcing and Supplier Management

Shipping companies procure multiple items from a range of suppliers globally. To maximize profitability and to remain compliant to regulations, shipping companies can use cloud based collaborative databases of prices and regulations around products such as bunker fuel.

Data Management & Disaster Recovery

Cargo ships transport valuable goods across turbulent waters and are often at the risk of natural disasters. Cloud computing plays an important role in helping companies secure data in a central and secure offshore location. Such data management practices can also help shipping companies in maintaining real time visibility over weather conditions globally.

Process Simplification

Due to the complexities involved in the languages and computing standards across countries, much of the process is carried out manually and on paper. Cloud technologies have been now leveraged to develop solutions designed for maritime and shipping industries that can help companies maintain a central system in spite of complexities.

Hanseaticsoft

Hanseaticsoft, a maritime software provider expanded its Asia presence, opening an office in Singapore. The company is focusing on tapping the market in Singapore and helping shipping companies understand the potential of cloud technology. The company's solutions allows data to be centralized, processed and accessed in real time. More then 40 maritime companies in Singapore are already using Hanseaticsoft's solutions. [12]

MPA & PSA Corporation

The Maritime and Port Authority of Singapore (MPA) has signed an MoU with PSA corporation for promotion of additive manufacturing (AM). Under the MoU an AM rapid production facility will be set up which will make use of specialized maritime digital cloud supported by Blockchain technology for more secure file transfers. [13]

UAVs Application Landscape and Case Studies

UAVs can help in reduction of congestion at ports by enabling ships to exchange goods and passengers without docking

Goods and Passenger Transport

Ships have to follow an extensively elaborate procedure for docking at a port, technically as well as in paper work. Drones can help ships remain at sea and can exchange goods or passengers with ports. This can especially be useful for larger ships which cannot be docked at smaller ports.

Surveillance and Monitoring

Ships employ a range of sensors on-board and also leverage data available from a host of external sources to remain updated about the weather and other factors that might affect the ships voyage. Ships can also leverage UAVs to extend their visibility into the ocean and can deploy them as the eyes and ears.

Search & Rescue

Rescue efforts in turbulent seas are often too difficult to be carried out by ships and boats. In contrast, aerial rescue can be fast and safe. UAVs can be deployed as a part of rescue missions to minimize the danger to human life. Such UAVs can be especially helpful to defence vessels.

Wilhelmsen's Ships Agency and Airbus

Wilhelmsen's Ships Agency and Airbus piloted a project of using UAVs to deliver spare parts, documents, water test kits and 3D printed consumables to vessels at anchorage. The pilot project was carried out with inputs from MPA and Civil Aviation Authority of Singapore. Under the pilot a command and delivery center was set up at the pier and the deliveries were carried out in a range of 3km from the shoreline. [14]

The Maritime and Port Authority of Singapore

The Maritime and Port Authority of Singapore has announced plans to leverage UAVs to carry out ship inspections. Trials for such inspections have been carried out for inspection of ship tanks and holds. These methods have been found to be safer and cheaper as ships do not have to create staging inside the cargo tanks and potential safety concerns arising from employees having to climb tall staging can also be avoided. [15]

Adoption Life Cycle

IBM and MPA have made noticeable strides in accelerating adoption of emerging technologies in Singapore

	Innovators & Early adopters	Early & late majority	Laggards
Blockchain	IBM, PIL, MAERSK	BLOCBOX, ZEABORN SHIP MANAGEMENT, PSA The World's Port of Call	AAL, NOL
Artificial Intelligence	IBM, MPA SINGAPORE	SHONE, CMA CGM	
Big Data	ASCENZ MONITOR · CONTROL · MANAGE	MPA SINGAPORE	
Cloud		MPA SINGAPORE, PSA The World's Port of Call	
UAVs	AIRBUS, MPA SINGAPORE		

Stakeholder Ecosystem and Initiatives (1/2)

AI has been implemented in conjunction with technologies such as cloud and big data to enable advanced applications such as behavioural analysis and facial recognition

Organization	Technology	Application
IBM & Mearsk	Blockchain	Supply Chain Management, Electronic Shipping Ledger, Real-Time Shipment Tracking
Pacific International Lines, IBM & PSA International	Blockchain	Fraud Prevention, Cost Efficiency, Security
Pacific International Lines, IBM	Blockchain	Bill of Landing
Blockbox & Zeaborn	Blockchain	Maritime Safety, Data Protection & Encryption
Fujitsu Limited, Singapore Management University, Institute of High Performance Computing, Maritime and Port Authority of Singapore	Artificial Intelligence & Big Data	Congestion Forecasting, Risk Hotspot Identification
Singapore Navy and Defense Science and Technology Agency (DSTA)	Artificial Intelligence, Facial Recognition & Augmented Reality	Ship operation simulations, Behavioral Analysis

Stakeholder Ecosystem and Initiatives (2/2)

MPA's collaborations with local and international partners has helped Singapore in advancing its technological standing in the maritime industry

Organization	Technology	Application
CMA CGM & Shone	Artificial Intelligence	Maritime Safety, Piloting Assistance, Sensor Data Collection
MPA & IBM	Artificial Intelligence & Data Analytics	Automated Movement Detection, Infringement Analytics, Pilot Boarding Detection
MPA & PSA	Big Data & Additive Manufacturing	Inventory Management, Repair and Maintenance
Wilhelmsen's Ships Agency and Airbus	Drones	Off-shore delivery

Factors Influencing Adoption: Drivers

A combination of geographical, political as well as economical factors are responsible for the success of Singapore's maritime technological advancements

Government Efforts

The Government of Singapore through various regulatory and administrative bodies has invested heavily in the development and adoption of advanced technologies. The Maritime and Port Authority of Singapore in particular has been involved in the multiple projects with local as well as international partners and has facilitated several pilot projects. The country has constantly been ranked as one of the leading Maritime Technology hubs by leading industry publications. [17]

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Convergence of Technology & Shipping Industries

Singapore is at the unique intersection of digital technologies and maritime. Singapore's geographic location and its history has made it one of the busiest and most connected ports in the world. Singapore port is linked with more than 600 ports across 120 countries and handles more than 130,000 ships annually. [18] On the other hand, Singapore's efforts of incubating and promoting technology innovation in the country has also cemented its position as the Silicon Valley of Asia. More than 80 of the leading top 100 tech firms in the world have presence in Singapore. [19] A combination of both of these factors has helped Singapore in becoming the hotbed of Maritime technology innovation.

Short-Term - **High**	Medium-Term - **High**	Long-Term - **High**

Ease & Convenience For Maritime Businesses

In addition to having strong presence of technology and shipping related companies, Maritime businesses also benefit from a strong supporting infrastructure of ship financing, expert legal counseling and accounting expertise. With a strong supporting infrastructure in tow, shipping companies in the country are able to respond effectively to market trends and maintain their technological leadership against global competition. [20]

Short-Term - **Medium**	Medium-Term - **High**	Long-Term - **High**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

Singapore's workforce in the maritime industry lacks the skills to adopt next gen technologies, hampering the industry from realizing the full potential of these technologies

Lack of Skilled Workforce

While government and the private sector in Singapore are making strides in technological development and adoption, they are also being held back by the lack of skilled individuals who can ease the adoption of advanced technologies among companies. Companies in the country are now compelled to spend considerable amount of their budgets on training existing employees and hiring professionals at higher pay grades which is affecting their overall profitability. [21]

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

Maritime Disputes Over Border Claims

Singapore has been involved in a territorial dispute with Malaysia, roots of which go back to 1979. Escalations to such disputes can hamper the company's growth plans and can also dissuade companies from expanding their operations in the country. [22] Apart from the dispute with Malaysia, countries in Asia are also affected by the tensions in South China Sea. Although not a direct claimant to the disputed sea, Singapore does stand to lose from escalating tensions in the area as many of the ships passing through South China Sea dock at Singapore. [23]

Short-Term - **High**	Medium-Term - **High**	Long-Term - **High**

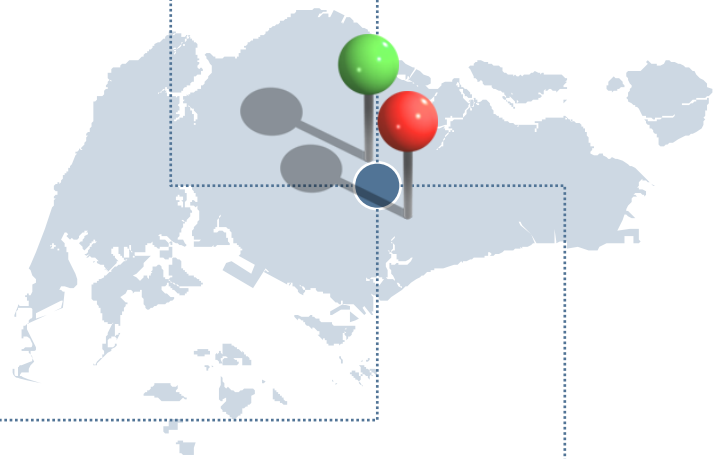
Source: Frost & Sullivan

Country Specific Initiatives and Future Roadmap

Singapore has undertaken multiple initiates to accelerate the digitization of country's maritime industry

Trade Unions in Singapore are helping workers acquire new skills and remain globally competitive . Trade Unions such as the Singapore Port Workers Union (SPWU) and the Port Officers' Union (POU) have invested heavily in employee skill up gradation via training and subsidies.[24]

The Maritime and Port Authority of Singapore is at the forefront of technological transformation in the country. Apart from spearheading technological development MPA has also been helping maritime startups thrive in the country through regulatory as well as financial assistance. [25] [26]



In the IMC 2030 Strategic Review report, MPC highlighted the need for strengthening the infrastructure around maritime related activities such as commodity trading, logistics and e-commerce. The committee framing the report identified autonomous systems, robotics, data analytics and artificial intelligence as key technologies for digital transformation of Singapore's Maritime industry.

Singapore has launched a programme named PIER71 to promote maritime innovation. The programme provides a platform for foreign and local companies start-ups, venture capitalists, and mentors to exchange knowledge and form organic partnerships.

Autonomous Ships – Singapore

Singapore has attracted multiple international partners into its maritime ecosystem and has collaborated with them to develop and test autonomous ships and related applications. The Maritime Port Authority of Singapore has made efforts to incubate technology innovation in the country and has inked partnerships with multiple companies in the industry.

Autonomous Ships Testing in Singapore:

- **Autonomous Vessel Development:** The Maritime Port Authority of Singapore (MPA) has signed an MOU with eppel Offshore & Marine (Keppel O&M) and the Technology Centre for Offshore and Marine, Singapore (TCOMS) to jointly develop autonomous vessels. These autonomous vessels are expected to be used for a wide range of applications including harbor operations such as channeling, berthing, mooring and towing operations. [30] [31]
- **SESAME Straits Project:** The SESAME (Secure, Efficient, and Safe maritime traffic Management in the Straits of Malacca and Singapore) project, a joint project between Singapore and Norway has conducted a test in the Straits of Singapore for e-navigation and ship to shore communications with an objective of increasing safety and efficiency of maritime operations. [32]
- **Wärtsilä Acceleration Center:** Wärtsilä has launched an acceleration center in Singapore to promote innovation and collaboration in Singapore's Maritime ecosystem. The center has co-created a project named Wärtsilä IntelliTug. The project has created a harbor tug with autonomous navigation in collaboration with MPA and PSA.

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team FINLAND MARKET OPPORTUNITIES

Future Watch

6.2 Country Benchmarking - Norway

FROST & SULLIVAN

Norway: Assessment of Key Technologies

Adoption of New Technologies is giving Rise to Radical Innovations and New Applications in the Maritime Industry

Snapshot of Advanced Technologies in Ships

BLOCKCHAIN

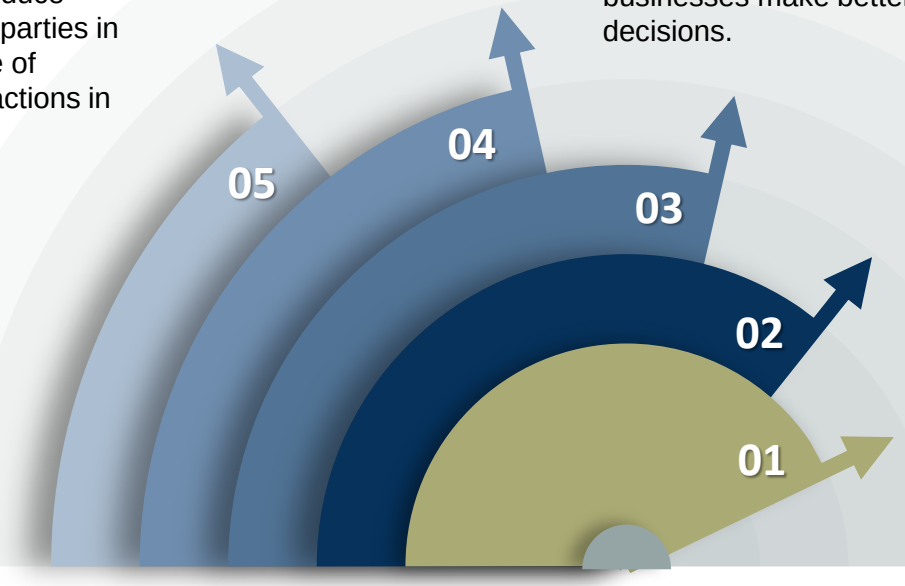
The decentralized distributed ledger technology enables the shipping industry to reduce paper work, connects parties in real time for exchange of documents and transactions in a secure way

BIG DATA

Big Data enables shipping companies to generate meaningful insights from extremely large volumes of data generated from sensors.

AI

AI-based algorithms gather and analyze logistic and shipments related data to provide insights that helps businesses make better decisions.



AR/VR

Immersive technologies revolutionalize the shipping industry by accelerating and simplifing processes such as training, ship building and remote maintenance.

CLOUD COMPUTING

Cloud technology in the shipping industry have significant benefits including ease of data access, availability of information regardless of time and location and reduction of data in silos.

Technology Development Status: Significance (1/3)

Blockchain Seems to be in the Nascent stage of adoption while AI is becoming Increasingly Important in Achieving Operational Efficiency and Autonomy

Blockchain

- Shipping companies in Norway are increasingly seeking ways to implement blockchain technology to reduce cost of operations by cutting down the usage of paper and implementing blockchain based storage solutions.
- Norway sees digitizing the paper based documents such as bill of landing (BoL), letter of credit, MOA etc. as a potential application where blockchain can be applied.
- Norway is still in a very nascent stage of implementing blockchain technology.

1 2 3 4 5 6 7 8 9

Technology Development

Artificial Intelligence

- Norway has the potential to become a pioneer in developing and implementing artificial intelligence based services in the maritime industry.
- Shipping companies, universities, government agencies and consortiums in Norway are initiating multiple projects that uses artificial intelligence in improving the operational efficiency of ships and to avoid anomalies in the journey.
- In addition to operation efficiency, AI is also being used to predict optimum routes in real time by analyzing large amounts of data, and providing intelligent navigation, safety and security within the maritime industry

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (2/3)

Cloud Computing and Big Data are helping the Norwegian Maritime Industry to Improve Efficiency and Reduce Costs

Big Data

- Big data is considered to be one of the top technologies transforming the shipping industry, as connected technologies generate more and more data , with the need for analysis of big data to unveil hidden patterns and trends
- As big data implementation is still in a nascent stage in the maritime industry, data has to be sent to third party vendors which is time consuming and inefficient in traditional approaches.
- Norwegian companies such as Xeneta, Wilhelmsen, DNV-GL and Dualog have developed their own big data platforms for improved operational benefits and reduced cost.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

loud Computin

- Cloud computing is having a significant impact on the way Norwegian shipping companies operate. Companies are keen to migrate their shipping systems and processes over the cloud to improve the communication with their staff at both land and sea.
- Private companies such as SolstadFarstad, Vesselman, OSM Maritime and Seamless have developed various cloud platforms to accelerate the usage of cloud computing across the industry.
- Development of strategy by the Norwegian government with particular focus on digitalization encourages companies to adopt advanced technologies.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Adoption of AR/VR in Norwegian Maritime Industry is high due to Increased Development of Interactive Content by Companies

AR/VR

- Virtual reality and augmented reality makes it possible to operate and control offshore operations remotely. Applications of AR/VR in the maritime industry such as training, education, navigation, remote maintenance and ship building are gaining traction in Norway.
- Many private companies such as Fostech, Haptiq and Navtor among few are showing interest in developing AR/VR applications.
- Norway's regional marine cluster ÅKP along with The Industrial Development Corporation of Norway (SIVA) had established a company named Blue Ocean Innovation Arena to initiate a virtual open space incubator to enable technologies within 3D visualization and VR.[2]

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Blockchain Application Landscape and Case Studies

Blockchain has the potential to Eliminate Paper Work and Secure Information by providing Visibility and Transparency across the Value Chain

Eliminate Paperwork

Blockchain in the shipping industry has the potential to reduce the paper work and improve efficiency by digitizing all the transactions. Blockchain's distributed ledger technology enables secure exchange of information between all the parties without the need of worrying about document tampering.

Accelerates the Processing Time and Provides Real-time Updates

Blockchain technology automates the tasks that are handled manually to accelerate the processing time. Blockchain provides real time updates about the shipment by tracking it at every stage.

Smart Contracts

When a buyer and seller agree the terms of transaction, a smart contract is created and integrated into the blockchain. The information related to the contract is stored in the form of blocks ensuring only people in the network have permission to access, thereby increasing the transparency and security.

DVN-GL

DNV-GL uses blockchain technology to safely store and update the information related to their products and supply chain certificates to reduce the fraud and tampering of documents, enabling transparency and adherence to rules and standards. [3]

AI Application Landscape and Case Studies (1/2)

Usage of AI Applications in Ships helps reduce Human errors and avoids Accidents

Optimized Route Planning

Artificial intelligence is used as a key ingredient in planning the route for ships. Artificial intelligence uses operational and weather data to create a detailed, reliable and optimized route, minimizing the fuel consumption.

Intelligent Maneuvering

AI based algorithms detects unusual and excessive maneuvering patterns, constantly monitors the speed and rate of turn and notifies the operator in real time to decrease excessive fuel consumption.

Anomaly detection

Artificial intelligence and machine learning algorithms detect anomalies by constantly learning from the behavior of the operator and sends real time notifications in case of any deviation in the route. AI/ML algorithms also predicts ships trajectory for the given area, predicts potential collision and grounding events.

Navtor and Weathernews Inc

Navtor, a Norwegian e-navigation company and Japanese based Weathernews Inc (WNI) have collaborated to launch an artificial intelligence based route planning service. Navtor integrates WNIs shipping weather service fleet management platform into its NavStation platform to provide services such as optimum route planning, save fuel and reduce costs, fleet monitoring, analyze ship efficiency and provide detailed auditing capabilities. [4]

Kongsberg

Kongsberg, a Norwegian technology company in the maritime industry is a key partner and developer of autonomous ship “Yara Birkeland”. Kongsberg provides deep learning and machine learning algorithms for optimization and enables remote operations of the ship. Kongsberg is also supplying and integrating all vessel control systems including K-Pos dynamic positioning, K-chief automation and K-Bridge ECDIS.[5]

AI Application Landscape and Case Studies (2/2)

Rise of Automation in Maritime Industry has Led to an Increase in demand for AI

Transas and Wilson ASA

Transas, acquired by Wartsila, a technology solutions provider for the marine industry has partnered with Wilson ASA, a Norway based fleet operator to provide navigational and communication components. Transas is to provide fleet operations solution A-Suite which utilizes AI/ML capabilities to improve navigation , safety assistance, and fleet efficiency.[6]

Kongsberg and Wilhelmsen

Kongsberg and Wilhelmsen have partnered to establish an autonomous shipping company Massterly, aiming to provide a complete value chain for autonomous ships including design, development, integrating control systems, advanced logistics services and vessel operations.[7]

Autonomous Test Beds

- Norway accelerates the development of autonomous ships by launching test beds for autonomous vessels.
- **Trondheimsfjord Test Area:** Trondheimsfjord is the first test area launched in Norway in September 2016, aiming to improve research and development on autonomous maritime transport. Partners include Kongsberg Seatex, SINTEF, NTNU, Maritime Robotics, Port of Trondheimsfjord, The Norwegian Maritime Authorities and The Norwegian Costal Administration.[8]
- **Storfjorden Test Area:** Storfjorden is the second test site launched in 2017 by the Norwegian Maritime Authority, Coastal Administration and a Consortium led by GCE Blue Maritime.
- **Horten Test Area:** Horten is the third test area launched in December 2017 led by The Norwegian Coastal Administration, Norwegian Maritime Authority, Kongsberg Maritime AS, Norwegian Defense Research Establishment (FFI), DNV-GL and University of South-Eastern Norway.
- Norway is also planning to launch two more test sites Grenland and Tromso by end of 2019.[9]

Big Data Application Landscape and Case Studies (1/2)

Vessel Management, Safety and Security are the Key Applications areas of Big Data in Maritime Industry

Real-time comparison of prices

In the ever changing landscape of freight rates, fuel and material costs, big data helps shipping companies to compare the rates for better decision making. Data analytics solutions can uncover patterns by analyzing internal and external data sources, market trends, buyer and seller habits.

Vessel Management & Predictive Maintenance

Decisions regarding ship management including hull maintenance, condition monitoring and performance of engines can be taken using insights generated from big data. Predictive algorithms help ships crew to perform scheduled operations that reduces the overall cost of maintenance.

Safety and Security

Big data improves the ship safety and security by using smart analytics tools that monitor the data generated from smart sensors. Big data has the ability to bolster safety, security, quality and compliance frameworks in the shipping industry.

NYK and Dualog

NYK, a Japanese shipping company and Norway based digital platform provider Dualog have entered into a strategic partnership, aiming to promote usage of advanced technologies in maritime industry. The companies together will focus on the development and usage of big data, internet of things, data science, data analytics and machine learning in ships. [10]

Xeneta

Xeneta, a Norwegian price comparison platform provider for the containerized freight and shipping logistics industry offers big data platform Xeneta Intelligence for large scale shipping companies. Xeneta Intelligence platform compares prices and long term contracts to benchmark and compare the current market prices. The platform also provides a customized dashboard facility providing easy access to insights.[11]

Big Data Application Landscape and Case Studies (2/2)

Insights Generated from Big Data Enables Better Decision Making across the Teams on Ship

Wilhelmsen

Wilhelmsen's ship management service provides digital reporting systems onboard. The service aims to reduce the data in silos using a business intelligence tool. The tool converts churns of big data into consolidated reports and creates insights that are accessible to relevant teams for further action. [12]

Bahri Data and DNV-GL

Saudi Arabia-based Bahri data and DNV-GL partnered to develop and jointly use big data capabilities for innovations in safety, security and compliance. Data scientists from Bahri data and DNV-GL's Veracity big data platform will be leveraged to develop a solution that helps charterers, regulators and port authorities to achieve safety and quality goals in the maritime industry.[13]

Cloud Application Landscape and Case Studies

Adoption of Cloud Technology enables Operations, Communications and Collaborations easier for Workforce Off and On Shore

Cloud based software platforms

Many Norwegian companies are providing their services over the cloud for easy accessibility of resources from anywhere. Cloud computing connects ships using a common platform and enables maintenance, support teams and customers to take better decisions.

Reduce Costs

Implementation of cloud computing in the shipping industry is growing as cloud increases the transparency and visibility of applications related to logistics, communications and tracking. The ability to manage routes, schedules , and operations in real-time by leveraging cloud reduces the costs

Storage of Data

Rapid growth in data generated from various sources is pushing IT teams in shipping companies to embrace cloud based storage solutions. Cloud storage helps companies to reduce the cost of maintaining servers and hard drives.

Vesselman

Vesselman offers easy to implement and cost effective solutions that improves ship performance using cloud based platforms. Technical managers in ships often updates worksheets manually in processes such as dry-docking, refits and repairs. Vesselman's SaaS based solutions digitizes the process by providing real time update of project status , requirement and crucial information on cloud. Companies such as PGS and DNV-GL among few are using Vesselman's services.[14]

SolstadFarstad and Yxney Maritime AS

Norway based SolstadFarstad and Yxney Maritime AS developed a cloud based database MarESS that gathers data from vessels and combines with other weather routing sources to provide ship managers a cost effective and fuel saving initiatives.[15]

AR/VR Application Landscape and Case Studies

Ship Building, Training and Remote Maintenance are the Key Application areas of AR/VR in the Maritime Industry

Simulation and Training

Virtual reality has the potential to transform traditional training and simulation approaches. Virtual reality provides immersive and interactive experience to employees, helping them to learn faster by visualizing the content.

Ship Building

Virtual reality allows engineers and designers to build ships by rendering the 3D and CAD based design models of engine parts. VR enables them to walk through the projected model of the ship. VR also solves potential engineering issues in real time.

Remote Maintenance

Augmented reality can be used to solve complex problems that occur in the voyage. Smart glasses equipped with Wi-Fi and bluetooth enables real-time communication with experts on shore. The expert can get a detailed view of the problems and informs the actions that need to be performed to solve the problem

Royal Norwegian Navy and SEA

The Royal Norwegian Navy (RNN) is using SEA's DECKsim virtual reality trainer. The solution is portable and enables RNN to train their employees on ship or at any land facility. DECKsim solution replicates flight decks in ships to train aircraft handling procedures. The solution has reduced flight deck officers' (FDO) flying hours by up to 50% reducing the training costs.[16]

YSA Design AS

A Norwegian based design house YSA Design is designing the cruise ships using virtual reality based 3D building information modeling (BIM) to digitally represent physical spaces in a 3D world. The virtual reality tour allows designers to experience the atrium and other areas of cruise ships.

Autonomous Ships – Norway (1/2)

Norway accelerates the development of autonomous ships by launching test beds for autonomous vessels. Norway has so far built 3 test beds for autonomous ships . The efforts are set to transform the many aspects in the shipping and offshore operations in Norway. Norway envisions autonomous ships as safe, environment friendly and cost effective modes of transportation.

List of Test Beds in Norway:

- **Trondheimsfjord Test Area:** Trondheimsfjord is the first test area launched in Norway in September 2016, aiming to improve research and development on autonomous maritime transport. Partners include Kongsberg Seatex, SINTEF, NTNU, Maritime Robotics, Port of Trondheimsfjord, The Norwegian Maritime Authorities and The Norwegian Costal Administration.[8]
- **Storfjorden Test Area:** Storfjorden is the second test site launched in 2017 by the Norwegian Maritime Authority, Coastal Administration and a Consortium led by GCE Blue Maritime.
- **Horten Test Area:** Horten is the third test area launched in December 2017 led by The Norwegian Coastal Administration, Norwegian Maritime Authority, Kongsberg Maritime AS, Norwegian Defense Research Establishment (FFI), DNV-GL and University of South-Eastern Norway.
- Norway is also planning to launch two more test sites Grenland and Tromso by end of 2019.[9]

> With critical developments in maritime autonomy technology and software taking place at Kongsberg Maritime in Horten, the location of the new test-bed will support a number of ground-breaking technology projects. The move towards greater autonomy at sea has the potential to transform maritime operations and while the technology has now been proven, we look towards the regulations. Establishment of these test-beds are an important step, as it shows close co-operation between the people making the technology and vessels and the organizations developing the rules that will allow them to operate.
>
> ***- Egil Haugsdal, President, Kongsberg Maritime***

Autonomous Ships – Norway (2/2)

Norway established **The Norwegian Forum for Autonomous Ships** (NFAS), an interest group for persons or organizations that are interested in the subject of autonomous ships.

The initiative to establish the forum was taken by the Norwegian Maritime Administration, The Norwegian Coastal Administration, the Federation of Norwegian Industries and MARINTEK (now SINTEF Ocean) in the early part of 2016.

Some of the **projects** that are carried out by **NFAS** are:

- The Ministry of Transport and Communications in Norway funded 1.4 million EUR for the development of autonomous transport in Møre og Romsdal.
- Online risk management and risk control for autonomous ships
- MAMIME: World's first Maritime 5G communication project
- Enable Autonomous Navigation in Close Proximity
- Concept development autonomous passenger ferry Ballstad
- Signing MoU between Smart Ship Coalition and NFAS
- ASTAT - Autonomous Ship Transport at Trondheimsfjorden
- Yara Birkeland
- Milli-Ampere: Autonomous passenger ferry
- Test area Trondheimsfjorden
- Test area Grenland
- NTNU AMOS - Centre of Excellent Research
- MUNIN - Concept study for unmanned bulk ship
- AAWA - The Advanced Autonomous Waterborne Applications
- AUTOSEA - Sensor Fusion and collision avoidance for advanced ships
- ENABLE*3 Shore based bridge concept

Adoption Life Cycle

Norwegian Companies Continue to Improve their Capabilities by Embracing new Technologies

	Innovators & Early adopters	*Early & late majority*	*Laggards*
Blockchain		DNV·GL	KONGSBERG, XENETA
AI	NAVTOR, MARITIME ROBOTICS, Klaveness Digital, KONGSBERG	WILSON, Wilhelmsen Ships Service	OSM, NAUTISK
Big Data	XENETA, DNV·GL	dualog, Wilhelmsen Ships Service	Camo Analytics, teradata.
Cloud Computing	dualog, VESSELMAN	SOLSTAD FARSTAD, OSM, SEAMLESS	
AR/VR	kognif ai, XVISION, MORILD INTERAKTIV, FASTECH	NAVTOR, Wilhelmsen Ships Service, haptiq, FOSNAVAAG OCEAN academy, PaleBlue	eon reality

Stakeholder Ecosystem and Application Areas

Organization	Technology	Application area	Alliances
DNV-GL	Blockchain, Big Data	digital certification, vessel safety and security	Bahri Data
Kongsberg	Artificial Intelligence, VR, Internet of Things	intelligent navigation, anomaly detection, autonomous ships	Wilhelmsen
Wilhelmsen	Big Data, AR	ship management, interactive bulk carrier 3d model app	
Xeneta	Big Data	container management	
Navtor	AI, AR	intelligent routing, e-navigation	Weathernews Inc
Dualog	Big Data, Cloud	ship management	NYK
Vesselman	Cloud	digitization of workflow	
Xvision	AR	marine animation	
Fostech	AR/VR	sales/marketing, training/education	
Klaveness Digital	AI, Cloud	logistics, shipping	
OSM Maritime	Cloud	training solutions	
Fosnavaag Ocean Academy	VR	concept and product development, sales and marketing activities	
Morild Interaktiv	VR	virtual prototyping, sales/marketing, training and familiarization	
Haptiq	AR/VR	interactive solutions	
PaleBlue	VR	vessel familiarization	

Factors Influencing Adoption: Drivers

Rising Demand for New Technologies and Initiatives by Government are Major Factors of Technology Adoption

S.N	Description of Driver (Technology and Market Aspect)	Impact		
		Short-Term	Medium-Term	Long-Term
1	**Government Initiatives:** In order to intensify and drive innovation in the Norwegian maritime industry, the government has developed many programs for the maritime cluster in Norway. Initiatives such as MAROFF by the research council of Norway and Maritim21 are acting as key drivers for developing and implementing new technologies in the Norwegian Maritime industry.	High	High	High
2	**Environmental and Climate change:** Environmental and climate changes are one of the important drivers for adoption of technology. Usage of technologies that reduce carbon emission and initiatives related to green shipping are paving the way for the development and commercialization of zero-emission solutions.	Medium	High	High
3	**Shipping 4.0:** The road towards achieving autonomy in shipping and maritime industries has already began. Application of new technologies has a huge potential to drive the economic, environmental and social sustainability in the shipping industry. Adoption of new technologies plays an important role in driving the industry towards shipping 4.0.	High	High	High

Factors Influencing Adoption: Challenges

Shortage of Technical Expertise and Complexity are Hindering the Technology Adoption

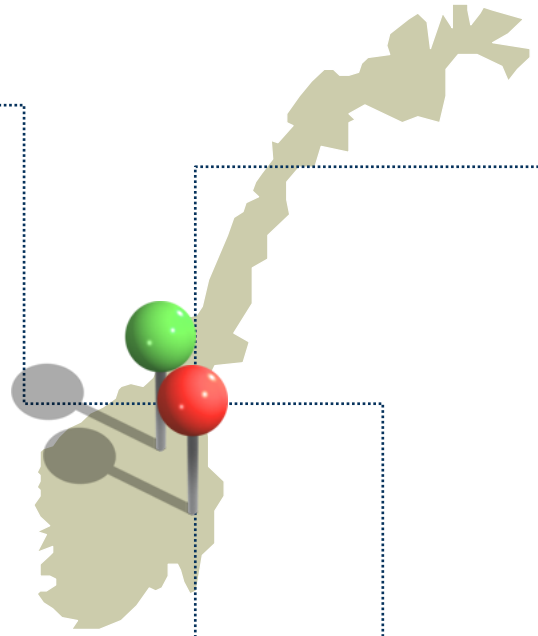
S.N	Description of Driver (Technology and Market Aspect)	Impact		
		Short-Term	Medium-Term	Long-Term
1	**Complexity in implementation of new technologies:** Adoption of new technologies in the maritime industry is often hindered due to high complexity of the technology and lack of skilled labor with particular skills. Continued efforts to invest in skills, education and training is required in the short, medium and long terms.	High	High	Medium
2	**Ways of working and Infrastructure Overhaul:** Embracing advanced technologies in the maritime industry increases overall operational efficiency and productivity. The adoption of advanced technologies require a degree of infrastructure overhaul which involves high investment costs. Many shipping companies have introduced new and agile working concepts which results in efficiency, but when it comes to reality the adoption rate of new technologies is still lagging behind.	High	High	Medium

Country Specific Initiatives and Future Roadmap

Norway Remains at the Forefront of New Technology Adoption with Introduction of Supportive Initiatives

The consortium led by Global Centre of Expertise Blue Maritime at More run by ÅKP AS, aims to become a global hub for safe and sustainable commercialization of advanced technologies and operations at sea.[18]

Norway's OpenBridge developed an open platform that provides an interface for ships and allows multiple vendors to develop new applications. The platform also accelerates automation and development of advanced maritime operations.[17]



Norwegian government framed strategy "Maritim21" for the research and development of Norwegian maritime sector. Maritim21 aims to stimulate R&D and innovation efforts from both companies and government authorities to develop new technologies that can give Norwegian companies competitive advantage.[19]

Norwegian based Training and Assessment Group (TARG) and Kongsberg Digital have jointly secured 13 million NOK from the Research Council of Norway and started a project InnoTraning to support and enhance simulator based training in maritime industry using AR and VR technology.[20]

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team FINLAND MARKET OPPORTUNITIES

Future Watch

6.3 Country Benchmarking - Germany

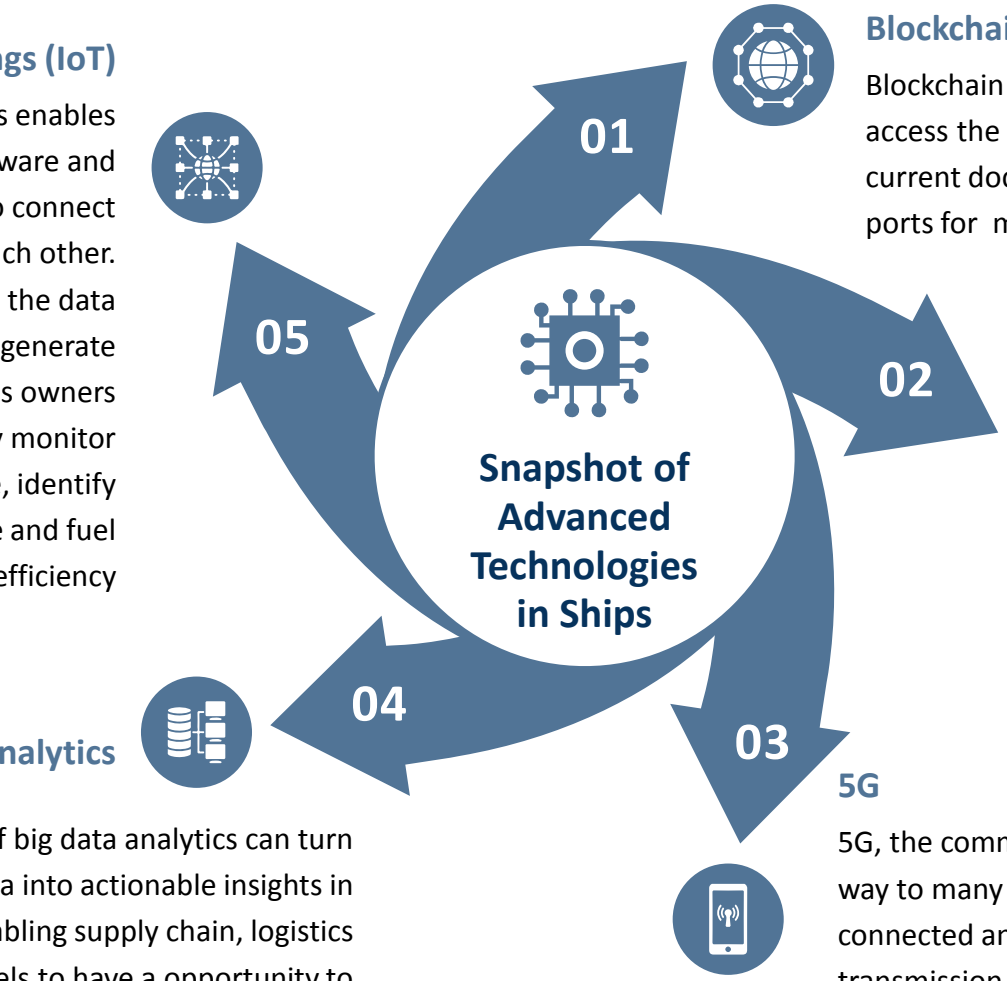
FROST & SULLIVAN

Key Technologies Assessment

Digitalization efforts in German Maritime Industry has Increased the Usage of Advanced Technologies

Internet of Things (IoT)

Internet of Things enables devices, sensors, software and appliances on ships to connect and interact with each other. IoT platforms records the data to process and generate insights that helps ships owners and managers to easily monitor vessel performance, identify equipment failure and fuel efficiency



Blockchain

Blockchain enables shipping companies to share and access the information securely and digitizes the current documentation and other processes in the ports for more operational efficiency.

AI

Artificial intelligence when applied to historical maritime data, enables ships to plan their route intelligently and enables them to reduce the congestion in the terminals.

Big Data Analytics

Utilization of big data analytics can turn unstructured data into actionable insights in maritime industry enabling supply chain, logistics and deep sea vessels to have a opportunity to achieve improved efficiency and quality.

5G

5G, the communication standard of future will pave way to many technological advancements such as connected and autonomous ships. Higher data transmission rates with reduced latency can improve efficiencies across shipping operations.

Technology Development Status: Significance (1/3)

Blockchain based projects are still in Pilot Stage while AI based Applications such as Intelligent Maritime Navigation and Predictive Maintenance have already hit the mainstream

Blockchain

- Adoption of blockchain technology in Germany is still in a very nascent stage with few private and government organizations being the early adopters and pushing the adoption further.
- Pilot projects RObоB and Tradelens have been initiated to reduce the paper work, digitize the existing documentation and container management to address the challenges faced by maritime industry in Germany.
- Federal Ministry of Transport and Digital Infrastructure (BMVI) in Germany is forming collaborations with private companies and universities to accelerate the commercialization of blockchain technology.

1 2 3 4 5 6 7 8 9

Technology Development

AI

- Artificial Intelligence has the potential to revolutionize the maritime industry by making shipping business more efficient.
- Applications such as intelligent route planning, predictive maintenance, reducing congestion in the terminals are implemented by private companies and sea ports in Germany.
- German government has initiated several strategies to accelerate the adoption of artificial intelligence in Maritime Industry.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (2/3)

5G Pilot Projects in Hamburg Port helps transforms the existing Communication systems and operations; SmartPort Analytics tool used in Hamburg Port Ensures smooth efficient operations

5G

- 5G will play a key role in enabling applications from emerging technologies such as IoT and Industry 4.0.
- Companies such as Deutsche Telekom and Nokia partnered with Hamburg Port Authority have started testing the 5G architecture using network slicing concepts in the port of Hamburg.
- The pilot tests accelerates the deployment of 5G into other applications such as ship-to-shore communications, autonomous and connected ships.

1 2 3 4 5 6 7 8 9

Technology Development

Big Data Analytics

- Analyzing big data generated from sensors places on the ships and sea ports can allow players in maritime industry to unlock the hidden patterns, market trends, insights and other useful information which helps them improve their performance, revenue, operational efficiency and streamline the flow of goods.
- Companies such as Deutsche Telekom, SAP, Carnival Maritime are using big data analytics solutions in application areas such as real time navigation assistance, reducing water consumption and intelligent voyage operations.
- Germany's SmartPort Initiative including intelligent solution for the flow of traffic, goods in Hamburg Port is accelerating the adoption amongst private and public players.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

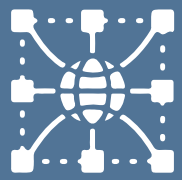
1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Hamburg Port in Germany Implemented several IoT applications to break the existing barriers of handling traffic and assisting ships in real-time



IoT

- Adoption of IoT keeps track of all the devices and assets on board, providing real time information about the location and time of arrival of the shipment which helps managers off and on shore to efficiently manage time.
- Hamburg Sea port is the early adopter in implementing IoT technology to manage the port operations such as infrastructure, traffic and maintenance.
- The SmartPort Initiative by Hamburg Port enables technological assistance to its stakeholders by improving the logistics operations, installation of sensors at vital locations.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Blockchain Application Landscape and Case Studies

Digitalization of Container Systems and identifying Counterfeit products are the major application areas of Blockchain in German Maritime Industry

Digitization and Elimination of Paperwork

Shipping transactions involve significant amount of documentation effort from multiple parties which pass through a long chain of network. Leveraging blockchain based Smart Contracts, a large part of the paperwork can be eliminated and contractual obligations can be automated to reduce processing times.

Container Management

Blockchain allows participants in the supply chain to collaborate in various cross-organizational business processes and information exchanges. Blockchain provides a registry of all the containers and enables a secure, smart contract based transactions between participants such as ports, terminals, and stakeholders.

Cargo Management

Many Marine accidents have emerged from mishandled cargo and lack of precautions while transporting sensitive goods. Blockchain enabled interfaces can be used to ensure accurate communication of weight and vital freight related data to all parties involved in the shipping process.

ROboB – Blockchain Project

ROboB (Release Order Based on Blockchain) is a blockchain based release order for the exchange of goods and services during export and imports. The project aims to digitalize the container system in the port using blockchain technology that provides access to authorized individual verified by digital signatures . ROboB is a joint project by IHATEC, DAKOSY, Technical University of Hamburg funded by Federal Ministry of Transport and Digital Infrastructure (BMVI). The project would operate till January 2020.[2]

Hamburg Süd

A Germany based container shipping company Hamburg Süd had jointly participated in several blockchain pilot projects in the areas of supply chain to digitally verify the counterfeiting of products at the transfer points.

Hamburg Süd is also part of blockchain based open commercial platform TradeLens and is currently planning to implement blockchain based TradeLens in applications such as paperless documents and forgery proof transactions. [3]

AI Application Landscape and Case Studies

Rise of Automation in Maritime Supply Chain and need for Intelligent Solutions has led to an increase in demand of AI

Intelligent Maritime Routing

Shipping companies are applying artificial intelligence algorithms to gather real time information such as weather data and maritime traffic and find patterns that suggests optimum route in the journey saving time and fuel.

Autonomous Ships

Companies across the globe are working towards enabling partial or total autonomous functioning of ships. In the near future, vessels such as tugboats and small ferries will be automated and gradually the technology will be expanded to larger and more complex vessels.

Simulation and Training

AI also finds applicability in training sailors in the shipping industry. AI can be applied for facilitating realistic training scenarios during simulator training sessions. Complex AI based engines can be designed to replicate the environments found at sea and can mimic variables such as weather and ocean currents.

Deep Blue Globe

Deep Blue Globe, a German based startup has developed an artificial intelligence based solution that suggests the optimum route in the journey of ships. The solution uses artificial intelligence based algorithms that combines earth's observational data and maritime traffic to suggest an optimized route that saves fuel and time of ships. The solution is expected to be used by fleet operators, tankers, cruise liners and small maritime operators.[4]

Port of Hamburg

Port of Hamburg has started developing artificial intelligence based tools that enables them to improve the predictions of maritime and land transports. The solution applies deep learning based techniques on the historical data and provides detailed predictions of the times when trucks should reach terminals. The tools also notifies the truck drivers entrance times and dynamically forecasts the workload in the terminals. [5][6]

5G Application Landscape and Case Studies

The Hamburg Port Authority, Deutsche Telekom and Nokia are Piloting 5G based applications at the Port of Hamburg in Germany

Improved Connectivity

5G based mobile network can transmit data from sensors installed on ships to give unique visibility of ship's location. 5G reduces the latency in transmitting data from sensors installed in ships, enabling port authority to monitor the ship's activity in real time.

Transmission of 3D data

5G has the potential to accelerate the adoption of AR and VR technologies. 5G network enables transmission of 3D data onto AR/VR applications platform without any delay. 5G when combined with AR/VR can help engineers in ship design, maintenance and monitor in real time.

Enhance Port Operations

Traffic lights in ports connected to 5G mobile network, helps port authorities to control the traffic in real time. As 5G has the ability to reduce the latency and transmits data at higher speeds, ship-to-shore communications would be made easier.

Hamburg Port Authority (HPA), Deutsche Telekom and Nokia

- Hamburg Port Authority (HPA), Deutsche Telekom and Nokia are testing various 5G applications in the port of Hamburg. Applications such as installation of sensors on ships of Flotte Hamburg GmbH & Co. KG. to transmit the movement of ships in real time across the port, traffic lights in the port are linked to the mobile network to operate them remotely from HPA control center to control the traffic, transmission of 3D data onto the augmented reality platform helping engineers to monitor the construction site from HPA.
- The field test was currently carried out as part of EU funded 5G MoNArch (Mobile Network Architecture) project and set to complete their trials by June 2019.
- The project is aimed to ensure rapid and reliable communication, to gain international attention for the port of Hamburg.[7][8]

Big Data Analytics Landscape and Case Studies

Big Data Plays a key role in Optimizing Shipping Operations by Collecting and Analysing the shipping data

Real time Navigation

Big data analytics applications assists truck and vessel drivers efficiently through personalized navigation using real time information about the locations. Analysis of information about the traffic situation, access to parking and infrastructure in the port gives ships and trucks to take better decisions and improve their navigational skills

Intelligent Voyage Operations

Analytics tools provides estimated time of arrival of cargo ships to truck owners in real time in order to reduce the congestion in the port area. Analytics tools with interactive dashboards can send real time notifications through mails and messages helping voyage managers to effectively handle cargo.

Reducing Water Consumption onboard

Big data analytics helps the captain of the ship to estimate the water consumption in both passenger and commercial ships. Water consumption is estimated using insights generated from analyzing the historical data related to passenger and weather data.

Hamburg Port Authority – SmartPort Solution

Hamburg Port Authority (HPA), Germany is using SmartPort solution developed by Deutsche Telekom and SAP to deliver automatic real time recommendations for trucks and vessels. SmartPort Logistics is a cloud based data analytics platform integrated with SAP connected logistics based on SAP HANA, vehicle specific real time services and applications from T-Systems' connected car portfolio. The solution monitors traffic flows both on and off shores, infrastructure and flow of goods.[9]

Carnival Maritime and Arundo Analytics

German based Carnival Maritime has collaborated with Arundo analytics to improve the usage of water consumption on ships. Arundo Analytics developed a microservice using its big data platform integrated with machine learning models, APIs and templates from Microsoft Cortana Intelligence Suite. The solution analyzes the historical data, passenger data and weather data to understand the water consumption patterns on ship and provides the insights to the team for taking better decisions.[10]

IoT Application Landscape and Case Studies

Data collected from IoT sensors installed in Vessels and Port's main Tangible Assets help Authorities to manage usage of Assets, Infrastructure and Traffic Efficiently

Improves transport and logistics

Ships and port equipped with IoT devices can improve the cargo handling capacity efficiently based on satellite coverage, sensors collecting information about weather, maintenance, machinery and state of cargo.

Environment Monitoring

Application of IoT sensors constantly monitors and capture the information related to the levels of CO2, Sulfur dioxide, Nitrogen dioxide. The information can be accessed through an interactive IoT dashboard enabling port authorities to necessitate actions regarding the increased levels.

Predictive Maintenance

Sensors installed in the vessels collect and record data and upload it into a cloud based platform that can be accessed by off and on shore teams, helping them to quickly take decisions regarding the equipment failures and also monitor the vessel performance and fuel consumption.

Hamburg Port, Kii and AQMesh

Hamburg Port Authority (HPA) launched a project along with Kii and AQMesh to identify the emissions of Sulfur dioxide, nitrogen dioxide and fine dust at various locations of Hamburg Port using sensors. The recorded sensor data is collected over Kii's IoT platform and made available for HPA employees in dashboards and APIs for analysis and decision making process.[12]

Hamburg Port

Hamburg port uses IoT based communications to connect the harbor port authority to ships. This is to notify them where to dock their ships, raising the drawbridges on time when a ship passes through; more than 40,000 trucks load and unload the containers every day in Hamburg port, using IoT and SAP HANA cloud platform trucks get real time notification regarding the arrival of the load, reducing the congestion and period of stay in the port.[11]

Autonomous Ships – Germany

German Government is currently searching for a suitable waterway networks to test autonomous ships. Test sites such as urban areas in Berlin, the lower reaches Elbe river and large scale ports have high chances to be considered as autonomous ships test sites. Germany seems to be moving very slow in terms of testing their own autonomous ships. Projects pertaining to autonomous ships are still in infancy stage in Germany, even 2020 there may not be a fully autonomous vessel in the market.

Projects related to autonomous ships in Germany:

- Germany acted as one of the participant and coordinator for project **MUNIN – Maritime Unmanned Navigation through Intelligence Networks**. MUNIN project is a collaborative research project, co-funded by European Commissions. MUNIN aims to develop and verify a concept for an autonomous ship.[25]
- Innovation Network **SCAS** (Systems and Components for Autonomous ships) in Germany is aiming to develop current and future projects in the field of maritime economy. The network SCAS of companies, research institutes and institutions has set itself the goal of realizing systems, components, sensors, communication services and technologies for partially or fully autonomous ships.[26]

> Autonomous shipping can bring significant advantages. Reduced crew expense is often cited as a major economic efficiency, but the biggest potential is within the area of ship design. Removing crew totally from vessels would allow for a total new ship design with fewer life-support systems and thus reduced costs. We found that updating existing vessels to UMVs is simply not economically attractive, so ultimately, this does mean developing new ship designs.
>
> ***- Hans-Christoph Burmeister, MUNIN Project Coordinator, from Fraunhofer CML***

Adoption Life Cycle

Hamburg Port of Authority seems to be the Early Adopter in Implementing Several Advanced Technologies

	Innovators & Early adopters	Early & late majority	Laggards
Blockchain		HAMBURG SÜD, DAKOSY	
Artificial Intelligence		Deep Blue Globe	7Cs SevenCs, Hapag-Lloyd, CODiE software products e.K.
5G		NOKIA, HPA Hamburg Port Authority, T-Mobile	
Big Data Analytics	ARUNDO, CARNIVAL MARITIME	HPA Hamburg Port Authority, CODiE software products e.K.	Hapag-Lloyd, hanseaticsoft A member of the Lloyd's Register family
IoT	HPA Hamburg Port Authority	Hapag-Lloyd	Media Mobil

Stakeholder Ecosystem and Initiatives (1/2)

Hamburg Port is the most Advanced Sea Port with adoption of advanced technologies such as 5G, AI, IoT and Big Data, aiming to achieve Port 4.0

Organization	Technology	Application
Hamburg SUD	Blockchain	Supply Chain, counterfeiting products, paperless documents and forgery proof transactions
Dakosy	Blockchain	Digitalization the container system
Deep Blue Sea Globe	Artificial Intelligence	Intelligent Maritime Navigation
Hamburg Port Authority	AI, IoT, Big Data Analytics, 5G	Prediction of maritime land transport, Control the traffic, transmission of 3D data, real time recommendation to vessels, reducing congestion
Arundo Analytics	Big Data Analytics	Usage of fresh water consumption on-board
Carnival Maritime	Big Data Analytics	Usage of fresh water consumption on-board

Stakeholder Ecosystem and Initiatives (2/2)

Shipping companies in Germany are Finding Innovative ways to Solve the Real World Problems in using Mix of Technologies

Organization	Technology	Application
Nokia	5G	5G equipment provider
Deutsche Telkom	5G	Data analytics platform for tracking real time location of ships
Mediamobil Communications GmbH	Communication Systems	Value added services, onboard IT systems, maritime satellite solutions
CODie	Analytics	Smart fleet reporting, Vessel management, crew management
hanseaticsoft	Cloud Computing	Cloud-based ship management, fleet management
SimulationX by ESI	Network-based modeling	3D view with dynamic labels and collision detection, Ship simulation

Factors Influencing Adoption: Drivers

Demand for Greener Ships, Government Push and Smart Solutions that help Improve Performance and Reduce Costs are the major drivers of Adoption of Technologies in Maritime Industry

Demand for Green Ships

Demand for efficient and environment friendly ships that release less or zero emissions using mix of technologies, increase in pressure and interest towards achieving high operational efficiency with reduced costs are driving the adoption. Federal Government in Germany will start a maritime research program focusing on green propulsion in 2019 and would invest through programs centering on the development of zero-emission eFuels.

Short-Term	Medium-Term	Long-Term
High	**High**	**Medium**

Government Initiatives

The maritime industry in Germany is one of most important sectors. Initiatives like industry 4.0 and digitalization will bring more opportunities to the maritime industry in terms of building smart ships integrated with new technologies that use resources efficiently and reduce operating costs and emissions. Hamburg Port Authority is already implementing and piloting several advanced technologies such as 5G, AI ad Big Data by partnering with local and international companies. The Maritime Agenda 2025 developed jointly by several ministries will shape the maritime industry in Germany and help companies maintain technology leaderships and target new growth markets.

Short-Term	Medium-Term	Long-Term
High	**High**	**High**

Need for Smart Solutions

Maritime industry has become more complex with a variety of players exchanging information in real time including vessels, cargo and logistics players, sea port authorities, storage providers, barge operators and other sensor providers. These players need to communicate with each other in real time in order to improve operational efficiency, reduce congestion and ensure smooth and safe voyage. SmartPort initiative by Hamburg has resulted in faster turnaround times for ships and helps achieve more efficient maintenance. Creation of such initiatives is driving the development of new intelligent business solutions integrated with advanced technologies

Short-Term	Medium-Term	Long-Term
Medium	**High**	**High**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

Lack of Skilled Labour and Digitalization Standards are Hindering the Adoption of New Technologies by German Maritime Companies

Digitalization Standards

Digitalization in marine technology comes with new safety and security requirements such as the approval and certification of ship components, systems and digital networks on board. Federal Government in Germany should make efforts to view the international agreement and standardization processes set by IMO, the ISO (International Organization for Standardization) and the IEC (International Electrotechnical Commission).

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

Talent Shortfalls

Like other sectors, German maritime industry is also facing talent shortages at both operational, planning and control levels. Despite of many government regulations to boost the technical knowledge in shipping industry, many companies are still facing issues in finding skilled labor. Efforts of companies to implement applications of intelligent shipping using technologies such as artificial intelligence and blockchain are majorly hindered due to lack of required skillsets.

Short-Term - **High**	Medium-Term - **High**	Long-Term - **High**

Source: Frost & Sullivan

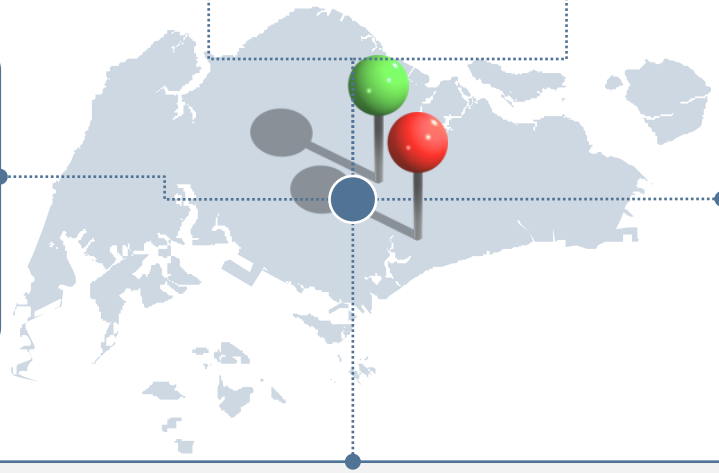
Country Specific Initiatives and Future Roadmap

Various Funding Programs and Initiatives have been made by German Government to accelerate the adoption of advanced technologies in Maritime Industry

Maritime Cluster for North Germany (MCN) founded in 2011 and currently consists of 350 members in the association, MCN aims to connect ship building, ship suppliers, marine engineering, shipping and offshore companies. MCN acts as a platform for its members to interact and promote innovation and collaboration within maritime industry.[19]

In January 2017, Federal Cabinet in Germany has approved Maritime Agenda 2025 developed jointly by several ministries to shape the maritime industry in Germany. Digitalization being the key focus area of Maritime Agenda 2025 with initiatives and funding to expand high speed broadband connections and provide real time services in navigation.[24]

German Association for Maritime Technology (GMT) founded in 1983, is supporting its member companies and research institutes to develop and innovate new technologies in maritime industry[18]



In April 2018, the International Maritime Organization initiated an effort to reduce the greenhouse gas emissions from maritime transport at least half by 2050. The Federal Government in Germany is aiming to reduce the greenhouse gases by using a mix of technologies delivering both efficient propulsion and lower greenhouse gas emissions from shipping fuels.[23]

Germany also has several other associations comprising members from ship building, ship yards, maritime partners, research institutions and various academia promoting research and innovation in maritime cluster.

- The Schiffbautechnische Gesellschaft e.V. - STG - (The German Society for Maritime Technology) – established in 1899 with 1500 members
- VSM Association – 145 members
- Center of Maritime Technologies e. V. (CMT) – established in 1965 with 85 members [20][21][22]

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team FINLAND MARKET OPPORTUNITIES

Future Watch

6.4 Country Benchmarking - USA

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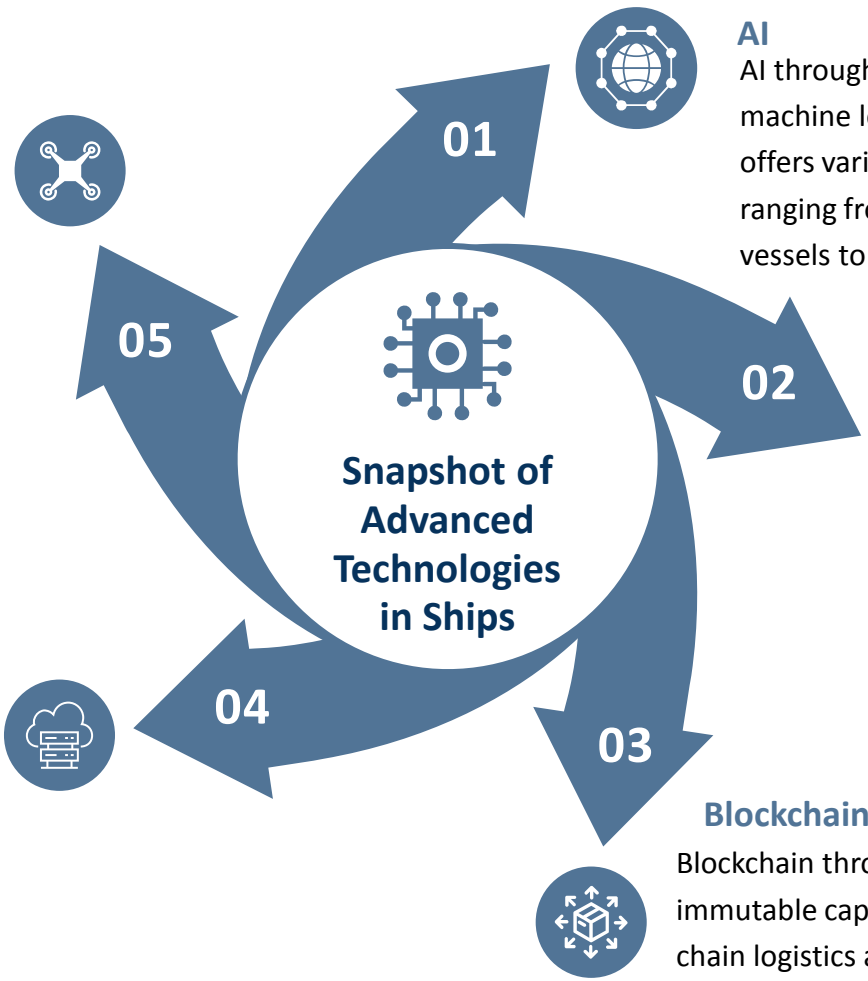
Key Technologies Assessment

AI and Cognitive Security is gaining traction amongst US shipping companies



AI

AI through its sub technologies like machine learning and deep learning offers various shipping applications ranging from autonomous surface vessels to digital assistants.

Cloud Computing

Cloud computing systems play a vital role for enabling digital ships by enhancing the access to datasets and being used as part of analytics functionality.

Blockchain

Blockchain through its transparent , secure and immutable capabilities is poised to revolutionize supply chain logistics and cargo trade over maritime routes. Smart Contracts will be impactful Blockchain enabled feature for the shipping industry.

Cognitive Security

With the increasing number of ships at or in port simultaneously, the shipping industry is highly vulnerable to cyber attacks. In this scenario, cognitive security comprising of advanced techniques based on AI and big data analytics empowers companies with predictive insights to tackle threats.

Augmented Reality

Augmented reality (AR) is set to provide immersive user experience in shipping industry for maritime applications.

Technology Development Status: Significance (1/3)

US companies are moving towards cloud infrastructure to achieve operational and cost efficiency

AI

- AI is playing significant role in US shipping industry by providing a blend of machine-human interaction and logistics collaboration. Human mimic intelligence is needed for systems in vessels to understand the environment and maritime conditions they encounter.
- Algorithms can provide onboard computers with tools and software that can be modeled for solving problems that occurs typically through predictive measure. Also, AI has significant role to play in maritime security, since the intelligence can provide insights to analyze image, video, and audio data.

1 2 3 4 5 6 7 8 9

Technology Development

Cloud Computing

- The US maritime shipping industry has been using cloud computing services to make operations, communications and collaboration easier for workforce across.
- US shipping companies, especially US Navy has initiated its shift from self owned data centers to cloud for operational and cost efficiency purposes. The cloud-integration with existing IT infrastructure enables US companies with myriad ways to explore the data and analytics capabilities within shipping and procurement areas.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (2/3)

Blockchain will enable transparent and secure global trade operations for US shipping companies

Blockchain

- Blockchain has the potential to completely revolutionize the US shipping industry across the entire value chain, from Ship manufacturers to cargo, freight brokers, and shippers.
- It is enabled by growth in digital currencies as methods of procuring products and trading cargo. This will develop from a fledgling industry process towards a mainstream method of transacting in maritime and global supply chains.

1 2 3 4 5 6 7 8 9

Technology Development

Augmented Reality

- US maritime sector is already adopting emerging technologies to optimize fleet management, automate processes and improve communication between crew on ships and staff ashore. Augmented Reality (AR) is making in roads in US shipping sector, into areas of training, simulation, customer experience.
- AR is also being explored by US naval agencies for designing and shipbuilding, by gauging parameters like ship interiors, piping requirements, electrical networks and personnel movements during emergencies.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Cognitive security to play a vital role in identifying advanced threat patterns for securing critical ship infrastructure, especially related to autonomous ships

Cognitive Security

- Considering the digitization trend hitting the marine sector with exponentially increasing adoption of advanced technology solutions for navigation, container inspection, communication and so on, bolstering security to protect confidential information and important computing resources is becoming critical.
- Algorithms calling upon advanced AI are being used to quickly access vast pools of data to perform real-time analytics designed to detect patterns and anomalies associated with malware.

1 2 3 4 5 6 7 8 9

Technology Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

AI Application Landscape and Case Studies (1/2)

AI will enabled cruise liners to enhance their shipping customer experience through personalized services

Predictive on board Management

AI through machine learning algorithms and predictive analytics enables predictive vessel management and maintenance which allows preventive measures before it disrupts operations. US shipping industry is focused on optimization of voyages through machine learning, allowing vessel officers to have accurate operational planning with demand forecasting in real-time.

Supply Chain Visibility

The supply chain process is complex affair involving enormous amount of data formats, systems, direct partners, and third parties. AI enables end-to-end supply chain visibility with full access to large datasets including historical shipping times, manufacturing details, and external data feeds like weather reports, to actively adjust vessel routes, based on predictive data.

Personalized Services on Board

AI enabled software including wearable devices will play a significant role in creating more immersive, seamless, and personalized experiences for every guest present on ship or cruise lines. US cruise liners such as Disney, Royal Caribbean are exploring AI tools to improve operational efficiency and to provide customized services based upon preferences and behaviors guests.

US Navy & Abeyon

In November 2018, US Navy Military Sealift Command has collaborated with a artificial intelligence firm Abeyon, and developed data analysis tool Clarifi.

The tool leverages predictive analysis functionality to monitor the condition and reliability 100 ships of Navy Sealift Command. The development team built machine learning based text analysis model to explore and identify equipment data and entities for predictive decision making in maintenance operations [1].

ClearMetal

US based ClearMetal has developed a AI based solution to provide end to end supply chain visibility to solve the data problems of shipping industry.

ClearMetal's proprietary machine learning technology tracks shipments moving across the globe automatically and cleans, corrects, and enhances transportation data, providing accurate real time data to its users.

AI Application Landscape and Case Studies (2/2)

AI based applications have enabled cruise owners in achieving operational efficiency while minimizing opex

Princess Cruises

California based Princess Cruises, a cruise line owned by Carnival Corporation was the first cruise line in US to introduced AI based wearable device called 'Ocean Medallion'. It is a 1.8-ounce device that interacts with the ship, enabling passengers to interact with food and beverage, retail, entertainment, lodging, recreation, and excursions seamlessly in real time.

The device leverages artificial intelligence to track and understand guest behavior on the ship. The deep learning algorithms evolves in real time to provide insights related to guest location on ship, time of the day and activities occurring at that time, thereby enabling personalized customer experience [3].

Cloud Application Landscape and Case Studies

Cloud computing is facilitating remote data access and operations, thereby enabling cost savings for US shipping companies

Maintenance and Component Serving

Cloud platform integrated with communication and big data analytics enables remote monitoring of critical on board assets. Data gathered from on-board sensors can also enable predictive maintenance, and remote assistance which leads to cost savings and ensures continued operations [7].

Real Time Data Accessibility

Access to real-time environment data empowers ships to avoid rough weather and inter-communication between ships aids in collision avoidance. Data acquired from automation systems and deck machinery could help in deriving variety of new offerings and also improve process efficiency.

Cloud services facilitates collaboration across the company and with offshore back office solutions companies for freight logistics. vessel operators have enough number of qualified engineers to deploy them with every vessel. Sharing expert knowledge-as-a-service through remote communications in critical situations helps operators to handle challenges effectively and negate the need to maintain expensive full-time experts [8].

Matson & AWS

US based shipping company Matson has selected Amazon to move its applications from its on-premises data centers to the AWS Cloud. This is enabling Matson to achieve faster performance, increased reliability and security, and remote assistance with at least 50% reduction in IT infrastructure costs [9].

AWS Cloud allowed Matson to leverage fast analytics and precise tracking of assets and shipments moving across the globe.

Royal Caribbean & Mesosphere

In Feb 2019, US based Crusieliner Royal Caribbean selected Mesosphere, a hybrid cloud platform provider to transform its existing IT infrastructure into a micro services architecture.

The platform will allow Royal Caribbean to keep ship shore systems in sync with real-time, allowing data access across multiple origination points. Mesosphere platform will allow easy configuration and deployment of services from a single user interface, thereby providing efficient operational experience, on ship and on shore [10].

Blockchain Application Landscape and Case Studies (1/2)

Smart contracts enables transparent tracking of shipments throughout the entire shipping value chain

Secure Real Time Information Management

Instead of mailing the documents to various parties, the exchange of information on board and offshore can become instantly and procedures can be completed even within a few minutes. Blockchain-enabled platforms will allow easy coordination of documents on a shared distributed ledger, making physical paperwork largely unnecessary.

Shipping Trade Tracking

Blockchain allows data and documents to be recorded and shared across the shipping supply chain in a transparent and tamperproof way, reducing exposure to fraud. This will lead to better end-to-end tracking of shipment orders and coordination among all parties, reducing errors and speeding up customs and paperwork clearance processes [13].

Transparent Freight Brokers

Use of Blockchain allows for transparency in pricing, which is provided by data on shipment movement and a record of past pricing. It can also ascertain whether the rates being charged are current or contracted rates. It can also potentially minimize or eliminate the role of unscrupulous brokers as all transactions would happen on the Blockchain trusted by all parties.

Shipchain

- US based Shipchain is a provider of end to end logistics platform and is helping global shipping carriers to solve challenges related to global trade through transparent Blockchain base contracts. The platform offers unified end-to-end track and trace of shipments right from the movement of ship from production facility to end user.
- It also provides a decentralized freight brokerage incentivization platform to encourage good stewardship by rewarding stakeholders in the supply chain for quality and timely delivery [14].

US Navy & ITAMCO

- U.S. Navy command, Naval Air Systems Command (NAVAIR) which handles material support for aircraft and airborne weapons systems for navy is exploring Blockchain develop a conceptual secure framework for a Blockchain supply chain system.
- The naval command has collaborated Indiana Technology and Manufacturing Companies (ITAMCO) to explore Naval Aviation Enterprise processes in permissioned Blockchain. The partnership is using SIMBA Chain – a blockchain-as-a-service platform developed in association with DARPA for this research project [15].

Blockchain Application Landscape and Case Studies (2/2)

Blockchain collaboration model to drive future of global trade

IBM & Maersk

- Maersk and IBM collaborated to developed a blockchain-enabled shipping solution TradeLens. It was developed to promote more efficient and secure global trade, bringing together various parties to support information sharing and transparency, and spur industry-wide innovation.
- The TradeLens ecosystem currently includes: More than 20 port and terminal operators across the globe. Through this ecosystem Shippers, shipping lines, freight forwarders, port and terminal operators, inland transportation and customs authorities can interact more efficiently through real-time access to shipping data and shipping documents, including IoT and sensor data ranging from temperature control to container weight.

Augmented Reality Application Landscape and Case Studies

Training and Simulation of ship processes through AR is prime focus area for US shipping industry

Ship Inspections

Periodic inspections of ships is necessary for systems and equipment's proper functioning. AR will enables ship inspectors to visualize the ships through AR based devices for on-site machining, shaft straightening and new building commissioning. They can take pictures through camera fitted on device for monitoring ship systems and equipment's for any failure.

Operational Management and Maintenance

AR will empower US Fleet management teams visualize display of all kinds of operational and productivity data, such as the movement of fleets, details about the routes and many more. Also the maintenance engineers can function through remote location for spotting engine areas for maintenance purposes. AR will enable them to visualize an entire ship in 3D for maintenance purpose of specific parts of the vessel.

Training and Simulation

Augmented reality plays an vital role in training in shipping sector. It provides real-life immersive experience in digital environment through high degree virtualization.

Augmented reality based simulation tools enables shipping workers to work in complex and risky environment through trainings.

Huntington Ingalls

- Virginia-based Huntington Ingalls is using augmented reality based tablets for shipbuilding. The tablets enables ship workers to see through ship's hardware, designs and other critical data in real time scenarios on the go.
- The AR based tablets provides shipyard workers with training videos, safety films and other instructions necessary for building digital ships. Huntington Ingalls is currently using this technology for building US navy's aircraft carrier [17].

US Navy & DAQRI

- US Navy is exploring augmented and virtual reality technology for use in recruitment, training, and operations. The navy developed Fleet Integrated Synthetic Training/Testing Facility (FIST2FAC), a AR/VR based simulator for ships to train in any given operating area.
- US navy has partnered with DAQRI for using augmented reality based helmet on battleships. The tablet is used and linked to helmet worn by the gunners on battleships. The gunners sees the command in the line of helmet display [18].

Cognitive Security Application Landscape and Case Studies

AI based security solutions is set to provide holistic view of cyber risk assessment for maritime stakeholders

Securing Critical Infrastructure

Targeted attacks on critical infrastructure areas such as electronic communication, collaborative supply chain platforms and so on are increasing. Securing endpoint devices, communication networks and data integrity will have a significant impact on successful digitization in the shipping sector. AI based cognitive security tools can mitigate the advanced threats through preventive measures.

Risk Assessment & Network Security

Cognitive security tools and solutions can be applied to both naval and cruise ships. The AI based security solutions will enable US shipping carriers to perform risk assessment of not only IT infrastructure but also the core operational networks (OT) such as PLC, SCADA networks on board. Cognitive security solution allows monitoring & control function of ship systems for any sort of vulnerability or cyber threat.

Identification of Threat Pattern

The predictive analytics and other AI enabled tools develops comprehensive understanding of threat patterns and helps in predicting future cyber attacks on vessel network and other IT infrastructure on board.

ABS & SecurityGate

- In March 2019, US-based American Bureau of Shipping (ABS) partnered with SecurityGate to develop in depth cyber risk analysis solution for maritime sector.
- The solution leverages SecurityGate's SaaS platform, providing a dashboard provides for degree of cyber risk across assets, operations and critical suppliers. [19]

Sparkcognition

- US based SparkCognition specializes in developing AI-based cyber security solutions for marine sector to secure IT, OT, and the IoT infrastructure.
- The company leverages machine learning algorithms to analyze real time sensor data, enabling more accurate risk mitigation and prevention policies [21].

Adoption Life Cycle

Major US tech giants and shipping companies are at the forefront of emerging technology adoption

	Innovators & Early adopters	Early & late majority	Laggards
AI	U.S. Navy, Carnival Corporation & PLC, Royal Caribbean International	loadsmart	
Cloud Computing	aws, Microsoft, Matson	Mesosphere, FLEXPORT	
Blockchain	IBM, Maersk	SHIPCHAIN, DARPA	
Augmented Reality	U.S. Navy, Carnival Corporation & PLC, Royal Caribbean International	Huntington Ingalls Industries	
Cognitive Security	ABS, U.S. Navy	sparkcognition™	

Stakeholder Ecosystem and Initiatives (1/2)

Start-ups are leveraging Blockchain to develop end to end supply chain solutions

Organization	Technology	Application
IBM	Blockchain	End to End Supply Chain Tracking
Shipchain	Blockchain	End logistics platform and is helping global shipping carriers
Slync	Blockchain	Slync is a provider of an intelligent Blockchain based platform for all global supply chain partners
American Bureau of Shipping	Cognitive Security	Cyber risk assessment and security solution
Royal Caribbean & Mesosphere	Cloud Computing	Hybrid Cloud based micro services architecture
Flexport	Cloud Computing, AI	Tracking containers and providing them analytics for their supply chain.

Stakeholder Ecosystem and Initiatives (2/2)

US shipping sector enjoys strong support of emerging tech start-ups to drive digitization in ships

Organization	Technology	Application
US Navy & Abeyon	AI	Developed data analysis tool Clarifi
Clearmetal	AI	AI based solution to provide end to end supply chain visibility
Carnival Corporation	AI	AI based wearable device called ‘Ocean Medallion’
Huntington Ingalls	AR	AR based tablet for Shipbuilding
US Navy	AI/AR, Cloud Computing	Augmented and virtual reality technology for use in recruitment, training, and operations, Cloud migration
Matson & AWS	Cloud Computing	Migration to Amazon AWS Cloud

Factors Influencing Adoption: Drivers

Exponential rise of data in connected environment is key factor for adoption of emerging technologies in maritime space

Exponential Rise in Data

The ability to gather masses of high-frequency data is nothing new in US maritime sector. Enabled by global connectivity and internet of things technology, the stream of numbers covering fuel consumption, performance, weather and hundreds of other variables has never been greater. Manual analysis that requires sophisticated analytics tools capable of comprehending information at scale and across timelines., where AI and other techs plays an important role. The sophisticated US emerging technology ecosystem comprising of big industry players and startups is accelerating the digitization in shipping industry[21].

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Increasing Connected Ecosystem

US shipping sector is moving towards autonomous shipping connected ecosystem and digitalization is one of the main drivers which is becoming a prime force in shipping. The demand for more remote monitoring, diagnostics and operations functionality is on the rise due to connected environment. The insight generated through digitization in connected ecosystem will improve operational efficiencies and vessel management, thereby enabling ease of business and will enable shipping companies to achieve their economies of scale. US Navy is leveraging emerging technologies for digitization process and using the insights to drive operational efficiency [22].

Short-Term - **High**	Medium-Term - **High**	Long-Term - **High**

Government Initiatives and Collaboration

Digital technologies and operating models are forging a collaborative ecosystem by pushing US shipping companies to collaborate with digital data providers. Companies like ABS, Mantis are partnering with tech vendors and providers to drive their business and operational efficiencies. In July 2018, US Maritime Administration (MARAD) granted over $20 million for Small Shipyards to drive their operational efficiency through technology [23]. The US navy is making significant investing in unmanned technologies to develop autonomous fleet with various digital capabilities, weapons and sensors, with ease of operation and maintenance[24].

Short-Term - **Medium**	Medium-Term - **High**	Long-Term - **High**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

High OPEX and Shortage of skills is slowing the digitization of ships

Increasing Cyber Attacks

Cyber hacker are using advanced techniques to attack the vessels and penetrate a ship's critical onboard Operational Technology systems through company's shore-based IT systems . Also, the International Maritime Organization (IMO) guidelines in response to attacks on shipping, is ineffective due to changing nature of advanced attacks. This is one major concern hindering the digitization of ships. Concerns over building the necessary IT infrastructure, as well as shipping regulations, also limits the exploration of emerging technologies. Emerging techs like cognitive security, AI, Blockchain can enable US shipping industry to overcome the security concerns[25] [26].

Short-Term - **High**	Medium-Term –High	Long-Term - **Medium**

Significant Cost Expenditure and lack of Skill talent

Majority of US shipping companies still consider the digitization an costly affair. The high IT costs for the development of the advanced hardware and software forms the core of decision making. However several digitization projects are being under executed, there are still security funding related issues with majority of US ship operators . Lack of investments in security and digital infrastructure as well as on training of resources for emerging technologies across the shipping value chain is limiting the adoption of digitization in ships. Successful transformation towards digitalization for the shipping industry will require updates and upgrades to accommodate the emerging digital trends[25] [26].

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

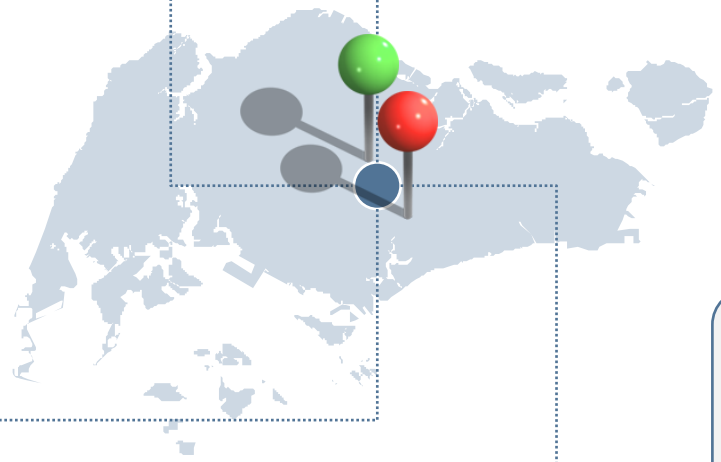
Source: Frost & Sullivan

Country Specific Initiatives and Future Roadmap

US is advancing in the arena of digital ships though research and development activities

The US Navy is adopting emerging technologies and initiating technical steps to expand AI and cyber security horizons for its growing ship-based ocean combat network, known Consolidated Afloat Networks and Enterprise Services (CANES).

US shipbuilding and cruise companies such as ABS, Mantis, Royal Caribbean, Carnival corporation are working on projects to perform diagnostics and other on-board maintenance and procedural tasks independent by leveraging AI technology.



The US navy is one of the leading player in adopting emerging technologies in the country. US Navy through its Cloud first policy its partnering with technology vendors to shift its owned-and-operated data centers to Cloud. Navy has initiated a research, development, test and evaluation (RDT&E) budget request of $20.5 billion, out of which $17.2 billion would be reserved for development of emerging technologies [25].

Augmented and Virtual reality technology area is being explored by US shipbuilding companies to impact the areas of digital shipbuilding, personalized customer experience, entertainment, training, visualization and simulation.

Autonomous Ships – USA

Autonomous applications in US maritime sector is lagging compared to autonomous applications for air and land based system. An autonomous surface vessel can be regarded as a remote ship that is equipped with advanced decision making mechanisms (with sensors and AI) for autonomous navigation, monitoring the on-board environment and performing rectification tasks, and other sub-tasks for efficient operation of vessel. Significant research is evident for autonomous surface vessels, although the technology is still in the development/concept stage.

List of Test Beds in US:

- **Great Lakes, Michigan Test Bed:** The Smart Ships coalition announced Great Lakes as the test bed for testing autonomous surface and sub-surface vehicles and related technologies. The test bed is open to all companies, research institutions and government agencies. The Great Lakes Research Center at Michigan Tech to supports an autonomous vessel test bed facility, and Marine Autonomy Research Site (MARS). All the operations at test bed location will be subjected to subject to US Coast Guard (USCG) regulations[27].
- **Boston Coast Trial Area:** In January 2019, US Navy has completed shipboard integration testing of the Knifefish unmanned undersea vehicle (UUV) and the Unmanned Influence Sweep System (UISS).
- **Sea Hunter Testing:** In January 2019, US Navy's unmanned surface vessel 'Sea Hunter' completed the first autonomous ship trial from San Diego, California to Pearl Harbor, Hawaii and back without the navigation and steering crew [28].

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team FINLAND MARKET OPPORTUNITIES

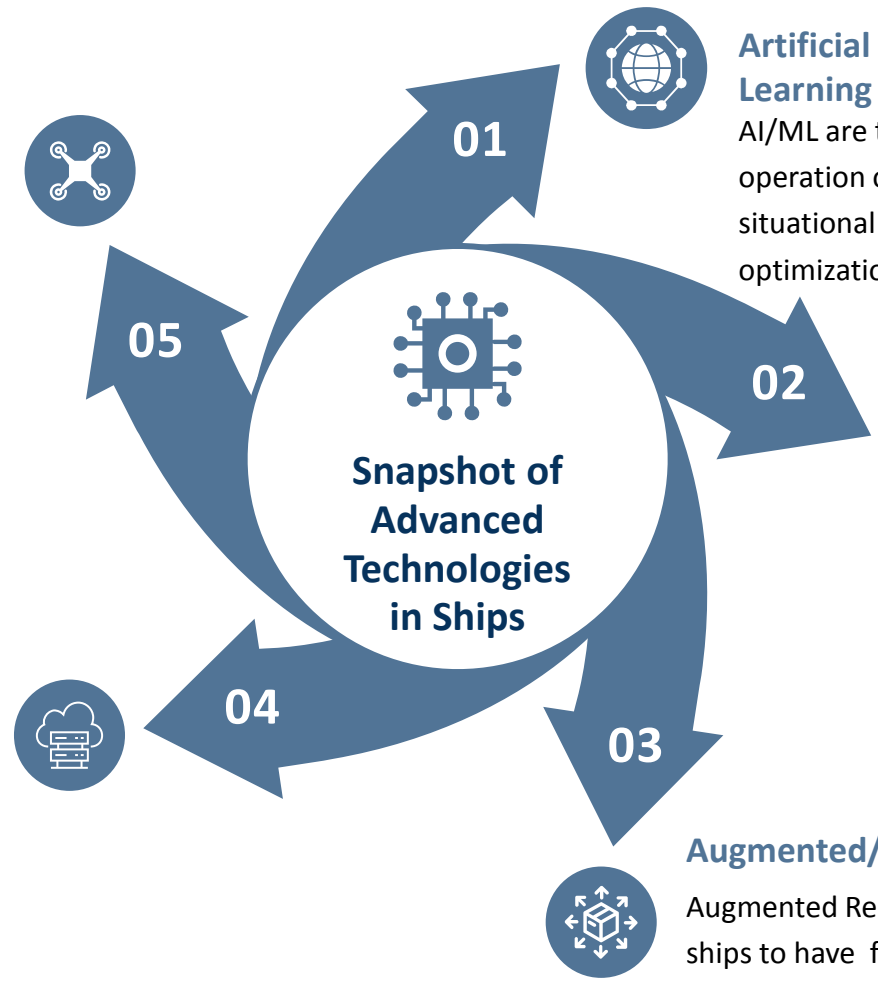
Future Watch

6.5 Country Benchmarking - Finland

FROST & SULLIVAN

Key Technologies Assessment

A mature ecosystem of companies in Finland has fuelled the country's emergence as a hub of marine digitization



Big Data

Big Data practices are being implemented to keep a close watch on ocean freight rates and to extract vital information about the vessel performance. [9] [10]

Artificial Intelligence/Machine Learning (AI/ML)

AI/ML are the enabling technologies behind operation of autonomous ships. Advanced situational awareness and navigation optimization using sensor data. [1] [2]

Blockchain

Blockchain promises to revolutionize the documentation and shipment tracking related procedures in the shipping industry. [3] [4]

Cloud

Logistics providers and port operators are adopting cloud services as a part of their digitalization efforts and to support various cost reduction and efficiency enhancement initiatives. [7] [8]

Augmented/Virtual Reality

Augmented Reality solutions are making it possible for ships to have features such as onboard real time visualizations for pilot assistance and is also aiding real time simulations for autonomous ships. [5]

Technology Development Status: Significance (1/3)

While AI is driving the marine industry towards autonomy, blockchain is helping companies reimagine their established business models to facilitate faster and more transparent transactions

AI/ML

- Finland's shipping industry is tapping into artificial intelligence to enable their digital transformation where AI is at the base of multiple pilot projects and trials.
- AI/ML algorithms are also the primary components of real time data collection, analysis and smart operations which act as an enabler for autonomous ships.
- AI systems will also be introduced in navigation and decision support systems to enable sailors take accurate and more efficient decisions.

1 2 3 4 5 6 7 8 9

Technology Demonstration

Blockchain

- Blockchain is being utilized to streamline processes being followed in logistics industry due to its fragmented and competitive nature.
- One of the primary motivations behind adopting blockchain is enabling traceability in supply chains where stakeholders can use data related to origin and processing of goods to verify the authenticity and legitimacy of the goods in transit.
- Digitization of documents and smart contract enabled payments and processing can also result in significant monitory as well as efficiency gains across the supply chain.

1 2 3 4 5 6 7 8 9

Technology Development

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (2/3)

AR has found application in on-board navigation and maintained whereas VR is helping fleet owners train their crew virtually in a realistic environment

Augmented / Virtual Reality

- Augmented reality will be deployed on board ships to enhance navigational safety on ship bridges. The technology is being considered by bridge system suppliers for providing enhanced visibility and to enable collaborative work among bridge teams.
- Among the use cases in focus is also the applicability of AR into maintenance and inspection. The usage of AR here is touted to help on-board engineers get real time support from onshore experts as and when needed.
- Virtual Reality is emerging as a promising technology to support the training and simulation exercises. VR based training is helping carriers simulate the sea conditions and test their staff to handle them.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

Cloud

- The advancements in various technologies related to shipping and logistics, cloud computing is emerging as one of the major enabler for boosting communications, operations and collaboration among workers in around the world.
- Ports and shipping containers are looking at cloud computing to facilitate secure data transfer between ships and ports across long distances.
- Various applications related to data analytics and operational efficiency management are also dependent on backend cloud infrastructure.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Big data implementations across fleets and ports is helping the industry in capturing and analysing vital data points related to their operations

Big Data

- Big Data technologies are being deployed in the maritime industry to capture a wide range of data points and to identify patterns of behavior from it.
- Companies have also adopted big data to optimize their business processes in accordance with the market trends.
- Big data practices have helped fleet owners keep detail record of vessel performance and plan their maintenance schedules accordingly.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Readiness Level

Denotes Significance

AI/ML Application Landscape and Case Studies (1/2)

Finland has gained edge in development and testing of autonomous ships owing to a range or research studies conducted in the region

Autonomous Ships

Autonomous ships or self sailing ships can decrease the potential of accidents and mishaps by eliminating the potential for human error. AI algorithms can take over the tasks of navigating a ship by keeping a track of vital information related to weather conditions and port conditions. [11] [12]

Performance Analytics

Data collected by automated systems is too complex and plenty for manual analysis. Machine learning techniques can improve the interpretation of data to create situational awareness by looking at the patterns emerging from data collected across a period of time. [13]

Asset & Energy Management

AI is being utilized to take decisions for ships as well as the whole fleet. Decisions based on predictive analysis of a range of variables can help fleet owners in cargo management as well as voyage scheduling and routing. [14]

Kongsberg & Finferries

- Kongsberg in collaboration with Finland's state owned ferry line Finferries demonstrated the world's first fully autonomous ferry in a voyage between Parainen and Nauvo.
- The vessel was monitored from a remote onshore operating center and used technologies such as sensor fusion and AI for navigation and collision avoidance.
- The demonstration was a part of Finferries' and Kongsberg's ongoing project named Safer Vessel with Autonomous Navigation (SVAN). [15] [16] [17]

Maritime AI-NAV

- Tallink Grupp, Fleetrange, Finnish Geospatial Research Institute (FGI) & Aalto University collaborated on a research project aimed at developing autonomous shipping solutions that offer safety at sea.
- Under the project the researches are using a variety of sensors in combination with technologies such as Radar Lidar ranging and satellite navigation for data collection.
- AI/ML techniques are being deployed to process the collected data. [18]

AI/ML Application Landscape and Case Studies (2/2)

AI solutions will have to be combined by edge intelligence to make the systems truly independent and capable of handling critical scenario without on-shore data processing

Conexbird

- Conexbird in collaboration with Multi-Link terminals is building world's first port that uses intelligent container cranes to optimize container flow.
- The technology provides a web based user interface for stakeholders to access information on container condition in real time.
- The solution named Conexbird OnFly will be initially deployed on container cranes at MLT Kotka port in Kotka, Finland. [21]

Kalmar Global

- Kalmar Global, a Finland based manufacturer of cargo-handling equipment and a provider of cranes and reachstackers to major Finnish ports has deployed AI based predictive condition monitoring into its reachstackers.
- The company's mobile equipment includes a gateway solution connecting the machine securely over the internet to the Kalmar Cloud to collect telemetry data. [20]

Ericsson

- Ericsson is working on a project under Finnish research and innovation program called Design4Value (D4V).
- Under the project Ericsson is working on developing autonomous ships that sail between multiple harbors and takes advantage of technologies such as edge computing and machine learning.
- The solution developed by Ericsson deploys machine learning in decentralized fashion to make the most of the limited amount of available computational resources. [22]

Blockchain Application Landscape and Case Studies

Blockchain adoption would enable a more automated and efficient transaction process with higher tractability and collaborativeness

Eliminating and Automating Manual Tasks

Logistics value chains are characterized with manual processes mandated by regulatory authorities. Companies are forced to rely on manual data entry and paper based documentation for customs processes. Blockchain can help overcome this friction by substituting paperwork with a trust based mechanism inbuilt in the blockchain. [24]

Shipment Tracking & Transparency

Authenticity is a concern for many stakeholders in the logistics ecosystem. A number of initiatives in blockchain are focusing on tracking of goods in real-time and to gather and share data on the origin and management of goods in transit. [25]

Payment Facilitation and Smart Contracts

Cross border trade always involves complex procedures on payments where bank guarantees and L/Cs have to be procured. Using blockchain this process can be automated where a blockchain based smart contract can act as a smart contract between the buyer and seller bypassing the need for a bank and eliminating the paperwork needed for the process.

Kouvola Innovation Ltd

- In 2016, Kouvola Innovation Ltd, an economic development fund owned by the city of Kouvola received €2.4m to help pay for a project designed to streamline the supply chain using blockchain.
- Under project named SmartLog the city developed a proof-of-concept to create a global blockchain platform for the logistics industry and give containers the ability to "dynamically" organize their own routes.
- Kouvolo Innovation was one of the initial members of IBM's blockchain-as-a-service for developers. [23]

Wärtsilä

- In 2017, Wärtsilä opened up Digital Acceleration Centers around the globe to speed up the innovation and co-creation with customers on a range of new business models and solutions.
- The first center opened in Helsinki, Finland worked on Intelligent Vessel Strategy developed in collaboration with a major cruise companies.
- These centers are focusing on technologies such as AI/ML and Blockchain and their applicability in commercial applications. [26]

Augmented/Virtual Reality Application Landscape and Case Studies (1/2)

AR solutions have helped ship crews have better visibility of their surroundings in unfavourable climatic conditions

On-Board Display

Ship crews have to be aware of a multitude of data points generated from complex instrument clusters while being aware of their physical surroundings often in situations of low visibility. AR based displays in this case can put all the important data right in front of their eyes. This can vastly improve situational awareness among the crew and help them make sound decisions. [27]

Maintenance & Inspection

Cargo ships are equipped with a wide range of instruments and equipment which can fail during voyage. At the same time ships do not have experts onboard for each and every equipment. Using AR based offline troubleshooting manuals or online expert help would enable ship crew to conduct maintenance activities with utmost precision. [28]

Training & Simulation

VR is being used to recreate realistic environments to train ship crews, simulating events that they might be faced with on a voyage. [29]

SEDNA Project

- The SEDNA project which has 13 partners across Europe including Aalto University and Aker Arctic Technology of Finland is working on development of AR based bridge systems to improve navigation safety and efficiency in Arctic ship operations.
- The project is focused at addressing the challenges in Arctic Navigation including the voyages through ice, where the visibility and maneuverability conditions are extreme. [30]

Wärtsilä

- Wärtsilä is developing use cases leveraging Augmented Reality to support repair and maintenance operations on ships in dry docks or in voyage.
- The company plans to equip ship crews and shipyard personnel with AR headsets or Smart Glasses to help them troubleshooting manuals and to contact experts on the go when need be. [31]

Augmented/Virtual Reality Application Landscape and Case Studies (2/2)

VR has empowered fleet owners to impart realistic training to their crew on-shore to train them better for their job

VTT & Kongsberg

- VTT Technical Research Center of Finland and Kongsberg are working on a concept of augmented reality systems for command and control center of cargo ships. [32]
- The plan put forward by Kongsberg plans to use the windows of the bridge as augmented reality displays of the vessels surrounding a visual portrayal of potential hazards that would otherwise be invisible to the human eye. [33]

Fake Production oy & Telia

- Fake, a Finnish startup developing advanced VR solutions has partnered with Telia and joined the Telia 5G Finland network to gain a first mover advantage in 5G enabled VR tech.
- The company has discussed about the potential of developing VR enabled digital twins in order to create a realistic virtual environment for remote ship operation or training. [34]

Cloud Application Landscape and Case Studies

Cloud and SaaS applications has enabled shipping companies maintain centralized data management systems and apply centralized data policy between global locations and ships on voyage

Integrated Freight Management

Software as a Service model has enabled multiple stakeholders across nations in the logistics value chain maintain their transactions on a single platform and has thus enabled efficient management of databases.

Data Collection & Management

The deployment of multiple sensors on board ships also results in the influx of a large amount of data. Ships are maintaining satellite uplink to update sensor reading data to centralized cloud systems which keep a constant track of vital data points and also develop patters of behavior which can help analysts notice irregularities.

Fuel Procurement Management

Cloud based procurement systems are also helping fleet owners manage procurement of bunker fuel. Cloud based systems can help companies capture fuel prices from a variety of sources and match it with ship locations.

Fleetrange

- Fleetrange, is a Espoo based startup that offers cloud solution aimed at helping companies improve their safety and service levels.
- The company's solution BOQA (Bridge Operational Quality Assurance) is designed for captains and fleet managers. The system helps them automatically track operational events such as heavy weather and restricted area entries.
- Fleetrange also provides an optional IoT unit which captures real time data from vessels such as ship-tracking, traffic-monitoring, vessel motion and live video. [35] [36]

Steveco

- Two of Steveco's Container Terminals Vuosaari at Helsinki and Mussalo at Kotka have become world's first ports to go live with Navis's N4 terminal operating system in a hosted private cloud environment.
- As a part of the implementation Navis servers and backend databases are being hosted in a private cloud data center and the implementation is expected to infuse reliability and efficiency into the port operation. [37] [38]

Big Data Application Landscape and Case Studies

Big data has enabled a more granular tracking of vital signs of a ships performance and the external factors affecting it

Chartering

Charterers perform the task of finding the right ship for the cargo at the most economical price point. Using big data analytics, charters can integrate multiple variables and evaluate a wider list of all possible options and keep track of the freight costs over time and develop their business models accordingly.

Operational Efficiency

Ships have to maintain an optimum speed for minimize fuel consumption. However the determination of the optimum speed depends on a variety of factors such as engine wear, maintenance and the climatic conditions. Big data algorithms can automate the process of calculating the optimum speed.

Vetting and Vessel Records Management

Cargo ships have a long serving life and have to maintain detail maintained records throughout their life . A detail record of the vessel related events organized using big data practices helps operators ensure their fleet is in operating condition and helps them predict downtime and align their maintenance schedule accordingly.

Helsinki Smart Shipping Cluster

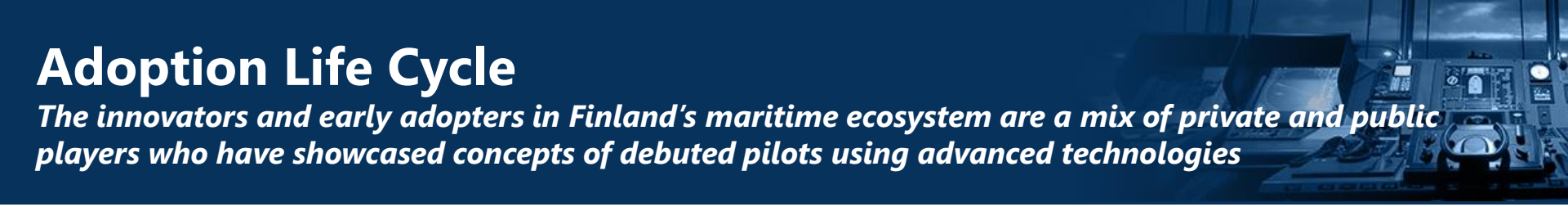
- Helsinki is developing a smart shipping cluster by bringing together expertise from the country's IT sector with the maritime industry.
- Big data systems are one of the key component of the overall development strategy.
- Under the MERIT project by City of Helsinki, marine technology companies are coming together with small and large ICT companies offering smart solutions. [39] [40]

Kongsberg & VTT

- The Future Operator Experience concept by Kongsberg and VTT imagines a future with smart workstations which uses facial recognition and other markers.
- The project is looking at Big Data to enable advanced decision making on monitoring, navigation and propulsion. [41] [42]

Adoption Life Cycle

The innovators and early adopters in Finland's maritime ecosystem are a mix of private and public players who have showcased concepts of debuted pilots using advanced technologies



	Innovators & Early adopters	Early & late majority	Laggards
AI/ML	KONGSBERG, ERICSSON, FinFerries, KALMAR	Fleetrange, NLS Finnish Geospatial Research Institute FGI, CONEX BIRD	
Blockchain	Kouvola.innovation, WÄRTSILÄ		
AR/VR	KONGSBERG, Sedna, WÄRTSILÄ	Telia, FAKE	
Cloud	Fleetrange, STEVECO		
Big Data	KONGSBERG, VTT, AWAKE.AI		

Stakeholder Ecosystem and Initiatives (1/2)

A strong push from academia towards stronger AI education has helped Finland gain an edge in terms of availability of talented employees

Organization	Technology	Application
Kongsberg & Finferries	AI/ML, Big Data	Autonomous Ships, Navigation and Collision Avoidance
Tallink Grupp, Fleetrange, Finnish Geospatial Research Institute (FGI) & Aalto University	AI/ML	Vessel Safety, Autonomous Ships
Conexbird & Multi-Link terminals	AI/ML, Big Data	Intelligent Container Cranes
Kalmar Global	AI/ML, Cloud	Predictive Intelligence
Ericsson	AI/ML, Edge Computing	Autonomous Ships
Kouvola Innovation Ltd	Blockchain	Supply Chain Automation, Smart Containers
Steveco	Cloud	Reliability and Efficiency Enhancement

Stakeholder Ecosystem and Initiatives (2/2)

Collaborations among private and public institutions is driving digitization efforts in the Finnish shipping industry

Organization	Technology	Application
Wärtsilä	Blockchain, AI/ML	Intelligent Vessel Strategy
SEDNA Project	AR	Navigation safety and efficiency
Wärtsilä	AR	Repair and maintenance
VTT & Kongsberg	AR	Command & Control, Ship Navigation
Fake Production oy & Telia	AR	VR enabled Digital Twins
Fleetrange	Cloud	Operational Event Tracking, Safety & Service Efficiency
Helsinki Smart Shipping Cluster	Big Data	Smart Shipping Solutions
Kongsberg & VTT	Cloud	Smart Workstations, Monitoring, Navigation and Propulsion.

Factors Influencing Adoption: Drivers

Finland is a conducive ecosystem for digitization initiatives due to the presence of a wide range of players in the ecosystem

Mature Partner Ecosystem

Finland has one of the most mature ecosystems when it comes to ship designing, building and marine research. Equipment and service providers for a wide range of functions involved in the maritime business are available or based out of Finland. This includes engineering companies such as Deltamrin and Elomatic, engine and propulsion providers ABB, Kongsberg and Wärtsilä and many others. Finland is especially known for being a global leader in icebreaker design and polar shipbuilding. The country has designed over 80% of the world's icebreakers and has also built and designed the largest cruise ship in the world. [43] [44]

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Digitization and Modernization Initiatives

The government of Finland has made significant investments towards digitization which has helped the maritime industry in upgrading their practices. The Finnish government's plan to educate at least 1% of its population with AI is expected to help the country solidify its position as the leader in AI based applications. Multiple cities such as Helsinki and Tuvalu have invested significantly in upgrading their technological infrastructure, while government agencies such as VTT have been the backbone of autonomous ships project. [45] [46]

Short-Term - **Medium**	Medium-Term - **High**	Long-Term - **High**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

A delicate ecosystem surrounding the Finnish waters may negatively affect the shipping industry in the country

Legal and Regulatory Hurdles

The maritime and logistics industry is subject to a range of laws and regulations from governments across the world. Innovations in technologies such as AI and blockchain are bound to bring fundamental changes in the operations and business models of shipping companies. As a result of this many technologies that portray a game changing potential in pilot phase might not immediately get deployed commercially. While Finnish government has shown leadership by amending the legislation to allow remote pilotage, there is still a long way to go to accelerate technological innovation in the space. [47]

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Medium**

Environmental Considerations in the Arctic Sea

Arctic sea is characterized with a highly sensitive environmental ecosystem and the atmospheric changes in the arctic have widespread implications on the global weather systems. Considering this the International Maritime Organization has started the process to force ships to use cleaner fuels in the north pole region. While Finland has supported and welcomed the decision, it can be predicted that such ban on HFO (Heavy-Fuel Oil) can also negatively affect the shipping industry of the country as presently 80% of marine transport worldwide uses HFO. [48] [49]

Short-Term - **Medium**	Medium-Term - **High**	Long-Term - **High**

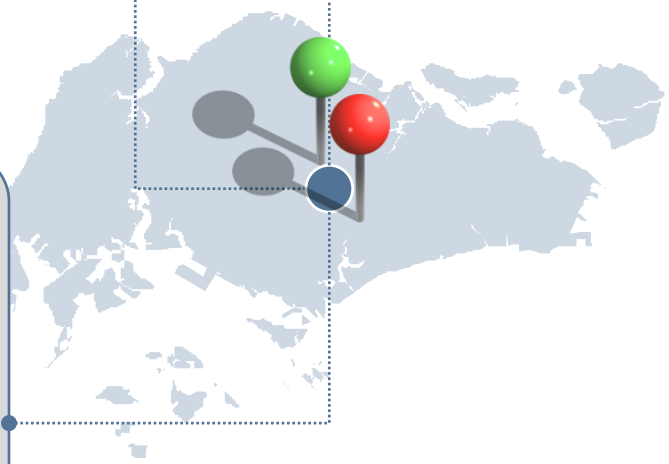
Source: Frost & Sullivan

Country Specific Initiatives and Future Roadmap

Academic institutions and private companies have taken steps to strengthen the underlying ecosystem behind marine digitalization

Finland has recognized the value in AI disruption and has taken steps to train its citizens in AI. The government has debuted a program under which it plans to impart AI education to 1% of its population. University of Helsinki and Reaktor have collaborated for the initiative and have seen participation from over 90,000 students. [50] [51]

DIMECC, a Finland based Co-creation platform provider is leading an ecosystem to enable fully autonomous marine transport in the Baltic sea by 2025. The ecosystem currently has over 80 companies and has facilitated multiple trials in the autonomous ships area. About half of the funding for the ecosystem's project has been sourced from Tekes – the Finnish Funding Agency for Innovation. [52]



Private companies in Finland have also weighed in to enable innovations in shipping. Nokia is working with Ukkoverkot to deploy a LTE network at the port of HaminaKotka, allowing the port to develop digital solutions like the Internet of Things (IoT). Ericsson has also tested its 5G systems and is looking to develop applications for ferries and cruise ships on basis of their technology. [53] [54]

Autonomous Ships – Finland

Finland has started pilots of Autonomous ships and has established a dedicated test beds for the same. The One Sea Ecosystem by DIMECC has seen participation from major industry players such as ABB Marine and Ports, Ericsson and Kongsberg.

Kongsberg is planning to develop projects focusing on landbased control centres, and artificial intelligence for developing remote and autonomous shipping operations in the future. Moreover, Kongsberg and Stena Line work together to develop intelligent awareness for ships.

Awake AI is a Smart Port and Ship platform enabling data exchange for autonomous shipping.

List of Test Beds in Finland:

- **Jaakonmeri Test Area:** The Jaakonmeri Test Area was launched in August 2017 with by DIMECC under the One sea ecosystem. The test area is open to all institutions who wish to test autonomous maritime traffic, vessels and related technology. The area also offers partners with the opportunities to test their vessels in adverse winter conditions. [55] [56]

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team FINLAND MARKET OPPORTUNITIES

Future Watch

6.6 Country Benchmarking - HOLLAND

FROST & SULLIVAN

Key Technologies Assessment

Holland has adopted the novel emerging digital technologies for testing in their ports and is expected to be a key player in global marine market.

Sensors

In the Netherlands, the use of wireless sensors is rapidly increasing in marine sensing applications owing to the convenience of wireless remote controlling and monitoring operations. Intelligent wireless sensors have built-in energy harvesting capabilities and data processing algorithms.

Artificial Intelligence (AI)

AI enables enhancement of conventional exploration and research methods in underwater marine system development

Robotics

The shipping Industry can rely on robotic technologies such as collaborative robots, swarm robots, autonomous unmanned vehicles, and drones, as well as advanced versions of traditional robots for collaborating satellites and UAVs for ship tracking, pollution and traffic monitoring.

Big Data

With the utilization of Big Data, warnings on Tsunami and red-tide, prevention, forecasting, disaster inversion, and visualization modeling after disasters can be analyzed.

Blockchain

Blockchain will permit transporters to digitize and organize their risky goods documents and automatically connect with relevant parties to streamline the approval process. In the Netherlands, terminals operators and software developers have congregated to form a new shipping blockchain.

Automation

Automation techniques such as video analytics, security and surveillance will make vessel operations easier, safer and efficient navigation by monitoring and controlling all the propulsion and machinery from offshore.

Technology Development Status: Significance (1/3)

Sensors and Robotics are widely adopted in Holland for various maritime applications testing.

Sensors

- Sensors play an important role in the development of innovative marine devices and are used for detection of various ocean parameters, such as pressure, flow, temperature, and other ocean ecosystems.
- Sensors for marine applications are considered to be significant due to their ability to provide real-time monitoring alerts to the user via smartphones or personal computers.
- In Holland, several sensor start-up companies are focusing on developing sensors that can be integrated on vessels for operating in polar/tropic regions, while ensuring optimal performances of marine engines on passenger vessels or cargo-ships.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

Robotics

- Robots will perform the majority of tasks such as engine maintenance and ship inspection for the shipping and logistics industries.
- Many start-ups originating from universities have the most state-of-the-art knowledge.
- In Holland, there are several robotics companies focusing on certain areas such as precision techniques where they need to be integrated within different technologies.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (2/3)

AI and Blockchain technologies are tested and developed in parallel that aids in digital transaction and predicting the hazardous situations during navigation

Blockchain

- Blockchain technology plays a vital role in the shipping industry by eradicating the paper-work based ledger in cargo shipments. Before the advent of blockchain technology, several documents were needed to approve departure and entry into the shipping port. Hundreds of pages are required to be submitted to banks, agencies, customs and other entities for a single shipment. Blockchain has overcome these limitations by digitizing the transit procedures.
- In Holland, the Dutch government is driving the development of new prototypes, project implementation, and international partnerships with the EU Forum, World Bank and the United Nations. The country has also launched government-aided blockchain pilot projects for the shipping industry.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

Artificial Intelligence

- Integrating Artificial Intelligence (AI) in Autonomous Underwater Vehicles (AUVs) and Remote Operated Vehicles (ROVs) reduces object collisions and improves autonomous navigation.
- ROVs built with the fuzzy logic control method provides a ubiquitous solution in obstacle avoidance in the three-dimensional space.
- Holland has been already leveraging AI in automated loading cranes at Rotterdam port. Based on the analysis, AI takes decisions on uploading and downloading items in container ship.

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System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Automation and Bigdata will drive Holland's marine sector, since majority of the decisions are based on captured data

Big Data

- In the shipping industry, millions of data points are generated from various sources such as vessel movements and ports. Companies can gather these data points for identifying efficiencies such as preferred ports or quicker routes.
- Big data will support in remote monitoring shipping activity to support sustainability.
- In maritime, big data is used for monitoring the vessels in real-time and analyzing the performance and navigation of the ships from built-in sensors and data acquisition systems.

1 2 3 4 5 6 7 8 9

Technology Concept/ Proof of Concept

Automation

- Automated Video Analytics in the maritime sector will enable the processing of real-time video input and assessment of potential threat in a given maritime scene. Maritime target segmentation/detection, classification of each detected target, tracking each target of interest (performed on each frame) to derive motion information, range estimation (if necessary) to extract the location/position relative to the ship.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Sensor Application Landscape and Case Studies

Innovations in sensor technology will enable high safety and secured navigation of ships

Sensors play an important role in the marine segment. The demand for sensor technology is very high in the implementation of underwater marine systems that aid in search and survey missions, climate recording, pollution monitoring, predicting natural disturbances, and marine life studies. The key sensor technologies that impact underwater marine systems include: acoustic sensors, image sensors, and wireless sensor networks.

- **Image sensors** with 3D vision will enable underwater applications, such as monitoring of underwater ecosystems, avoiding collision with objects, autonomous navigation and surveillance. Image sensing techniques will transform the underwater industry by providing 360 degrees surround view cameras for autonomous AUVs and ROVs.
- In underwater applications, acoustic signals travel better than radio waves and light waves. **Acoustic sensors** are increasingly deployed for underwater applications. Some of the underwater marine applications enabled by acoustic sensors are bath velocimeter, acoustic holography, underwater target detection, object classification, subsea geological mapping and profiling, seismic simulation and measurement, and tsunami detection. Acoustic sensors are utilized in underwater telephones, telemetry, and underwater sensor networks.
- Adoption of wireless sensor networking technology in underwater observatories has the potential to improve the quality of monitoring significantly, using the **wireless sensor network's (WSN's)** on-board computational, sensing, and wireless communication capabilities. The WSN sensor nodes and algorithms help locate, detect, and inspect the structural damage caused by loading events and progressive environmental deterioration.

Intertech B.V & Datum Electronics

Intertech B.V. and Datum Electronics Ltd have partnered for demonstrating Datum's products such as; torque sensors, torque transducers, torque meters, marine shaft power meters, and wind turbine condition monitoring systems. [1].

Vicrea and Libelium

Libelium and Vicrea have partnered and developed a wireless sensor network for managing canal traffic by controlling the flow of boats in the Netherlands. The companies have also developed a novel laser solution for monitoring speed, distance and direction. The sensor is also used for detecting any ship and also determine the ship movement. [2]

Robotics Application Landscape and Case Studies

Leveraging Robotic technology for marine application will eliminate the need for a human workforce for hazardous tasks

- Currently, in marine sector, most of the activities are carried out manually by crew members and examples of tasks include cleaning, ship inspection, and ship patrolling. This in turn requires large crews that have to be on-board along the ship‘s journey, which would eventually increase the cost for manning.
- Shipboard robots are automated machines that are used to perform tasks as programmed or assist humans who provide solutions for complications that arise inside a ship.
- An unmanned underwater vehicle is a vehicle or a robot that is able to operate under water without the physical presence of a human operator inside it. It is either controlled remotely by an onshore human operator or through autonomous operations. It can be further be classified into remotely operated vehicles (ROVs) or autonomous underwater vehicles (AUVs). Underwater applications are risky and tough for humans to operate, hence, usage of robots to replace humans will be an ongoing trend.

RanMarine Technology B.V.

RanMarine based in Rotterdam has developed an underwater drone called the “WasteShark” for clearing the litter from water. The drone serves as the smart vacuum cleaner that sweeps up the garbage in the water without harming the aqua life. [3]

Kranendonk

Kranendonk, a robotic supplier, aids in high-end automation solutions for the shipbuilding industry from profile cutting to pipe shop through effective and efficient usage of CAD-connected robot lines. By leveraging smart robotics technology, cutting and welding processes can be automated throughout the shipyard. [4].

Blockchain Application Landscape and Case Studies

Blockchain will enable companies to reduce processing time and eliminate paperwork ledgers in the marine supply chain

Blockchain technology enables the efficient flow and tracking of goods, eliminating unnecessary delays and costs. It also provides trust and transparency in the supply chain, which reduces errors and fraud. Some key significant applications of blockchain technology:

- **Storage on the distribution cloud:** Instead of relying on data storage services in a centralized cloud, such as Dropbox, Amazon, or Google Drive, blockchain technology offers the ability to store data and files in a P2P network (peer-to-peer), that is, stored by multiple network members.
- **Automated Security:** The combination of digital identities based on the blockchain: smart contracts and electronic locks of the Internet of things, will allow the creation of automated security systems that provide or hinder access in a fully automatic mode.
- **Online payments:** One of the main uses in this industry is based on the ability of blockchain to make it more simple and reduce the cost of micro-transactions. With the help of blockchain, a company will be able to provide automatic access to the product, right after the buyer makes a corresponding payment registered through blockchain.

ABN AMRO, the Port of Rotterdam Authority and Samsung SDS

ABN AMRO partnered with the Port of Rotterdam Authority and Samsung SDS for developing a container logistics pilot platform using blockchain technology for efficient and paperless administration processes for the international finance and logistics within distribution chains. [5]

GoodFuels Marine and BLOC

GoodFuels Marine and Blockchain Labs for Open Collaboration (BLOC) have completed the bunker delivery and transaction by utilizing the blockchain technology. The transaction was delivered to Samskip vessel through a REINPLUS FIWADO Bunker barge in Rotterdam. [6]

AI Application Landscape and Case Studies

Integrating AI in ships will enable autonomous navigation and motion algorithms by predicting the impending marine ecosystem diagnostics.

- Machine learning and artificial intelligence are employing a increasing impact on port operations through applications such as addressing many of the incompetence characteristics, maximizing the productivity of terminal machinery and remote monitoring in the maritime supply chain. Technological innovations in underwater vehicles are trending toward miniaturization, which enables scalability. This will inherently reduce vehicles' size and component cost, and enhance its' functional/operational characteristics. Another trend exhibited currently is the development of bionic underwater vehicles. Bionic underwater vehicles are adaptively controlled vehicles that leverage **artificial intelligence**, machine learning algorithms, and neural networks for autonomous navigation and motion algorithms.
- Since many marine devices are connected to the Internet, volumes of data will be generated. AI collects this data and makes inferences, predicts the impending marine ecosystem diagnostics based on complex analysis algorithms. With the combination of IoT (for periodic control) and AI (for analysis process), connected marine devices will become "smart" to "intelligent" over time.

Port of Rotterdam and IBM

Port of Rotterdam has partnered with IBM for leveraging AI and IoT for improving efficiency and enables the Dutch port to host autonomous ships by 2025. [7]

Big Data Application Landscape and Case Studies

Data insights on the environmental and situational awareness by utilization of big data

- Big Data analytics plays a vital role in disrupting the marine market. In general, connected devices certify a constant stream of data inflow. By leveraging analytics, IoT platforms can enhance the insights gained from the data. From these insights, ship operators/owners can make decisions on vessel maintenance such as propeller polishing and hull cleaning, thus creating an era of “Digital Ships” or “Connected Ships”.
- Big data analytics also allows ship operators to determine the ideal speed for fuel consumption, considering factors such as freight rates, schedules and bunker cost. The data on fuel consumption data can also be used for cost-benefit analysis of vessel maintenance.

Port of Rotterdam

Port of Rotterdam has applied big data analytics for monitoring the sustainable supply chain analysis for Reefer containers.

We4Sea

We4Sea has launched a new project for aiding ship owners to reduce CO2 emissions and increase the fuel efficiency by utilizing big data technology. This project aims in providing the detailed insights on technical, logistical and operational features in a ship, while these features have an high impact on the fuel efficiency. [9]

Automation Application Landscape and Case Studies

LiDAR and Camera systems aiding the autonomous ships with great accuracy and precision in navigation

- Autonomous machines can be regarded as self-governing devices or systems that are able to make decisions independent of human input. The machines are equipped with various sensors, such as motion sensors (for trajectory and object tracking), touch sensors (for detection of the external environment) to send information to the data processor of the machine. Cameras and LIDAR are equipped for navigation and collision avoidance of the robot.
- Functions are performed in a sequence by the machine as programmed by an operator. The machine disregards the external environment when performing tasks. The machine is able to make decisions without human input or guidance under various external environments with the help of sensors and artificial intelligence.

Praxis Automation Technology and WEG Electric Equipment

Recently, Dutch based Praxis Automation Technology and Brazilian based WEG Electric Equipment signed up a Memorandum of Understanding (MoU) for supporting the bidding of Saab and Damen Shipyards Group for building 4 corvettes for the Brazilian Navy. Praxis and WEG will be associates for supplying the complete Integrated Platform Management System (IPMS). [10].

Marble BV

Marble BV has developed a ship automation system called MS-3080 for generating alarm, monitoring and controlling the interior subsystem of the ship. [11]

Adoption Life Cycle

Port of Rotterdam has been the major test-bed for emerging technologies

	Innovators & Early adopters	Early & late majority	Laggards
Sensors	Intertech b.v.	SIRI MARINE; datum electronics; libelium	VICREA
Robotics	RANMARINE technology	AQUATIC DRONES	KRANENDONK Smart robotics
Blockchain	GoodFuels	Port of Rotterdam; CARGOLEDGER	
Artificial Intelligence	IBM; Port of Rotterdam		
Big data	Port of Rotterdam; we4sea efficiency solutions for ships		
Automation	PRAXIS AUTOMATION TECHNOLOGY	MARBLE	

Stakeholder Ecosystem and Initiatives

Sensors and automation techniques have been the key focus area for the stakeholders in developing digital ships

Organization	Technology	Application
Intertech B.V	Sensors, power transmission and motion control.	Marine shaft power meter systems, Naval shaft power meter
RanMarine Technology B.V.	Autonomous Drones	Extracts unwanted material and gathers data about the marine environment.
Kranendonk	Robotics	Shipyard automation
GoodFuels Marine and Blockchain Labs for Open Collaboration (BLOC)	Blockchain	Bunker delivery and transaction
Port of Rotterdam and IBM	Artificial Intelligence	Autonomous Ships
We4Sea	Bigdata	Reducing CO_2 emissions and increasing the fuel efficiency
Praxis Automation Technology	Automation	Control and Navigation Systems
Marble BV	Automation	Control and Navigation Systems

Factors Influencing Adoption: Drivers

Advent of IoT and Government support has been the key for Holland's growth in marine sector

Advent of IoT

Adoption and proliferation of the Internet-of-Things (IoT) will provide an impetus for wide-scale adoption of smart sensors. The small size, low power, signal processing, and communication capabilities of the sensors will prove to be key success factors driving growth opportunities in marine industry. Rotterdam port in the Netherlands leverages Automatic Identification System (AIS) data for monitoring vessel arrivals, berthing and departure times accurately.

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Government Initiatives

The Dutch government have formulated a shipping policy that enables ship owners to maintain their vessels on profitable and competitive terms by retaining a high-quality reputation, strong maritime environment and creating a level playing field for its ship owners. This policy also allows ship owners to determine annual fiscal profits on the basis of ship tonnage. Having a Dutch flag allows companies to leverage additional fiscal measures, apply crew regulations and reduces 30% cost in employing Dutch crews. In addition, the Dutch government is supporting and conducting extensive research in the development of the Dutch Maritime Network (Stichting Nederland Maritiem Land) and the branding of its trademark "Maritime by Holland". [13]

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Extensive R&D and maritime infrastructures

The huge disparity in the Netherland's marine infrastructure has prompted Dutch government to allocate more public funding toward better marine services in terms of deploying remote ocean and environmental monitoring. These services require connected devices and efficient networking technologies, which is a great boost toward adoption of IoT. The Netherlands marine industry has been supported by the Dutch government by creating positive conditions for further development of maritime expertise. MARIN, well-known for its research in ship building, ship design and ocean engineering, is boosting the Netherlands marine market by developing innovative research projects. The Netherlands maritime infrastructure has a compact matrix of services in the areas of maritime administration, finance, insurance, accountancy, brokerage, chartering, chandlering and waste disposal.

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Medium**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

Accessibility and Environmental Safety have been the major challenges hindering Holland's maritime growth

Accessibility

Transforming the Netherlands as a logistic hub requires further improvement of accessible infrastructure for the country to be positioned as a maritime nation. All the modalities must be organized, where in particular, the inland waterways and short sea transport offer excellent opportunities that increases Netherlands' accessibility and reduces the existing congestion. [14]

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

Environmental Safety

At the environmental level, the challenge resides in the advancement of sustainable usage of the sea and seaports and in the reduction of emissions. The expected growth in transport, the anticipated decline of fossil fuels and raw materials and the tightening of international environmental legislation will require additional efforts by the maritime cluster. However, the government is supporting the country by taking initiatives such as the pursuit of 'zero emission vessels', by eliminating legal barriers for innovation, enabling the vessels and their activities to become cleaner and safer.

Short-Term - **High**	Medium-Term - **High**	Long-Term - **High**

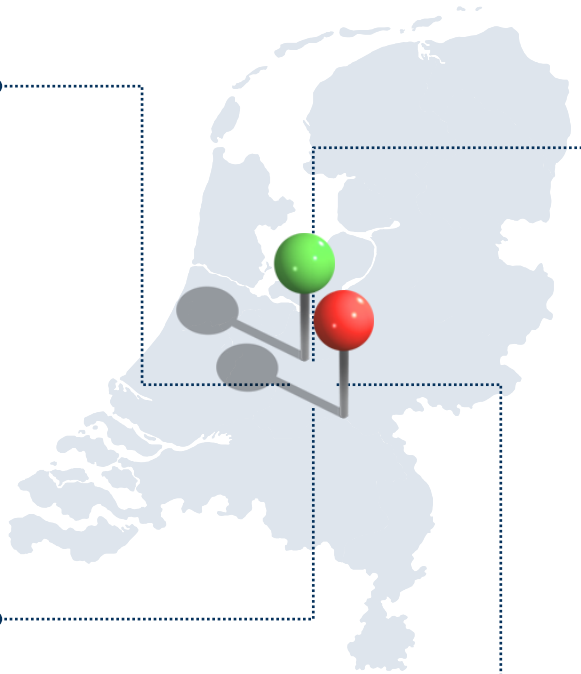
Source: Frost & Sullivan

Country Specific Initiatives and Future Roadmap

Holland has carried out several research projects for digitizing the country's maritime sector

At the occasion of a Dutch water and maritime trade mission to Poland, the Dutch partnered with Poland for developing the marine project called "the Room for the River project" where all main Polish rivers will be used for inland navigation by 2030. [15]

At the UK-Netherlands Innovation Showcase event, the Dutch and UK ministers have made a commercial agreement that includes Royal IHC, a Dutch supplier of ground-breaking and efficient equipment, ships and services for the offshore, dredging and marine mining markets, has planned to inaugurate new offshore base in Newcastle. [16]



Oman Maritime Water Treatment made a joint venture with the Nature Group of the Netherlands, Ramky Enviro Engineers and Khimji Ramdas for constructing a complete International Protocol of Marine Pollution (MARPOL) compliant facility at the shipping port, ensuring ship disposal and waste collection are carried out in compliance with MARPOL [17].

The Port of Rotterdam in the Netherlands aims to be prepared for autonomous ships by 2030. With other countries, the Netherlands are operating maritime autonomous surface ships (MASS) and will be undergoing legal and regulatory reviews. [18]

Development Status of Autonomous Ships

Several research institutes and startups have started piloting of autonomous vessels

- A Dutch consortium has launched a Joint Industry Project (JIP) for studying and demonstrating the technical opportunities for autonomous shipping. The Delft University of Technology, MARIN and the Netherlands Organisation for Applied Scientific Research (TNO) are researching on autonomous vessels. This research work is developed along with industrial partners, the Dutch Ministry of Infrastructure and Water Management, the Dutch Ministry of Defence, a classification society, the Dutch pilot sector, and the educational institutes Maritime Institute Willem Barentsz, the Shipping and Transport College and Rotterdam Mainport Institute [19].

- MIT and Amsterdam Institute for Advanced Metropolitan Solutions (AMS) are developing 5 year research project called the “Roboat” that supports in garbage collection, delivery services, transportation and infrastructure [20].

- Xomnia, a Holland based Big data company has developed a self-driving boat based on AI and deep learning technologies. The self-driving boat is integrated with five cameras serving as eye vision. The captured images are transmitted to the deep learning network that serves as brain. Through this process, the boat automatically navigates based on the gathered data and experience [21].

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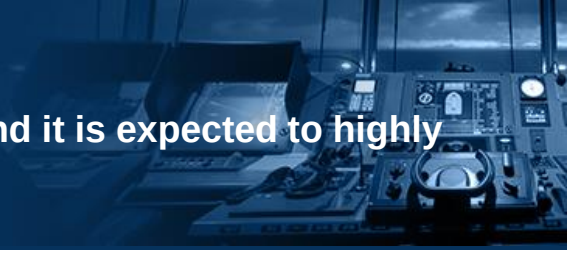
Future Watch

6.7 Country Benchmarking - JAPAN

FROST & SULLIVAN

Key Technologies Assessment

Japan has tested all the emerging technologies for building a smart ship and it is expected to highly impact the global marine industry



Sensors

Advancements in sensor technologies have changed remote sensing into an operative means of monitoring marine areas. Various sensors and remote sensing platforms have their self-competences for monitoring and mapping water pollution of various types, concentrations and characteristics. Presently remote sensing provides multiple airborne and satellite sensors for acquiring data on the dynamics of marine regions.

Mixed Reality

Mixed Reality will transform marine maintenance services, by simplifying the troubleshooting process and speeding up the repair and service works. Moreover, tasks such as inspections, on-site machining, alignment measurements, newbuilding commissioning and shaft straightening are performed fast and simple.

Artificial Intelligence

Artificial intelligence (AI) can gather and analyze the data for the container shipping industry to sketch out the plans accurately. AI can also be used for forecasting whether the container will get rolled by the carrier/left on the dock or if the shipping operator will cancel the booking.

Cybersecurity

In the marine sector, integration of cyber security will aid in key areas such as risk and technology assessment , functionality and reliability of autonomous systems

Bigdata

In maritime sector, big data is utilized for predictive analysis and for managing marine sensors. Big data is also leveraged for properly tracking cargo for maintaining privacy and security. Big data can be leveraged for future decision-making for predicting and avoiding expensive problems, and produce more reliable cargo delivery opportunities.

Robotics

Robotic technology can be used for ship health monitoring and operational real-time optimization through continuous data input from various data sources like sensors.

Blockchain

Blockchain technology in the marine sector will improve the environmental efficiency. Moreover, efficient supply chain connectivity, provides visibility and exchange of time-stamped proofed data, decreasing the industrial operational costs with intermediaries with high security.

Technology Development Status: Significance (1/3)

Sensors and Robotics are widely adopted in Japan for various maritime applications testing.

Sensors

- With the advent of IoT, marine devices are completely controlled and connected by a smart digital network. Leveraging IoT in the maritime sector can open up avenues for controlling ships as well as monitoring and interacting with the environment.
- In Japan, various research institutes and start-ups are working on the development of sensors which would possess multiple functionalities. Sensors which can be flexible, harvest energy, communicate wirelessly and with one another are expected to have a high impact in the marine industry.

1 2 3 4 5 6 7 8 9

System Test, Launch & Operations

Robotics

- In marine applications, Robotic technologies are highly leveraged by defence and transportation sectors. Robots will mitigate hazardous risks thereby increasing the safety of human personnel.
- The key focus is to improve the degree of automation (making it more unmanned/autonomous), thereby enhancing robotic capability in marine vessels.
- Japan is adopting a collaborative strategy for increasing the penetration of robots.

1 2 3 4 5 6 7 8 9

System/ Subsystem Development

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (2/3)

Blockchain and AI will drive the marine sector by providing predictive data analytics and secured transactions

Blockchain

- Blockchain will be useful in traceability and transparency of materials. Leveraging blockchain will reduce paperwork and transform to digital form.
- In Japan, the government is driving the development of blockchain project implementation and new prototypes. With the support from the Japanese Government, NTT Data has formulated a new blockchain consortium for exploring the use cases of blockchain technologies in marine logistics applications. The key members of this consortium were the Japanese logistics giant Nippon Express, conglomerate Marubeni Corp and insurer Tokyo Marine & Nichido Fire Insurance Co, and others.

1 2 3 4 5 6 7 8 9

Technology Concept/ Proof of Concept

Artificial Intelligence

- Developments in artificial intelligence have the capability to transform the present approach to vessel maintenance and possibly will prove to be a advantageous to marine reliability and safety.
- Japan is working on a technology that is leveraging AI for detecting suspicious vessels. The government is planning to test the AI-based technology using the vessels of the Self-Defence Forces in 2021. Moreover, the Japanese science ministry is planning to develop a new device for monitoring microplastics in the sea using AI and other technologies.

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System Test, Launch & Operations

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Technology Development Status: Significance (3/3)

Mixed Reality along with the Big Data analytics will provide immersive and complete user experience on the ship navigation

Big Data

- Big data will increase the ability of performance monitoring, increase components interdependencies and eliminates human error.
- Big data analytics can support operations in various ways e.g. predictive analysis and monitoring of emissions of the vessel performance.

1 2 3 4 5 6 7 8 9

Technology Concept/ Proof of Concept

Mixed Reality

- The impact of mixed reality in the maritime sector is expected to be revolutionary.
- The marine sector has already executed the technology for optimizing fleet management, improving communication between staff ashore and on ship crew and automating processes.

1 2 3 4 5 6 7 8 9

Technology Concept/ Proof of Concept

Cybersecurity

- In the marine ecosystem, cybersecurity will aid the digital systems for loading, managing and controlling of hazardous cargo for interfacing with marine terminals, ports. These digital systems includes shipment-tracking tools that are available to shippers via internet.

1 2 3 4 5 6 7 8 9

Technology Concept/ Proof of Concept

1 2 3 4 5 6 7 8 9

Denotes Technology Reediness Level

Denotes Significance

Sensor Application Landscape and Case Studies

Developments in sensor technology provides high safety and secured ship navigation

- As the marine industry is moving into the new age of autonomous driving, electronics will play a vital role in realizing this transition. Sensor technology is a key driver for developments in vehicle efficiency, control and safety.
- Ship manufacturers are focusing on improving vehicle performance while providing adequate safety, comfort., and object detection, classification and avoidance in varied weather or lighting conditions. Therefore, they are using sensors and actuators in the marine control and navigation systems in order to optimize the features of the vehicle to provide a unique driving experience to the driver.

NERC & The Japanese Science & Technology Agency (JST)

JST and NERC have partnered to develop 3 marine sensor proof of concept research projects under the Strategic International Collaborative Research Program (SICORP). The research projects is mainly focusing in developing in situ particulate radioactivity sensor, developing in situ holographic imaging and chemical spectroscopy in deep-sea environments for analyzing the scalability of marine particles and improving the sample using novel microfluidic lab-on-a-chip nucleic acid extraction technologies [1].

Yamaha Motor Co., Ltd., & Fujitsu Limited

Yamaha Motor Co., Ltd., and Fujitsu Limited partnered for conducting an IoT-based field trial for improving the 470 (Four-Seventy), a type of small dinghy used in sailing competitions. With the execution, dinghy's speed and inclination can be measured via sensors that are attached to various parts of the boat. Further data analysis is performed using Fujitsu's cloud service. [2]

Fujitsu Limited & Fujitsu Laboratories Ltd.

Fujitsu Limited and Fujitsu Laboratories Ltd. have developed a miniaturized photodetector for high-sensitivity infrared cameras in the ship navigation application under human observation. The sensor can automatically identify ships sailing up to six nautical miles away. [3]

Robotics Landscape and Case Studies

Leveraging Robotics will reduce the involvement of human to survey in hazardous environment

- Introduction of robots/automation will delegate the risks to the robots as they can perform tasks in hazardous conditions such as poor lighting, toxic chemicals and tight spaces without causing any harm to human operators.
- Smaller crew size with automated and autonomous robots. Since the robots are made of aluminium, they are light yet strong. This in turn reduces the tonnage of a ship, thereby reducing fuel costs.
- Autonomous transportation and inspection will be the norm in the shipping industry.

University of Tokyo & Kyushu Institute of Technology

Researchers from the University of Tokyo and Kyushu Institute of Technology have developed an autonomous maritime robot for finding samples of seafloor life and accumulate them. [4]

Yanmar & JAMESTEC

Japan based Yanmar along with Japan Agency for Marine-Earth Science and Technology (JAMESTEC) have developed and demonstrated autonomous pilot technology for auto-docking system and auto-navigation robotic boat. [5]

Blockchain Landscape and Case Studies

Blockchain in marine sector will enable cargo / ship transactions without any complexity

- Blockchain makes the purchasing process for fleets much simpler, bringing the manufacturer, dealer, regulator, and fleet on the same platform.
- Service and maintenance records on Blockchain are immutable and traceable, resulting in greater reliability and transparency.
- Use of Blockchain in freight brokerage ensures price transparency, cutting out middlemen, shipment tracking, and instantaneous payment.
- Fleets can save time and money using Blockchain for operations such as asset utilization, driver monitoring, auditor and regulator records, and asset tracking.

NTT Data & Tokio Marine & Nichido Fire Insurance

NTT DATA and Japan based insurance company Tokio Marine & Nichido Fire Insurance have developed a trial version of blockchain technology for marine cargo insurance claims. [6]

SkuChain & NTT Data

Blockchain company SkuChain is partnering with Japanese tech giant NTT data to build a Blockchain platform. The solution combines Blockchain, IoT, and RFID technology, and has been piloted in Japan's manufacturing sector. [7]

AI Landscape and Case Studies

Integrating AI in ships will support collision avoidance and makes decisions with no human intervention

- Artificial Intelligence (AI) technology involves the simulation of human thought processes. This technology is emerging as a key platform in enabling development of improved sensing and automation devices and systems.

- Advancements in artificial intelligence will enable shipbuilders and ship owners to build autonomous ships that is controlled via sophisticated AI systems. Integration of AI in marine systems will improve the efficiency by reducing the impact of human error, cut down emissions by improving the efficiencies of various onboard systems and automatically optimize the best routes.

Navtor & Weathernews Inc.

Norway based Navtor and Japanese based Weathernews Inc. (WNI) have partnered for developing smart ship routing services for integrating weather information in ship voyage using artificial intelligence technology. [8]

Eco Marine Power

Eco Marine Power, a Japan based developer of vessel renewable energy systems is integrating AI in a range of its ship related technology projects using Neural Network Consoles developed by Sony Network Communications. [9]

Big Data Landscape and Case Studies

Collection of data insights gathered during vessel/ship navigation is analyzed by using Big Data

- Big Data refers to a set of data management tools, appliances, and techniques for effective analysis of huge amounts of data sets to derive intelligence on business operations and customer interactions.
- Big Data analytics improve the production efficiency by inhibiting unplanned maintenance and unscheduled downtime. Companies are gradually shifting from preventive maintenance to predictive maintenance. Big Data analytics plays a vital role in achieving this predictive maintenance.
- Big Data analytics along with Transport management systems and warehouse management system (WMS) are expected to increase visibility across the supply chain. Companies must invest in and adopt technologies to remain competitive in the fast-changing logistics ecosystem.

Fujitsu Ltd.

Fujitsu Ltd. has developed a maritime big data platform for Nippon Kaiji Kyokai (ClassNK) for collecting and storing machinery operational data such as engine data and marine weather information from moving vessels. This information will enable the shipyards and shipping operators to gather data on vessels during navigation. [10]

Mixed Reality Landscape and Case Studies

Provides Immersive Virtual User experience for easy tracking and navigation

- Mixed reality represents the combination of IoT trends and AR/VR. With mixed reality, the real and the virtual worlds will create new environments in which both physical and digital objects can coincide and interact with each other. Mixed reality modifies the engagement patterns that allows behavioural and natural interfaces. These interfaces allows users to experience an immersive virtual world, while serving upon the digital intelligence.

- In the marine sector, MR is used for underwater surveying, trigger warnings, developing scenarios and simulating the outcome of actions. The technology also improves safety of navigation, collision avoidance, ship security and environmental protection.

JRCS Mfg. Co., Ltd. & Microsoft Japan Co., Ltd.

JRCS Mfg. Co., Ltd. partnered with Microsoft Japan Co., Ltd. to launch a project called JRCS Digital Innovation LAB for leveraging artificial intelligence, mixed reality and other pioneering technologies for promoting workstyle innovation in the marine industries and the merchant shipping via digital transformation. This accelerates the remote training platform development and other world-class digital products and services.[11]

Mitsui O.S.K Lines (MOL)

Mitsui O.S.K. Lines (MOL) have introduced new training programmes to its VR-powered mariner safety education goggles for monitoring response to onboard fires and cargo falling from cranes. [12]

Cybersecurity Landscape and Case Studies

Communication between offshore and onshore ships is performed securely by Cybersecurity

- Cybersecurity denotes the security of control systems and information networks and systems and equipment that communicate, stores and act on data. Cybersecurity incorporates ships, offshore assets, ships and also includes 3rd party suppliers, technicians, subcontractors and external components such as sensors and analytic systems that interface data systems and networks.

ClassNK and TÜV Rheinland

ClassNK, a Japan-based classification society has partnered with TÜV Rheinland for providing digital services for cybersecurity, safety and privacy for the marine sector. Both the companies are planning to formulate the guidelines for cybersecurity for onboard software. [13]

Adoption Life Cycle

Fujitsu and Mitsui O.S.K. Lines, Ltd. have been the major contributors for developing the Digital Ship Concept

	Innovators & Early adopters	Early & late majority	Laggards
Sensors	MUSASINO, FURUNO, TOKYO KEIKI	FUJITSU, TOYO Corporation	YAMAHA
Robotics	東京大学 THE UNIVERSITY OF TOKYO, JAMSTEC, Kyutech	YANMAR	
Blockchain	TOKIO MARINE NICHIDO, skuchain	NTT DATA, MOL	
Artificial Intelligence	NAVTOR, MOL, eco marinepower	WNI weathernews	
Big data	FUJITSU, MOL, Monohakobi Technology Institute	NYK LINE, JMU	
Mixed Reality	JRCS, JRCS CORPORATION, Microsoft		
Cybersecurity	ClassNK	TÜVRheinland®	

Stakeholder Ecosystem and Initiatives

Sensors and robotic techniques have been the key focus area for the stakeholders in developing digital ships

Organization	Technology	Application
Musasino	Sensor, Monitoring System	Provides accurate and reliable tank level gauging on oil, product and chemical tankers.
Fujitsu Ltd.	Sensor	Infrared Cameras for Autonomous Ship Navigation
Yanmar	Robotics	Auto-docking system and auto-navigation robotic boat
Skuchain	Blockchain	Supply chain management
Eco Marine Power	Artificial Intelligence	Improve control algorithms and analyse research data.
Mitsui O.S.K. Lines, Ltd.	Big Data	Transport onboard big data from vessels to Data Center

Factors Influencing Adoption: Drivers

Advent of IoT and Growing trend towards Autonomous Ship has been the key for Japan's growth in marine sector

The Dawn of IoT concept in the marine sector

IoT is transforming ship manufacturers by enabling new upgrades with smart ships. This concept has transformed the marine market by providing both safety and constantly connected features. The marine industry has potential to be an IoT leader with high adoption capability of IoT cloud service. For instance JRCS – a major Japanese maritime services company is leveraging mixed reality, the Internet of Things (IoT), and artificial intelligence to transform the training methods for ship crew, ship maintenance and enforcement of navigational standards and safety. [14]

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Growing trend toward autonomous ships

Globally, the trend toward autonomous ships drives development of enhanced safety features in transportation and accelerating the growth to a sustainable future. There is also anticipation for new models for autonomous driving ships which benefits both the onshore and offshore shipping operators. With the upgrade of sensors and actuators, ships are potentially capable for Level 5 autonomy, which does not require driver interaction. With growing familiarity with the technology and greater acceptance of autonomous ships, the demand for is expected to increase over the near term.

Short-Term - **High**	Medium-Term - **High**	Long-Term - **Medium**

Collaborative Work Culture Drives the Development of Smart Ship

Smart ship developers along with OEMs can create innovative and advanced technologies and products that can lead to disruption in the marine market. More M&As are anticipated amongst different stakeholders such as technology developers, information and communication technology (ICT)-related companies. For instance, Japanese telecommunications company KDDI and Inmarsat have partnered for distributing Fleet Xpress to the Japanese maritime market, covering cruise lines, oil and gas, commercial fishing. [15]

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

Source: Frost & Sullivan

Factors Influencing Adoption: Challenges

Regulatory hurdles and lack in business models have been the major challenges hindering Japan's maritime growth

Regulatory Hurdles

Sensors for marine applications need to undergo standard regulatory processes for testing and certification before launch into the market. Sensor technologies offer high safety, comfort and convenience to marine operators but also have risks associated with them. Parameters such as navigation through tidal rivers and environmental sustainability have to be checked.

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

Lack in the development of tangible business models

For the wide reception of marine based sensors such as underwater wireless sensor network technology appropriate business models must be developed. Business models such as open source, monopoly and service oriented architecture can be implemented. Research and development activities for these markets are extremely challenging.

Short-Term - **High**	Medium-Term - **Medium**	Long-Term - **Low**

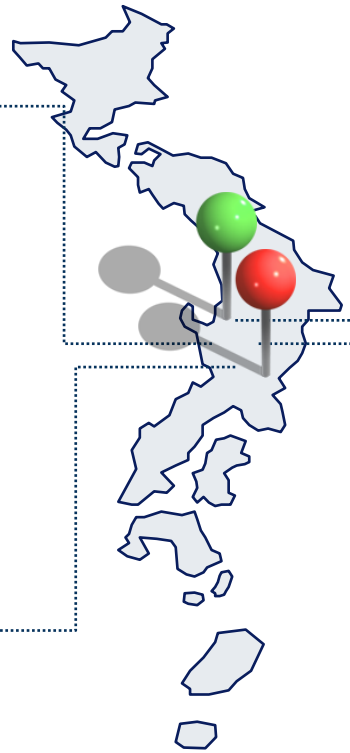
Source: Frost & Sullivan

Country Specific Initiatives and Future Roadmap

Japan has carried out several research projects for digitizing the country's maritime sector

Japan's New Energy and Industrial Technology Development Organization (NEDO) planned a 3-year ocean energy R&D demonstration project (until the end of 2020) for accelerating the commercialization of marine energy technologies. The project is conducted in two stages while the initial stage is focused on the feasibility of carrying out long-term empirical research on ocean energy generation and final stage will be the commercialization process. [19]

Japan is planning to build a large underwater drone for monitoring remote islands guarding from the Chinese intrusion. This unmanned submersible will be shown in the Ministry of Defense's policy document from April 2019. [16]



In May 2018, 46 companies of Japan maritime industry have formulated a new consortium called the Internet of Ships Open Platform (IoS-OP) for promoting partnership in data sharing and technology development between stakeholders. [17]

NYK Line, MTI Co. Ltd., Nippon Telegraph and Telephone Corporation (NTT), and NTT DATA Corporation have developed next-generation onboard IoT platform at 'Hidaka', a domestic coastal vessel operated and maintained by Kinkai Yusen Kaisha Ltd. of NYK Group.[18]

Development Status of Autonomous Ships

Japan has carried out several research projects for digitizing the country's maritime sector

With respect to autonomous ships, Japan and Norway are considered to be the leaders in this space. For instance, circa 1960 in Japan, the growth of autonomous vessels has experienced various developments, from the engine room automation to the navigation automation and also from the advent of the Smart vessel to the whole vessel automation.

- Japan's Ministry of Land, Infrastructure, Transportation and Tourism (MLIT) nominated NYK and NYK Group companies MTI Co. Ltd., Keihin Dock Co. Ltd., and Japan Marine Science Inc. (JMS) for participating in a demonstration project employing remote control and ship maneuvering support functions. Japan is looking to begin the practical implementation of the autonomous ships by 2025. [20]
- Boston-based Sea Machines Robotics along with Toyota AI Ventures, Brunswick Corp are developing autonomous ships integrated with situational awareness, advanced perception and navigation assistance technology for a range of vessel types such as containerships. [21]
- In 2019, Japanese shipping company Nippon Yusen Kabushiki Kaisha (NYK) expects to test an autonomous containership called "The boxship" that would sail from Japan to North America [22]
- Japanese Government has approved a joint autonomous vessel project by Mitsui OSK Lines (MOL) along with Mitsui E&S Shipbuilding (MES-S) arm of the Mitsui Group, Tokyo University of Marine Science and Technology (TUMST), and Akishima Laboratories (a division of MES-S). This project trial the auto-berthing and un-berthing of ships. Moreover, the project engages seagoing vessels for testing and improving the autonomous technologies. [23]

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