THE UK'S ACADEMIC CAPACITY & CAPABILITY FOR SHIPBUILDING REPORT

Edited By
Ian Edgecomb, Tahsin Tezdogan, David Hitchmough, Yi Huang, Thomas Fitter, Simon Benson, James Murphy and Cammy Acosta

National Shipbuilding Office

September 2023

AUTHORS’ FOREWORD

The following report is a snapshot of the UK’s leading research areas in shipbuilding and provides insight of work being conducted in other nations. It provides a summary explanation of the areas recommended for critical investment.

This report used the Web of Science Database Collection and the Research Excellence Framework 2021 database for primary data collection with a limitation of works produced between June 2018 and June 2023; therefore, it is acknowledged that some works, countries and / or companies may not have been captured throughout the study period.

This study does not intend to purposefully exclude or miss any works, countries and / or companies. The report includes examples of published academic research in each of the main shipbuilding topics from UK maritime academic institutions. It should be noted that further UK institutions are involved in maritime shipbuilding research through the Clean Maritime Demonstration Competitions (CMDC 1-4), Zero Emission Vessel and Infrastructure (ZEVI), UKRI and EPSRC funding and their work will have been captured in the report findings if the work has been published.

It should also be noted that a number of the funded research projects will have included UK industry partners such as Rolls Royce and BAE Systems as mentioned and were included as a result of industrial authorship of the published research. The industry participation in shipbuilding R&D is not restricted to those mentioned and there are a greater number of companies who are part of research collaborations between industry and academia. Where papers have been published these will have been captured in the findings of the report.

While we have not referenced individual UK Catapult Centres in the report, there are a number of the UK Catapult Centres that are at the forefront of research into UK shipbuilding and include: Connected Places Catapult; OffShore Renewable Energy (ORE) Catapult; and, the High Value Manufacturing Catapult. It should be noted that the Catapult centres are considered to be innovation facilitators who assist in the transformation of ideas, products and services, bringing together expertise from across the UK to collaborate, including academia, enabling businesses to thrive in global markets. Where those collaborations have included academic institutions, any papers that were published by institution as a result of the research would have been identified and included in the report.

AUTHORS

Edited By

Mr Ian M. Edgecomb	University of Strathclyde
Mr Thomas Fitter	University of Liverpool
Mr David Hitchmough	Liverpool John Moores University
Mr Yi Huang	University of Strathclyde
Dr Tahsin Tezdogan	University of Southampton
Dr Simon Benson	Newcastle University
Mr James Murphy	University of Liverpool
Ms Cammy Acosta	University of Liverpool

Researchers

Ms Cammy Acosta	University of Liverpool
Mr Ian Edgecomb	University of Strathclyde
Mr Thomas Fitter	University of Liverpool
Mr David Hitchmough	Liverpool John Moores University
Mr Yi Huang	University of Strathclyde
Dr Gabin Kayumbi	The Alan Turing Institute
Mr Taylor Larsen	Liverpool John Moores University
Mrs Guanlan Liu	Newcastle University
Mr Kaymar Motaghedolhagh	University College London
Mr James Murphy	University of Liverpool
Dr Amin Nazemian	University of Strathclyde
Mr Dave Nwosu	Liverpool John Moores University
Mr Christopher Ryan	University College London
Dr Tahsin Tezdogan	University of Southampton
Ms Wan Wang	University of Southampton
Mr Yongchang Xie	University College London
Dr Ming Zhang	University of Strathclyde

Principal Investigators

Dr Ian Whitfield	University of Strathclyde
Prof. Evangelos Boulougouris	University of Strathclyde
Dr Zhiming Yuan	University of Strathclyde
Prof. Andy Plater	University of Liverpool
Dr Milad Armin	Liverpool John Moores University
Dr Simon Benson	Newcastle University
Prof. Adam Sobey	University of Southampton
Dr Mehdi Baghdadi	University College London
Dr Yuanchang Liu	University College London

EXECUTIVE SUMMARY

This document reports on an investigation of the UK's shipbuilding research capacity and capability. The project was funded by the National Shipbuilding Office and completed by MarRI-UK and their partner institutions around the UK. The purpose of this report is to provide an insight into the UK's current capabilities, understand what other nations are doing and provide a series of recommendations for enhanced competitiveness.

The study explores four critical questions set out by the NSO:

1. **What are the UK's leading research areas in shipbuilding?**
2. **What are the UK's key competitors worldwide doing?**
3. **Where are the areas the UK can improve on and require critical investment?**
4. **How can the UK achieve enhanced competitiveness?**

The project explores research output bounded specifically to maritime engineering and technology topics that underpin the UK's shipbuilding industry. It does not review broader areas such as manufacturing in detail. Recommendations are based on a quantitative analysis of published research in the past five years.

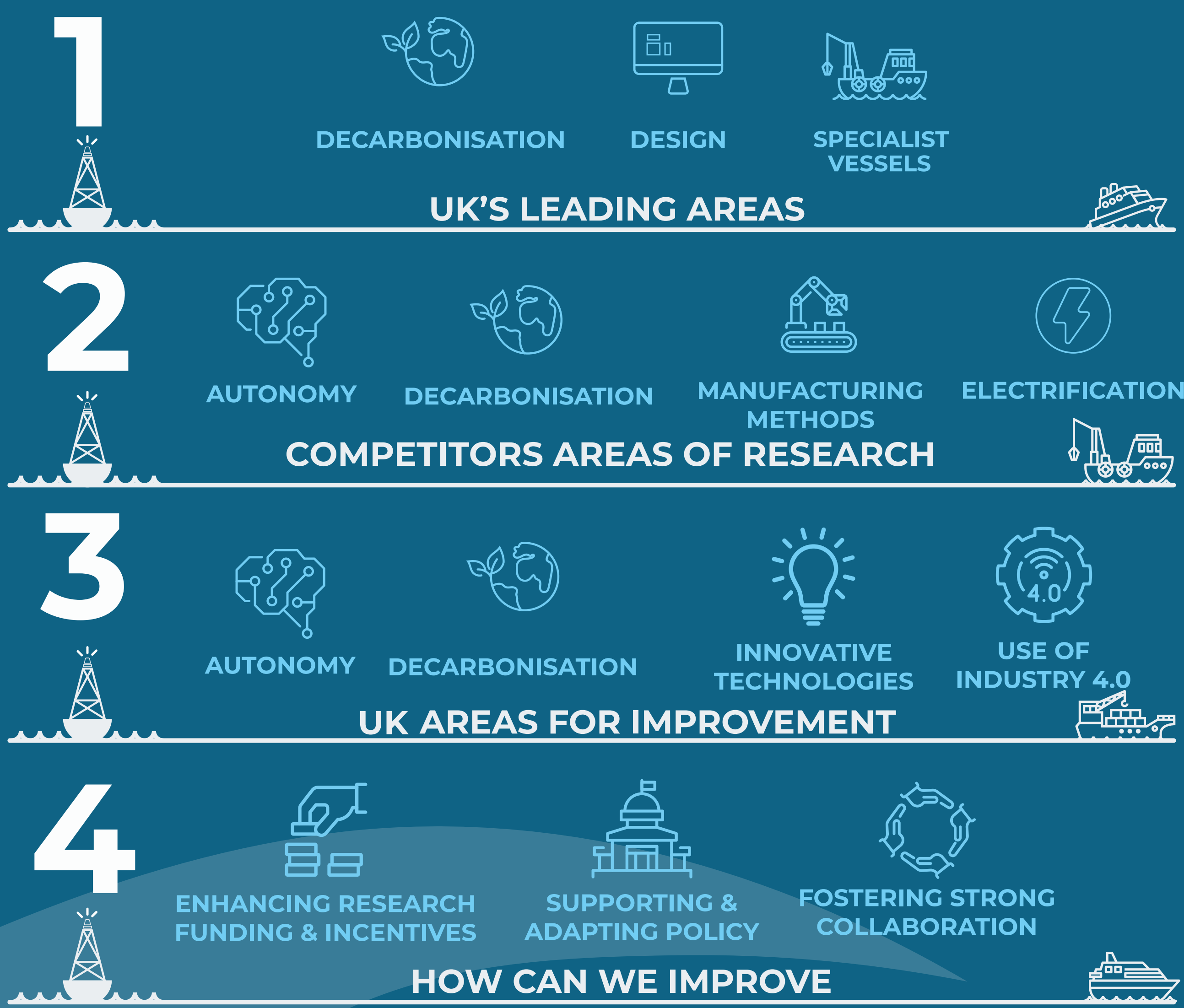
Within these bounds, it has been identified that the UK produces leading research output in **decarbonisation, design, and specialist ships,** the UK does excel in other research areas aswell and these are briefly highlighted below.

In **decarbonisation,** the UK research contribution is in analytical strategies, energy-saving devices, alternative fuels and carbon capture. Shipbuilding as a mechanism to deliver decarbonised shipping operations is a central aspect of the UK's decarbonisation strategy and current research position. In **design,** the UK currently has a well-researched position in ship systems optimisation, biomimicry for propulsion and ship control. In **ship types,** the UK is at the forefront of research into specialistic vessels, with a focus on the use of innovative technologies and underwater vehicles. The UK does also have a strong research profile in the following areas. In **autonomy,** there are specific areas where the UK holds a relatively prominent research position, particularly in the development of navigation and control systems and the development of Unmanned vehicles. In **digital,** the UK excels in incorporating Product Life-cycle Management tools, information management and the use of computer-aided engineering methodologies. In **future shipbuilding,** UK research excels in digital manufacturing, integrating Computer-Aided Design, Computer-Aided Manufacturing, and data analytics for improved risk-based design, production, and logistics. In **manufacturing,** the UK has a research focus on advanced techniques, exploring the use of additive manufacturing such as automated fibre placement, lean manufacturing techniques and the integration of Artificial Intelligence.

Within the same bounds, it is highlighted how the UK's key competitors have adapted to worldwide challenges. Countries in the European Economic Area have a strong research focus on the development of sustainable technologies and decarbonisation strategies such as the development of greener propulsion systems and the use of alternative fuels. China, South Korea and Japan have a stronger research emphasis on the development of newer manufacturing methods and techniques such as the development of modular construction, they also have a strong research lead on the development of autonomy and automated systems. The United States and Canada have a very similar research focus as the UK with the US leading in the development of all-electric and carbon-neutral systems and a strong presence and development of military vessels.

For the UK to enhance shipbuilding competitiveness, it is necessary to enable shipyards to integrate advancements in innovative onboard technologies such as alternative fuel systems, energy efficiency devices and autonomy systems. This can be achieved by linking shipbuilding to the UK's current research strengths and future research opportunities with Industry 4.0 and 5.0 technologies in an array of topics such as decarbonisation, design, manufacturing and digital. An example of this is by becoming the leader in the use of Virtual Reality / Augmented Reality technologies to enhance safety, reduce schedule delays and reduce costs.

Finally, this report details an array of methods that can be used to help achieve enhanced competitiveness through the development of Artificial Intelligence, Autonomy and Innovative Technologies. This can be done by enhancing research funding and incentives, supporting and adapting policy and, fostering strong collaboration and partnerships between academic institutions, industry and the UK government.



ABBREVATIONS & DEFINITIONS

AI - Artificial Intelligence
AR - Augmented Reality
AUV - Autonomous Underwater Vehicle
BAE - British Aeronautical Engineering
BIM - Building Information Management
CAD- Computer-Aided Design
CAM – Computer-Aided Manufacturing
CAGR – Compound Annual Growth Rate
CFD - Computational Fluid Dynamics
DNV - Det Norkse Veritas
EPSRC - Engineering and Physical Sciences Research Council
EEA- European Economic Area
FEA - Finite Element Analysis
fNIRS - Functional Near-Infrared spectroscopy
GCN - Guidance, Control and Navigation
GNSS - Global Navigation Satellite System
HLAW - Hybrid Laser Arc Welding
IIoT - Industrial Internet of Things
IMO - International Maritime Organisation
IoT - Internet of Things
LAHW - Laser Arc Hybrid Welding
LSAM - Large Scale Additive Manufacturing
LNG - Liquefied Natural Gas
MSRC - Maritime Research Safety Centre
NSbS - National Shipbuilding Strategy
PLM - Product Lifecycle Management
UCL - University College London
UK - United Kingdom
UKRI - UK Research and Innovation
UAV - Unmanned Autonomous Vehicle
US - United States
VR - Virtual Reality
WAAM - Wire Arc Additive Manufacture

SECTION 1

INTRODUCTION

INSTITUTIONS INVOLVED

FUNDED BY

National Shipbuilding Office

INSTITUTIONS INVOLVED

MarRI-UK Research & Innovation

University of Strathclyde Glasgow

Newcastle University

Liverpool John Moores University

University of Southampton

University of Liverpool

UCL

The Alan Turing Institute

INTRODUCTION

To drive the UK to the forefront of the shipbuilding industry, we need to expand and invest in innovation and effective engineering; we can understand and start this thrust by evaluating the UK's current positioning in leading research. The UK's shipbuilding research expertise exists through its network of academic institutions, which continue to be an international powerhouse for maritime research and education. These institutions are typically located in regions that continue to be centres of leading maritime industry, hold extensive brownfield capacity for renewed shipbuilding activity, retain workforce skills linked to shipbuilding processes and maintain strong cultural attachment to the shipbuilding industry.

However, even with the UK's expertise in shipbuilding and research, powerhouses in the European Economic Area and Asia have been receiving larger amounts of funding, projects and attention over the past several decades. The Government has recognised this and aims to rejuvenate and revitalise the shipbuilding and maritime industry.

The Government has placed several projects to help understand the UK's current capabilities to achieve this aim. This report explores the academic research capabilities and current capacity within the UK.

AIM AND OBJECTIVES

This report aims to highlight the UK's existing academic research expertise and identify the opportunities to disrupt the market to stay one step ahead and improve competitiveness compared to other nations. This work will enable a better understanding of how to achieve the National Shipbuilding Strategy (NSbS) vision of being a globally successful, innovative and sustainable UK shipbuilding enterprise. The report is structured in the form of four questions as set out by the National Shipbuilding Office:

UK's Leading Research Areas

What are the UK's leading research areas within the maritime sector and the areas of targeted research and development that offer the most potential for improving the UK's capacity to compete in world shipbuilding markets?

What Are Our Competitors Doing?

How are the UK's critical competitors from Europe (Norway, Netherlands, Germany, Denmark, Sweden, Italy, France, Spain), Asia (Japan, South Korea, China), and the Americas (US, Canada) approaching technological and process changes in shipbuilding.

How Do We Improve?

How can the research expertise and capacity in the UK be best leveraged to drive the productivity and competitiveness of the UK's maritime sector, ultimately enhancing the economic development of the UK?

What Can We Improve Upon?

How critical is investment in higher-level research skills explicitly applied to disruptive technologies that could benefit existing and emergent members of the UK's maritime shipbuilding industry?

METHODS

The aim set out by the National Shipbuilding Office required a collaborative effort from experts in academia.

Themes were proposed by MarRI-UK's academic partners and approved by the National Shipbuilding Office, **the themes shown on the right were to be explored by researchers.**

The partner institutions researched and collated the topics highlighted in the introduction. As the study explored the recent capacity and capabilities of the UK's shipbuilding industry, the search was limited to works produced in the past five years. All researchers were to use the same database as a primary source of data collection, Web of Science and were given autonomy in using other data sources for extra information.

The review followed a systematic structure using key search terms and refinement based on titles and abstracts. It was then categorised into themes that appeared in the literature, the results of which can be found throughout this report.

Key search terms are found to the right.

The Research Excellence Framework 2021 database was also used to understand the UK's impact. The following report summarises these databases in the UK's leading areas of research, areas that have room for improvement and what other nations worldwide are doing in the shipbuilding sector.

EXPLORED THEMES

- Autonomy
- Decarbonisation
- Design
- Digitisation
- Future shipbuilding
- Facilities and Capabilities
- International Research
- Markets
- Manufacturing
- Safety
- Ship Types
- Supply chain

KEY SEARCH TERMS

Automated, Automatic, Autonomous, Autonomy, Boat, Concept, Conversion, Decarbonisation, Design, Digitisation, Engineering Management, Facility, Power, Marine Engineering, Markets, Propulsion, Regulation, Renewable Energy, Rotor, Ship, Supply Chain, Vessel.

SECTION 2

UK'S LEADING RESEARCH AREAS

To answer the first question set out by the NSO, a systematic literature analysis was conducted to determine the UK's current leading areas of research in terms of shipbuilding. The research team are aware that the UK is not leading in all areas, and further, at the end of this section, a list of the areas that have the most potential to drive the UK forward is presented.

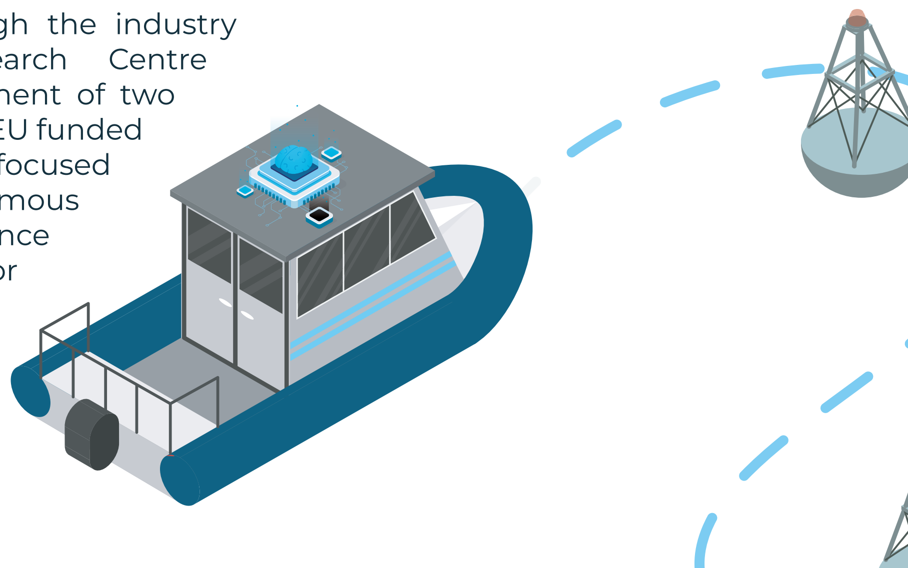
AUTONOMY

For autonomous smart ships and shore architecture, we noted many UK papers on the topic are relative to the overall themes covered by those from all over the world. Investigation of these papers indicated that generally, many of them were not advancing the state of the art in autonomy, and more often represented a review or investigation of current technology. Nevertheless, research has shown that the UK strengths on human factor, use of AI technology for safe autonomous navigation, Advanced Collision avoidance methodologies, Health aware control for autonomous vehicles and cyber security. Furthermore, the country leads in research pertaining to certain technologies, albeit with limited application in the marine context, such as sensor technologies, algorithm development (including motion planning and optimisation), and monitoring systems. In general, the UK's emphasis is not on commercial shipbuilding, resulting in the autonomous ship development being primarily confined to high-level design stages, as well as the smart shore architecture within the UK. Leadership in the realm of smart autonomous ships is held by other European countries like Norway. Nevertheless, the UK possesses a solid foundation in autonomous ship technology, with many universities and companies already actively engaged in research in this field.

UCL has strong research in designing and developing autonomous navigation systems for unmanned surface vessels. Funded by UK EPSRC, The Royal Society, US ONR, etc., the research team at UCL has successfully innovated a set of sensing/perception system using multi-sensor fusion and learning based segmentation algorithms to provide safe and reliable understanding of challenging maritime environment and assist with collision avoidance and decision making. Another pillar is motion planning and control for autonomous vessels and primary outcomes include adaptive formation control in constrained environments, reliable decision-making for anti-collision navigation, continuous-time planning subject to varying maritime environmental conditions, etc.

Liverpool John Moores University has developed a few anti-collision algorithms for autonomous ships using AIS data and AI technologies, displaying advantages and innovation over the existing methods likes in their low time cost and hence their values for realising real-time anti-collision in the real world. Furthermore, it has pioneered a study on use of the state-of-the-art phycological methods (e.g. Functional near-infrared spectroscopy (fNIRS)) to detect the impact of different levels of autonomy onboard ships or even in future remote control centres on seafarers/remote operators' competence on safe navigation. Alongside this Queen's University Belfast have develop tracking control of uncertain surface vessels using global finite-time convergence.

The University of Strathclyde, through the industry sponsored Maritime Safety Research Centre (MSRC), participated in the development of two autonomous commercial ships in the EU funded project 'Autoship'. Its contribution focused on the safety assessment for autonomous navigation, advanced collision avoidance algorithms, health drone control for autonomous vehicles and cyber security.



DECARBONISATION

In line with the UK's broader decarbonisation targets, the study has shown that the UK is placing emphasis on the decarbonisation of shipping. Shipbuilding as a mechanism to deliver decarbonised shipping operations, is a crucial aspect of this strategy, ranging from the entire construction of ships to the components and innovative technologies supplied to international shipbuilders. The UK's current research contribution in this area is related mainly to analytical works investigating and assessing the current state-of-the-art technologies rather than innovating disruptive technologies.

Analytical Strategies

The UK's contribution to decarbonisation research mainly focused on analysing the shipping industry's carbon footprint. This is achieved by considering how existing and future governing body guidelines and decarbonisation targets will influence the UK's current shipbuilding strategy.

Other Notable Projects

University of Cambridge have developed a small modular reactor core design for civil marine propuslion systems, using micro-heterogeneous duplex fuel, and finally Cranfield University have developed a Techno-economic and risk evalution method for combine cycle propulsion systems in large container ships

Electrification

UK research investigated the impact of electrification for inland and short-sea shipping. It has also expanded on the impact to the national grid and the port infrastructure required.

Carbon Capture

UK research has shown interest in carbon capture technologies, including some related to the onboard capture of CO_2 with some analysis of its viability and operation of these systems onboard ships.

Alternative Fuels

The UK has a number of research papers focusing on the use of hydrogen, ammonia and methanol as alternative marine fuels. These papers cover an array of topics such as the concerns and suitability, carriers, refuelling and bunkering logistics. Solent University have developed a Life-cycle assessment for alternative marine fuels for application in super yachts.

The UK has also directed its attention towards fuel cell technology, capitalising on its expertise in safety and reliability analysis to assess the viability of such systems. Notably, there is evidence of the UK's exploration of solid oxide fuel cells, evaluating the feasibility and integration.It is worth mentioning that around the world, nuclear power research within shipbuilding has yet to advance as far as other technologies. However, this does not suggest a complete absence of research in this area; rather, this indicates that alternative propulsion and fuelling methods have taken precedence in both the UK and global research. It is worth noting that the UK has substantial experience in the nuclear field, particularly in nuclear decommissioning and handling.The UK plans to invest clean maritime technologies like dual and multi-fuel engines and wind-assisted propulsion. These advancements aim to decrease carbon emissions and enhance the country's competitiveness in global shipbuilding markets while aligning with sustainability objectives.

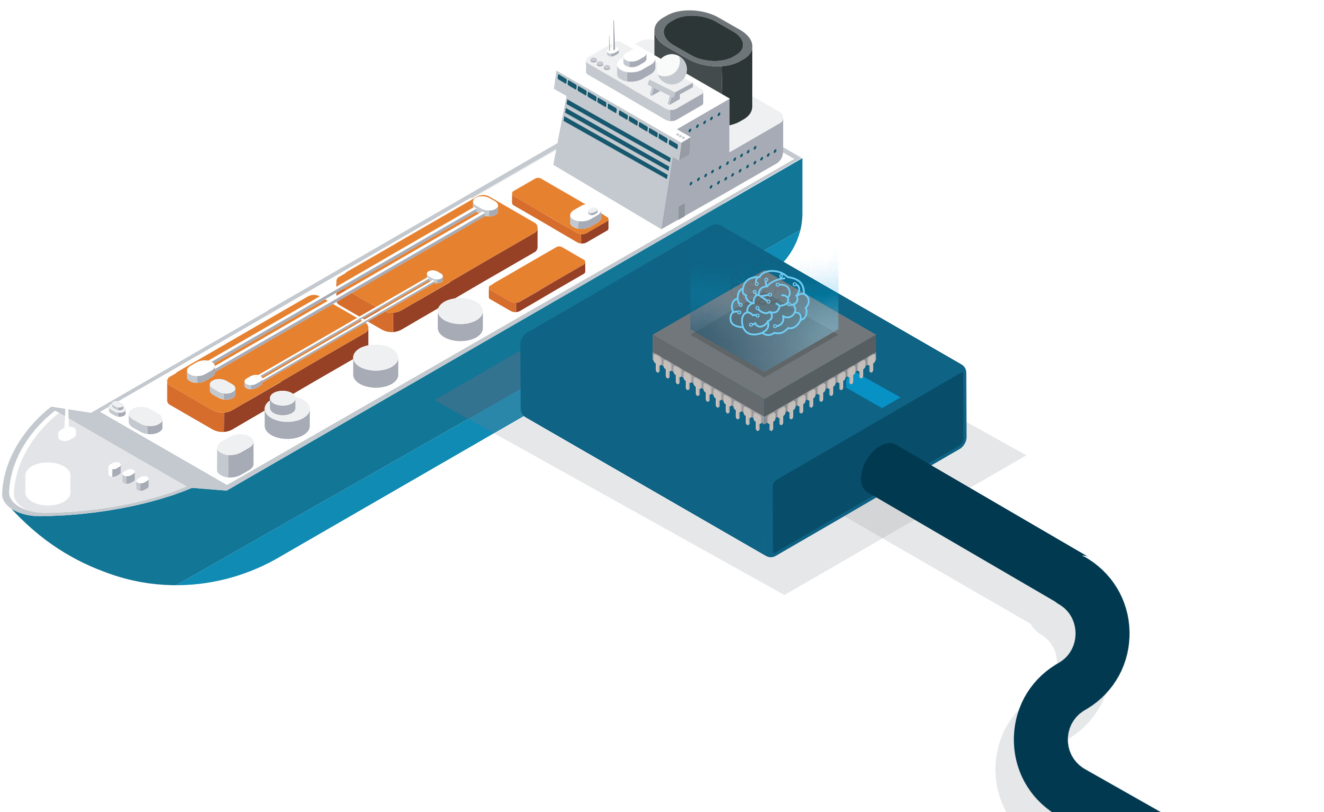
DESIGN

The UK currently has a well-researched position in ship design optimisation - taking existing ship designs, whether hulls or sub-systems and optimising using Computer Aided Design (CAD) and Computer Aided Engineering (CAE) software to optimise performance and reduce costs. The UK has several papers focusing on biomimicry – looking at evolution within nature and using similar profiles and behaviours within the design - for propulsion and ship control. Alongside this research, the UK has a leading position in developing autonomy with ship systems such as within control and navigation systems.

Intelligence Design and Implementation

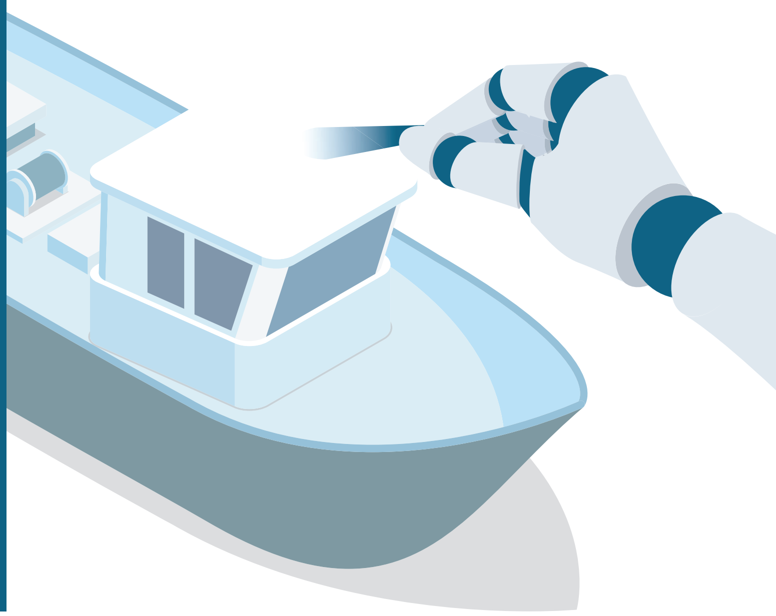
In collaboration with industry, UCL has produced leading research on trimaran designs for naval vessels. Liverpool John Moores University has developed several optimisation techniques, including the Risk Assessment Informed Decision Support (RAIDS) tool, which has impacted safety standards, regulations and how ships are built in the UK. The University of Strathclyde has developed the Robust Holistic Design Approach (RHODA), successfully implemented in full-scale EEA-funded technology demonstrators (e.g. H2020 TRAM).

The University of Strathclyde has informed IMO policy and regulations through its participation through RINA in MSC, SDC and MEPC, emphasising cleaner and safer ship designs. Furthermore, The UK has conducted significant research on safe evacuation, flooding survivability, intact stability, fire prevention and risk mitigation for ships, which is integral to ship design.

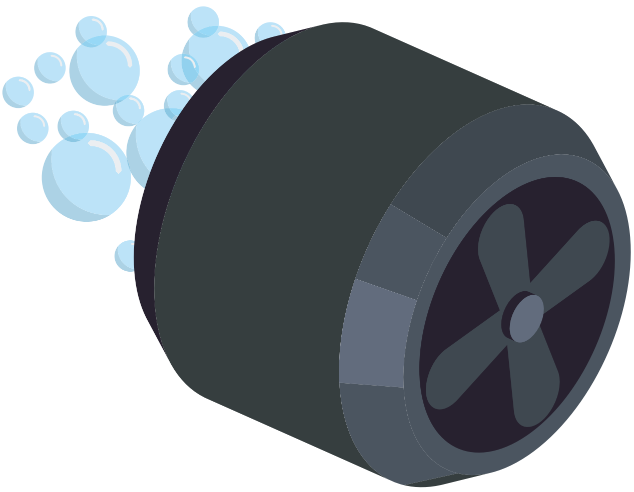


Automated Design

The pursuit of further improvements to ship design, particularly with the introduction of new technologies and larger ships, is ongoing, the vessels produced within the UK exhibit innovative designs and a strong emphasis on hydrodynamics. This commitment is evident through the substantial UK literature dedicated to the subject. Notable UK interest areas lie in CAD, specifically in Computational Fluid Dynamics and Finite Element Analysis design approaches. The UK has demonstrable expertise in design optimisation and pioneering methods, including novel hull design, high-speed hulls, and advanced marine vehicles.



In summary, the UK is leading in the following areas of design research for ship building.



Automated Design Processes

We focus on greener technologies and support tools to aid decision-making processes and holistic design optimisation.

Safety Assessment

Technology evaluation and qualification for new technologies and the impact on the safety of the ship.

Propulsion Design

Developing greener engine solutions to minimise carbon footprint.

DIGITAL & FUTURE SHIPBUILDING

The shipbuilding industry is adapting to become more environmentally friendly and technologically advanced. This involves using smart technologies and sustainable methods as Industry 4.0 – looking at the integration and development of autonomy within shipbuilding processes - and the development of Industry 5.0 – where it considers how the user (in this case a shipbuilder) would interact and manages Industry 4.0 systems. The shipbuilding sector is evolving with more efficient and flexible construction processes, all while keeping environmental concerns in mind. Digital ship design tools and technologies such as the Internet of Things (IoT) and augmented reality alter shipbuilding processes. Simultaneously, there is a strong focus on developing emission-free vessels and exploring eco-friendly methods and alternative fuels. The UK's shipbuilding research excels in digital manufacturing, integrating CAD/CAE, and data analytics for improved design, production, and collaboration.

In summary, the UK is leading research in the following areas of Digitisation and Future Shipbuilding.

Innovative Technologies

There is an emphasis on the IoT, sustainability, automation, Digital Twins, and additive manufacturing to enhance competitiveness and improve repair / retrofit capacity. Innovation encompasses commercial ship design, climate change mitigation technologies, and cybersecurity for the Global Navigation Satellite System (GNSS).

Management Systems

Product Lifecycle Management (PLM) is a leading research area, with the University of Strathclyde leading in PLM implementation and digital transformation.
UK companies are pioneering in the area of digital twins. Future advances encompass smart design, optimisation algorithms, and digitalised ship operations. Energy efficiency research explores AI, machine learning, and low-carbon energy. Emission control targets SOx reduction via scrubber optimisation, noise reduction, and alternative fuels like LNG, ammonia, biofuels, hydrogen, and hybrids.

Business Models

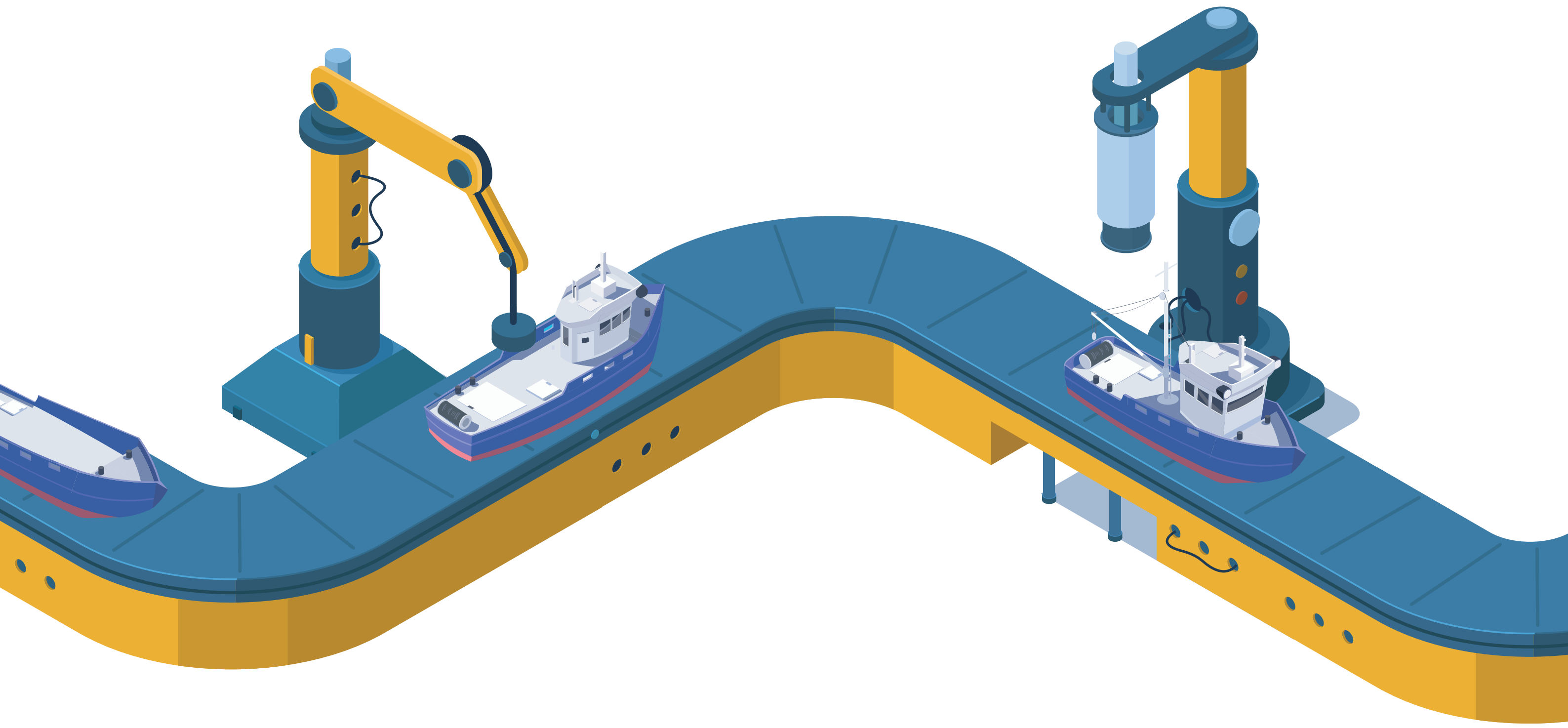
The future of shipbuilding is undergoing exciting advancements, particularly in the UK and other countries. In the UK, significant research areas include shipbuilding skills, digital twin training, shipyard business models, and shipbuilding resilience. The focus is ensuring a skilled workforce and incorporating advanced technologies like VR for safer ship engine training. Shipyard business models are being improved for better production performance, while shipbuilding resilience involves digitalisation and collaboration.

MANUFACTURING

Manufacturing is one of the UK's leading industries, holding 6% of the worldwide share of manufacturing research, and with many institutions such as the Alan Turing Institute, the Institute for Manufacturing, the MTC, the National Manufacturing Institute of Scotland and the Advanced Forming Research Centre. UK shipbuilding research has a strong focus on Large Scale Additive Manufacturing, Component manufacturing through re-manufacturing methods, material traceability and Lean Manufacturing in particular, a manufacturing methodology that focuses on a circular economy while maintaining and even reducing lead time. A summary of the leading research areas within the Lean Manufacturing priority area is provided below:

Lean Manufacturing

Existing sectors within the UK with strong evidence of expertise in Lean Manufacturing include the management and business sector, the engineering and technology sector and the logistics and operations sector. Recent work conducted in this research area aims to reduce production costs and improve lean achievement through lot-sizing optimisation and pull-from-the-bottleneck control. Understanding and explaining the barriers to successful lean implementation within the shipbuilding industry is a priority for the UK, to minimise waste and provide a more efficient and competitive industry while maintaining high-quality standards.

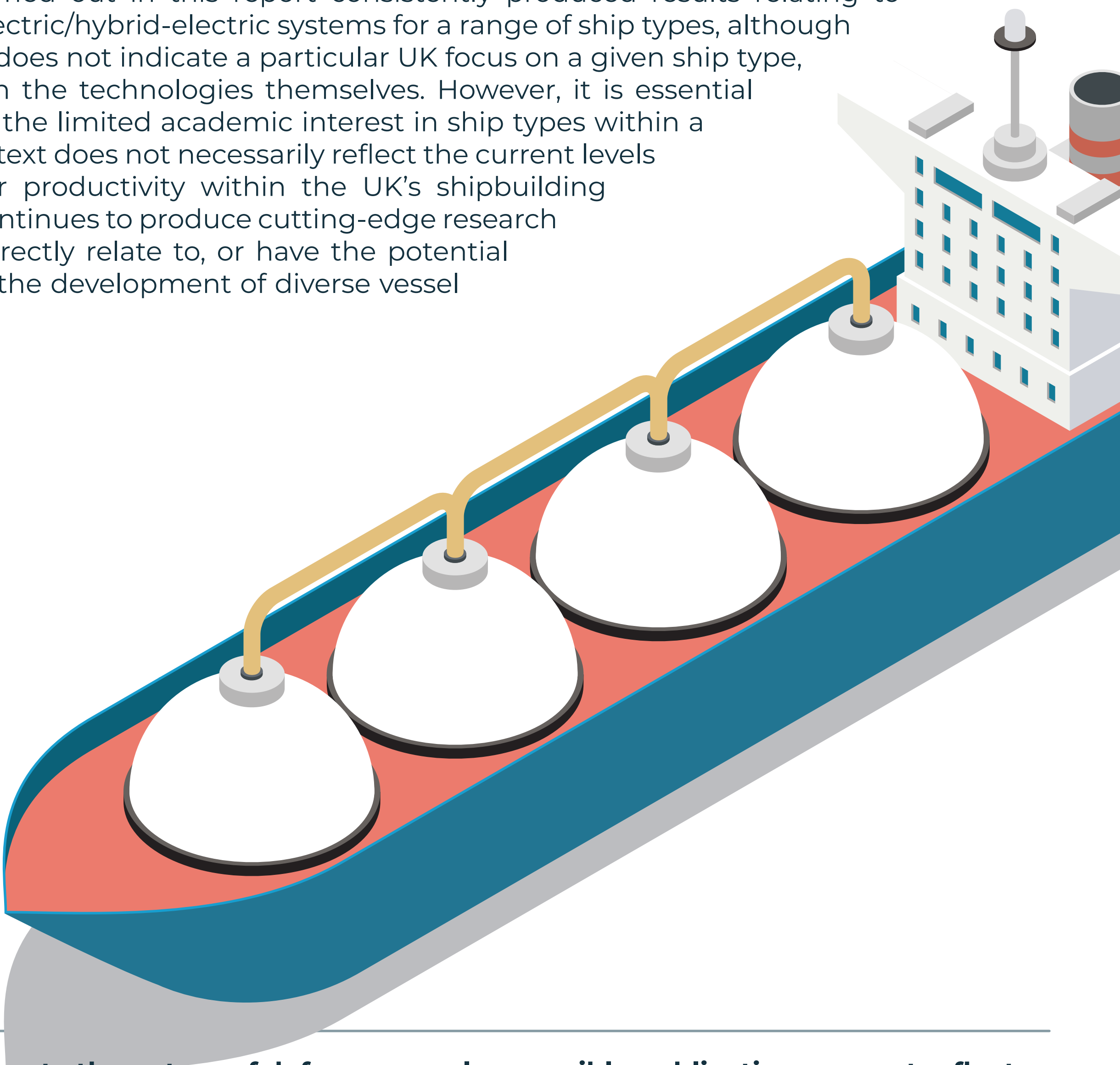


SHIP TYPES

The UK is leading in research into specialist vessels and underwater vehicles.

This is evidenced by the UK's share of 26% of the published works on these types of vessels being used by referenced by others in the field. The UK has a specific focus on fishing vessels and AUVs, with some interest in other areas, notably in tanker, tugboat and general cargo ships. Search results consistently pointed to the use of parametric modellers which are being used in the representation and generation of ship hulls in UK research and shipbuilding. The UK is producing literature on ship types related to the suitability of hydrogen powering and hybrid/hybrid-electric systems on these vessels. Finally, particularly in passenger vessels, UK research has a focus on assessment of safety and flooding scenarios as well as evacuation.

The research carried out in this report consistently produced results relating to hydrogen and electric/hybrid-electric systems for a range of ship types, although it is felt that this does not indicate a particular UK focus on a given ship type, rather a focus on the technologies themselves. However, it is essential to highlight that the limited academic interest in ship types within a shipbuilding context does not necessarily reflect the current levels of investment or productivity within the UK's shipbuilding sector. The UK continues to produce cutting-edge research on topics that directly relate to, or have the potential to contribute to, the development of diverse vessel types.



***(Note that the due to the nature of defence vessel, accessible publication may not reflect the true scope of the state of the art)**

AREAS THAT OFFER THE MOST POTENTIAL

As mentioned throughout this section, the UK has several leading areas of research, although it is important to highlight some aspects of the leading areas. It is also important to critique other research areas that offer the most potential to drive the UK shipbuilding sector forward.

1

Autonomy And Design

The UK's leading position in autonomy and design related research focuses on optimisation and the development of intelligent systems and the implementation of these systems. These areas have great potential in driving the UK's shipbuilding industry.

2

Decarbonisation

Within decarbonisation, the UK has the potential to focus on alternative fuels and greener energy systems, the UK has already proven its leading research in these areas and by providing investment into these areas they can become the forefront of the industry.

3

Digital And Future Shipbuilding

The UK has the most potential in adopting Industry 4.0 and 5.0 techniques into current shipbuilding activities, based off the research conducted in the field not only in shipbuilding but other industries as well.

4

Manufacturing

The UK has a significant focus and the most potential in lean manufacturing and large scale additive manufacturing techniques, optimising and producing more efficient methods of shipbuilding.

5

Ship Types

Whilst the UK does have leading research in specialist vessels and underwater vehicles, the UK has a lot of unpublished research in terms of ship types as most works tend to be collaborative works with other nations. The UK has potential to become the leading worldwide competitor in ship types if more projects are focused at a national level - this is not to diminish or stop international collaborations as these are benefical to both parties but an emphasis on promotiong national projects in ship types may drive the UK's competitveness.

Shipbuilding Facilities

Globally, the research focus on ship-building facilities and a nations ability to design and manufacture ships has been minimal in the past five years, with only 147 papers published within the field. The UK has only produced around 11% of these papers and should use this knowledge gap to enhance its competitiveness.

The UK has an opportunity to branch into this research area and develop the next generation of shipbuilding facilities, manufacturing powerhouses and dockyards. Recommendations on how the UK can apply these critical investments are included in Section 4 of this report.

6

SECTION 3

WHAT ARE OUR COMPETITORS DOING?

Whilst the UK has several leading research areas, it is important to understand what other nations worldwide are focusing on and identify the gaps in which the UK could potentially focus on to increase its competitiveness.

Nations in the European Economic Area (EEA) are actively embracing cutting-edge technologies for shipbuilding and decarbonisation.

Norway, The Netherlands, Germany, Denmark, and Sweden focus on robotics, alternative fuels, and ship design improvements. Italy, France, and Spain are investing in noise reduction and the alignment of technologies.

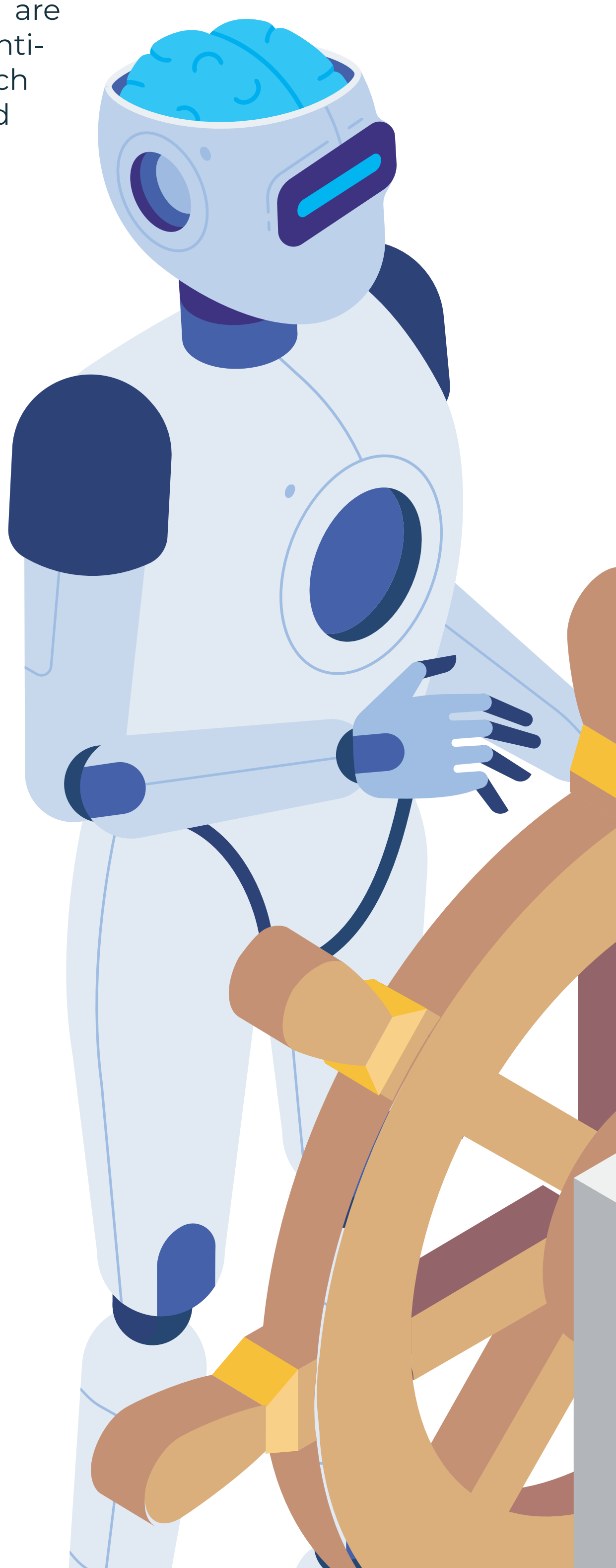
Asian competitors, like Japan, South Korea, and China, emphasise robotics, digitalisation, and advanced propulsion systems.

North American nations, the US and Canada, also embrace modern equipment and machinery and foster skilled talent. Collaborative research and development, public-private partnerships, and investment incentives drive these efforts.

AUTONOMY

Nations in the EEA are actively investing in anti-collision and autonomous navigation technologies. The EEA is also leading in autonomous shipping projects and design processes; examples are in control and monitoring systems. Countries such as Norway, Poland, The Netherlands, Germany, and Denmark emphasise fault detection and multi-vessel control in smart and autonomous ship and shore architecture; Norway, The Netherlands, France and Germany are leading with particular emphasis on using AI and robotics.

Nations in Asia, such as Japan, South Korea, and China, are at the forefront of technological advancements in anti-collision and autonomous navigation, investing in research and development to enhance autonomous systems and navigation algorithms. Japan, South Korea, and China are leading in automated design, focusing on using AI, big data analytics, and machine learning; these nations are also leading in using AI and fault detection systems in smart autonomous ship and shore architecture. Japan, South Korea, and China are leaders, particularly emphasising integrating AI and developing the shore architecture.



The US focus on anti-collision, emphasising disruptive technologies and exploring advances in autonomous navigation. Investment has been made in autonomous uncrewed vehicles, emphasising underwater vehicle development. There is also research into control and monitoring systems for these vessels. Smart autonomous ship and shore architecture projects such as "Sea Hunter" have shown innovation in optimising vessel parameters such as continuous uncrewed operation. The US are leading in developing autonomous ships with a focus on control and navigation systems to seek potential in improving safety efficiency, reducing workforce, emission and enhancing data collecting capability.

DECARBONISATION

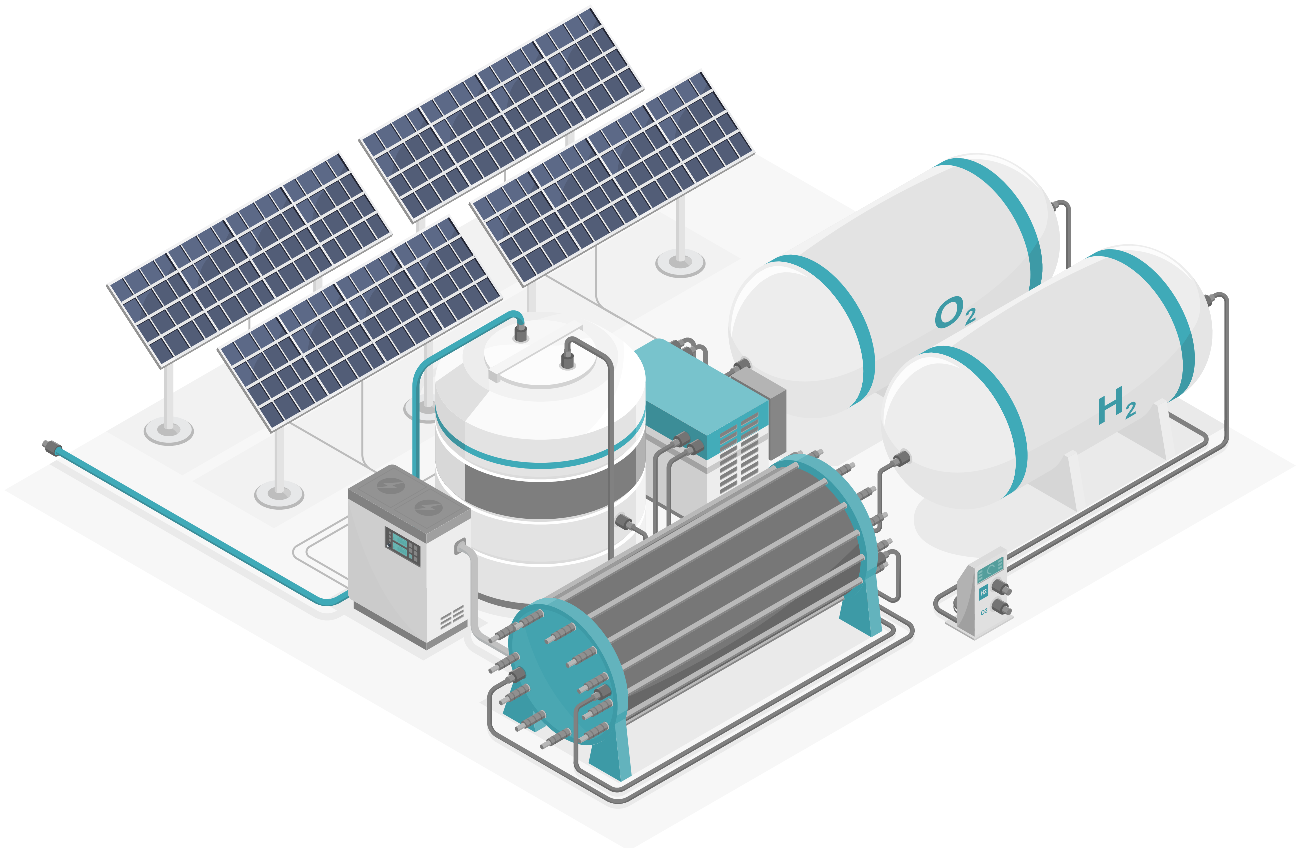
Overall, the global trend in the maritime industry is leaning towards sustainability and decarbonisation, with each nation contributing its unique approach to help tackle these challenges. For example, The EEA emphasises resource efficiency and waste reduction, Asia innovates in green design and construction, and the Americas explores circular economy principles.

The EEA, China and South Korea focus on developing carbon capture technologies, optimised energy systems and implementing sustainable practices, not exclusively in the shipbuilding sector. The EEA's goals for carbon capture are to improve its efficiency by looking at the use of innovative materials and how these can be implemented into power and energy systems.

Countries in the EEA, such as Norway, Germany and the Netherlands, are looking at greener fuel sources such as ammonia, methanol, thorium-based reactors, and hydrogen fuel cells. Italy, Denmark, and Norway are investigating the development of alternative propulsion systems such as wind power e.g. Flettner rotors and rotor sail solutions.

Asian nations focus on developing intelligent ships and prioritising using greener fuels like hydrogen and ammonia. South Korea uses intelligent energy management and advanced propulsion systems to optimise ships' fuel efficiency, reducing costs and emissions.

The US prioritises investment in low-carbon fuels such as **Liquified Natural Gases (LNG)** and innovative ship technologies. Canada is emphasising LNG and electrification and studying the potential of Arctic shipping routes.

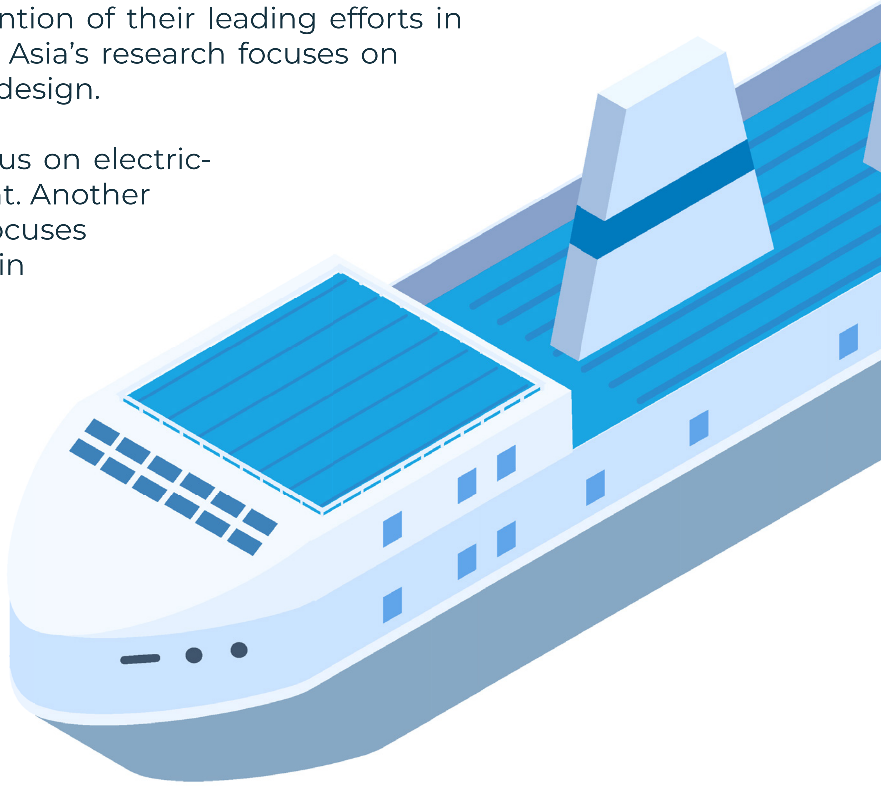


DESIGN

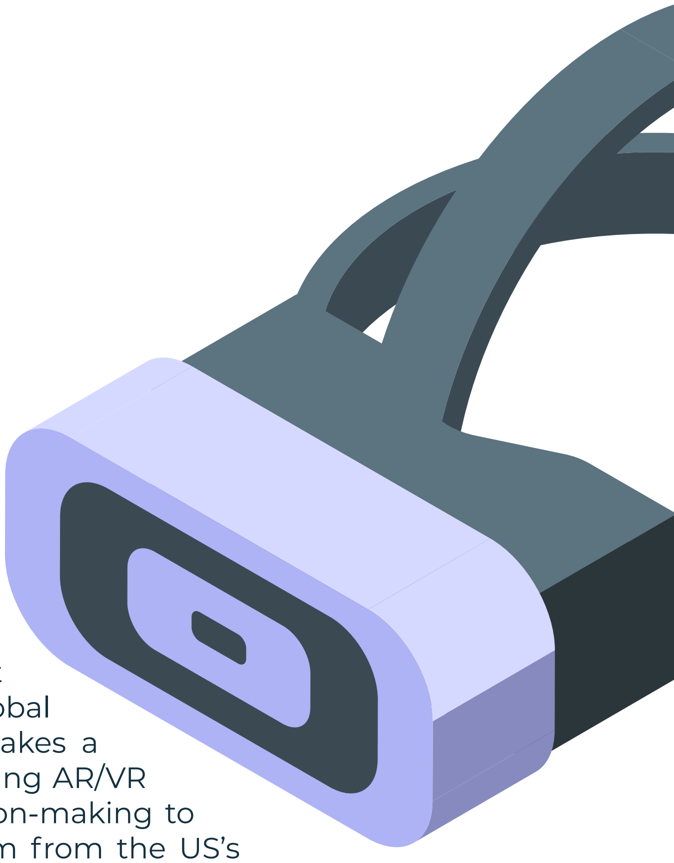
EEA countries such as Norway, Finland, France and Italy are focusing on developing alternative fuel and power systems such as wind-powered ships and ammonia, methanol and liquid hydrogen-fuelled ships. These projects are part of the EEA's flagship €80 billion Horizon 2020 framwork programme and aim to satisfy the UN's sustainable goals and reach a carbon-neutral status. Many EEA countries focus on developing optimisation techniques for designing and incorporating energy-saving devices.

Asia's countries focus highly on ship automation, particularly in developing UAVs. This aligns with the previous mention of their leading efforts in autonomy and cleaner engine designs; Asia's research focuses on liquid hydrogen and hybrid powerplant design.

Literature from the Americas has a focus on electric-powered systems and their development. Another prevalent research area within the US focuses on topics such as AI and biomimicry in ship design, aligning with findings from UK research.



DIGITAL



Competitors across EEA, Asia, and the Americas are strategically approaching shipbuilding technological changes for enhanced productivity and decarbonisation through project funding. In the EEA, research centres on digitalisation, sustainability, and supply chain optimisation, utilising AR, IoT, and data analytics.

Countries in Asia, particularly China and South Korea, are pushing the boundaries in the maritime tech sector. They prioritise advancements in AR algorithm enhancements digital twins to boost efficiency and predictive maintenance—strategies that reflect their broader commitment to leading the global digital transformation. On the other hand, the US takes a slightly different approach with an emphasis on refining AR/VR simulation quality and harnessing data-driven decision-making to drive innovations. This difference in focus might stem from the US's long-standing culture of seeking technological excellence and precision. Meanwhile, Asia's leadership in digitisation, machine learning, and IoT, particularly concerning fuel efficiency and decarbonisation, showcases their determination to tackle environmental challenges and solidify their place at the forefront of sustainable shipping solutions.

The EEA excels in digital twin adoption particularly within engines, enhancing ship designs and processes – by utilising automation and digital methods such as computer aided design software. The US evaluates collaborative simulations, risk assessment, and the integration of Industry 4.0 into manufacturing and design processes. Competitors globally investigate alternative fuels such as hydrogen, ammonia and methanol – similar to the UK, emissions reduction through the use of alternative propulsion systems and the electrification of ships, and energy-efficient designs through the use of computational fluid dynamics and data-driven analytics. Collaboration, digital twins, smart technologies, and sustainability practices are what drive innovation, making these regions formidable competitors in the evolving shipbuilding landscape.

FACILITES & CAPABILITES

Major shipbuilding powers such as the US and China currently dominate this research area. Despite confronting deindustrialisation in recent decades, the US has maintained a prominent position in research for shipbuilding facilities and capacities. This prominence is mainly due to significant governmental investment, particularly through the national defence budget and sustained naval expansion. This funding strategy has fostered robust collaborations among academia, research institutions, and industry stakeholders, advancing shipbuilding technologies and methodologies.

In contrast, China, a substantial player in shipbuilding, faces challenges in synchronising industry with academia. Nevertheless, initiatives are underway to mitigate this disparity, with the National Natural Science Foundation of China financing projects encouraging collaborative knowledge exchange.

In the context of the EEA, the focus of funded projects tends to be targeted towards broader policy in the industry, contemplating environmental and societal impacts that ensure the industry's sustainability. The US federal government has also displayed interest in the social implications of the shipbuilding industry, initiating investigations into the effects of shipbuilding facilities on local communities.

This study only captures published research and within the bounds of the search methodology as described within section 1, it might not capture the full breadth and depth of the industry. This is especially true in the case of facilities and capabilities. While South Korea and Japan are internationally recognised in terms of facilities, the relatively muted focus on these facilities in published literature contrasts with their role in facilitating top-tier research on other shipbuilding-related topics.

FUTURE SHIPBUILDING

Beyond the UK, other EEA countries like Norway, the Netherlands, France, Spain, Germany, Denmark, and Sweden are also making strides in maritime innovation. They emphasise sustainability, autonomy, and efficiency. Japan, South Korea, China, the US, and Canada are investing in advanced shipbuilding techniques, including alternative fuels and eco-friendly designs, to shape the global shipbuilding industry's future.

In summary, the global shipbuilding industry is undergoing a transformative journey of innovation, sustainability, and technological advancements. Each country's contributions play a pivotal role in shaping the future of shipbuilding, from cleaner propulsion systems to disruptive technologies that redefine industry standards.

MANUFACTURING

In Asia, specifically in countries like China, South Korea, and India, significant research efforts are dedicated to advancing manufacturing processes in shipbuilding. This includes a focus on lean manufacturing practices, such as optimising lot-sizing in ship-pipe part production and implementing lean shipbuilding modes to address manufacturing challenges. Research also extends to innovative fault diagnosis systems, virtual flow production systems, and leveraging innovation-driven technology for ship manufacturing improvements. Particularly, China excels in various welding research areas, including robotic welding, laser welding, and Wire Arc Additive Manufacturing (WAAM), with a strong emphasis on automation, quality control, and real-time data analysis.

Nations in the EEA like Spain, Norway, Sweden, and Germany are making significant strides in welding manufacturing research. Their efforts are centred on advanced welding techniques like laser welding, hybrid laser arc welding (HLAW), and laser-arc hybrid welding (LAHW). The overarching goal is to replace conventional welding methods with more efficient and high-quality alternatives. Additionally, European research focuses on systems engineering, digital twin models, and organisational learning to streamline ship design and production, improve safety, and reduce environmental impact. Machine learning applications are also used in friction welding for predictive maintenance and quality control, aligning with decarbonization objectives.

Lastly, in the Americas, countries like the US, Canada, and Brazil are investing in lean manufacturing practices to enhance shipbuilding productivity. Their research aims to reduce waste, improve production processes, and address challenges like long manufacturing cycles and complex supply chains. Similar to the research in Asia, innovative manufacturing technologies are explored, such as WAAM for fabricating shipbuilding steel plates and laser forming for rapid manufacturing of metal parts. Additionally, Finite Element Analysis (FEA) methods are used to predict weld metal cooling rates, ensuring structural integrity while potentially reducing energy consumption and emissions. The focus is on optimising processes to enhance competitiveness and align with decarbonisation goals.

SAFETY

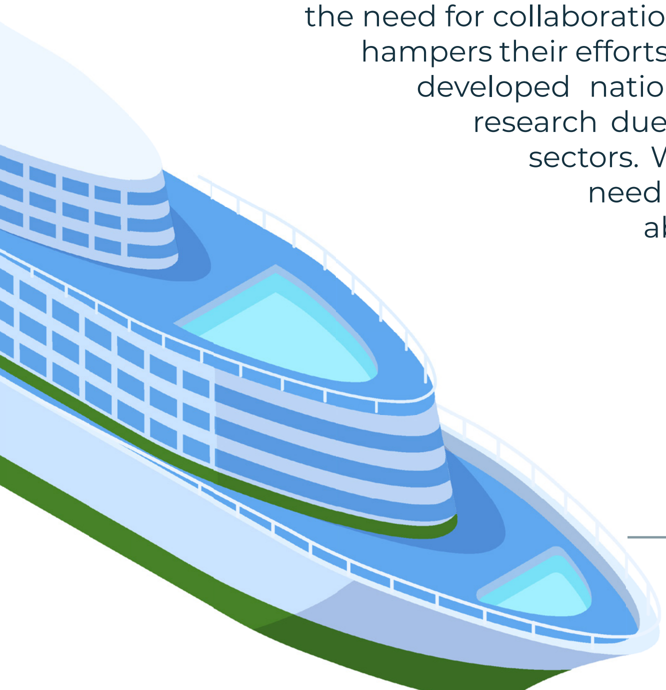
VR and AR can improve training and safety; the US, South Korea and France have already implemented this by creating real-world scenarios that can train workers in a safe and immersive environment. They have also been able to develop electronic courses and 3D simulations to enhance this level of training.

The use of robotic systems has been recommended as an investment point for the UK, but countries in Asia and the EEA have already implemented these into practice and research. Applications have included the use of robotic welding processes, painting, component and material handling, and assembly. Whilst it is acknowledged that the UK may have implemented some of these solutions into research and practice, there is a significant need to understand how these competitors have adapted and why they are continuing shipbuilding practice.

SHIP TYPES

It has already been established that the UK currently holds a leading position in research on specialist vessels and underwater vehicles. However, regarding other research areas, the UK must catch up on other major international players, including the US – who have a heavy focus on developing military vessels. China, South Korea and Japan – who all have a speciality in developing cargo haulers and specialist vessels. It is noteworthy that, besides these three leading shipbuilding nations, the UK also trails behind the EEA regarding the number of funded projects and investment amount.

When considering the global research perspective into the various ship types, the main barrier in the current research stage is an imbalance in focused research and manufacturing processes. On the one hand, manufacturing powerhouses like China and Korea face challenges due to inefficient investment caused by a lack of practical industry-university-research cooperation. While these countries possess dominant manufacturing capabilities, the need for collaboration between industry, academia, and research institutions hampers their efforts to develop further. On the other hand, de-industrialised developed nations like the UK encounter difficulties in shipbuilding research due to a need for firsthand data from the manufacturing sectors. With a diminished manufacturing base, these countries need help accessing real-time industry data, hindering their ability to conduct comprehensive research and develop cutting-edge shipbuilding capabilities.



SUPPLY CHAIN

On a broader global scale, EEA shipbuilding makes up a small part of the world's ship production but holds about 13% of its ship orders in value. EEA suppliers contribute around 16% of global ship machinery and equipment, including essential parts like engines, generators, and electronics. They are using digital advancements (like Industry 4.0) to make their supply chain more efficient.

To compete with Asia's cheaper labour, EEA shipbuilders focus on making advanced, valuable ships through innovation and specialisation. The US invests in technologies like 3D printing and simulation to improve shipbuilding. They are leading in research on technologies such as 3D printing, data analysis, robotics, simulations, IoT, cloud computing, and AR.

MARKETS

Whilst the rest of this section focuses on individual aspects of research, it is essential to understand the UK's market stance compared to other nations; this summary briefly explains the competition's current market position.

Key companies in the shipbuilding industry can be categorised as significant shipbuilding powers and their various state champions, such as South Korea's Korea Shipbuilding & Offshore Engineering Co, Hyundai Heavy Industries, China's China State Shipbuilding Corporation, France's Chantiers de l'Atlantique, Italy's Fincantieri and Japan's Mitsubishi Heavy Industries and Oshima Shipbuilding.

China leads in adopting digital shipyard solutions globally, with the Asia Pacific region having the largest share. The global digital shipyard market is projected to grow from $1,129.6 million in 2021 to $3,444.5 million by 2028 at a CAGR of 17.27%.

The EEA is expected to experience significant growth as shipbuilders invest more in robotic technology. North America will also grow due to increased research and development efforts for digitising shipyards.

The shipbuilding market encompasses earnings from ship construction, conversion, and alterations. In 2022, Asia-Pacific led the market, followed by Western EEA. Growing seaborne trade is expected to boost market growth. Increased consumer demand due to rising population, purchasing power, and living standards drive production and industrialisation. However, the market could face challenges due to the substantial working capital required for hardware and software, potentially impacting its growth.

SECTION 4

WHAT CAN WE IMPROVE UPON

Understanding the UK's and other nations' capabilities and expertise in shipbuilding is only one aspect of this report; the following sections expand upon some of the areas within the UK's research that are lacking or require more investment to help drive its competitiveness. The following section is split into the following segments:

PART 1
AREAS FOR CRITICAL INVESTMENT

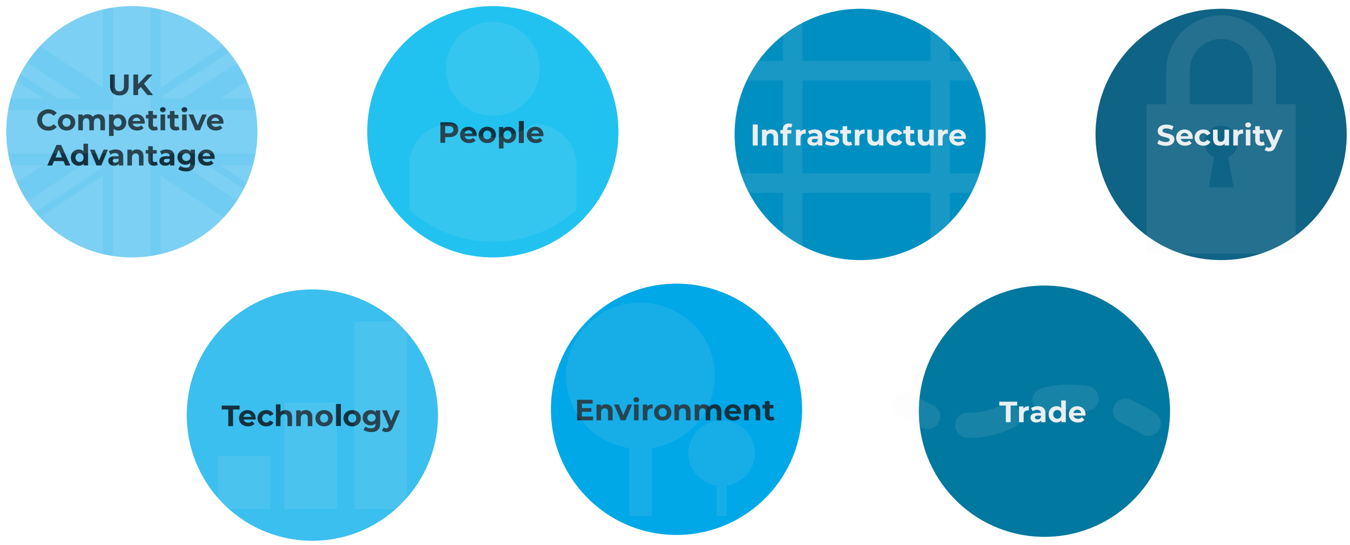
PART 2
AREAS FOR FOCUSED RESEARCH

PART 3
HOW CAN WE ACHIEVE THIS?

The final segment of this section will give insight into the methods by which these recommendations can be implemented.

AREAS FOR CRITICAL INVESTMENT

The Maritime 2050: Navigating the future strategy paper[1] outlines the UK Government's future vision and aspirations for the maritime sector in the UK. Maritime 2050 focuses on proactively addressing forthcoming challenges and opportunities while acknowledging the country's strengths, positioning the UK strategically to take full advantage of them. According to the paper, the ambitions and goals will be attained through a dedicated emphasis on the following seven themes:



This report also shows that upskilling the workforce quickly and efficiently is essential so they can use these new technologies. Additionally, improving their working conditions and making tasks less laborious will significantly impact productivity and the overall attractiveness of the sector. These investments in shipbuilding, cost reduction strategies, and the development of new business models will collectively shape the future of the shipbuilding industry. The industry also focuses on building shipyards, getting the right people to work there, and being ready to face challenges. As also discussed in Maritime 2050, the UK's shipbuilding industry wants to be more efficient, better for the environment, and successful worldwide. The following recommendations require critical investment and should be considered the first action points from this report to enhance the UK's competitiveness.

[1] https://www.gov.UK/government/publications/maritime-2050-navigating-the-future

Digitisation And Disruptive Technologies

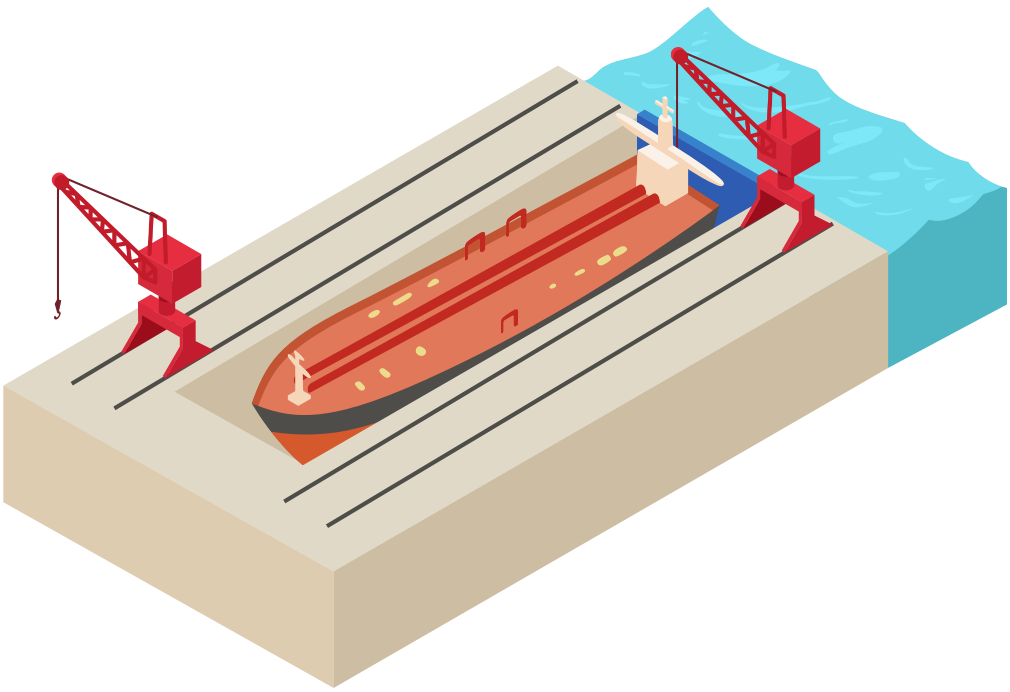
Investing in higher-level research skills for disruptive technologies is crucial for the UK's maritime shipbuilding industry. It drives innovation, competitiveness, and sustainability. Disruptive technologies like digital manufacturing, AI, and IoT enhance processes, attract global customers, and align with eco-friendly practices. Such investments future-proof the industry, ensuring adaptability to emerging trends. Collaboration and knowledge exchange accelerate innovation, while economic growth and job creation result from embracing these technologies. Investing in research skills for disruptive technologies is a pivotal step towards industry transformation, global leadership, and long-term success.

Ship Types

In the case of UK research in ship types under a shipbuilding context, the investment in research skills is essential. The UK being a global leader in shipbuilding-related research concerning specialist vessels and AUVs is a direct result of the flow of funding from EPSRC or UKRI.

Facilities And Capabilities

Investment in rejuvenating and retrofitting existing ship-building facilities is of the utmost importance. While research in this area may be limited, it is crucial to underscore that substantial investment in methods and critical infrastructure is an indispensable prerequisite for the UK to position itself competitively in the shipbuilding industry. These investments are fundamental for revitalising our shipbuilding capabilities and laying the foundation to participate and thrive in the shipbuilding sector actively. While discussing the facilities and capabilities of the UK shipbuilding industry, it's essential to recognise these strengths also exist in other industrial sectors. The beauty of advanced technologies like AI, autonomy, and innovative methodologies is their versatility. They serve as a testament to the adaptability of the UK's industrial prowess. Just as these technologies are utilised in other domains, they could readily pivot into shipbuilding if the challenges or opportunities demand it.



AREAS FOR FOCUSED RESEARCH IMPROVEMENT

The UK's shipbuilding industry is experiencing transformative changes driven by cutting-edge technologies. Key disruptive advancements include additive manufacturing, shipbuilding robotics, ballast-free ship design, alternative fuels, and low-emission propulsion systems. These innovations address environmental concerns, efficiency, and competitiveness. Targeted research areas for enhancing the UK's capacity in world shipbuilding markets include updating infrastructure, modernising shipyards, adopting advanced machinery, and nurturing skilled talent through industry-focused education. Collaboration between academia and industry is vital to align research with industry needs. Open data sharing can improve coordination, while financial support and investment incentives can attract more commercial lenders to the sector. Resilience against disruptions and noise reduction are also priorities.

Autonomy

One area deserving of focused research in shipbuilding is the application of artificial intelligence for the design and safety of vessels. Autonomous and AI systems represent a future trend in ship development. If the UK can achieve a leading position in Guidance, Navigation, and Control (GNC) systems in particular, the UK can place itself competitively. Although the current research on autonomy in the UK is somewhat behind other countries, there is scope for the UK to rectify this if there is a demand. Autonomy research can be improved by engaging in collaboration with the National Robotarium, these cutting-edge research domains can be leveraged to benefit the shipbuilding industry in the UK.

Moreover, autonomy is currently a rapidly developing area, and the advancement of AI has brought about more possibilities within autonomy and can act as a disruptive technology. Investment in higher-level research skills, particularly disruptive anti-collision and autonomous navigation technologies, is paramount for the UK's maritime shipbuilding industry. Investment into AI can also be directed into the integration within design processes to help reduce schedule delays and costs and drive towards "right first time", whether through AI generative design or AI assistants to help manage the ship.

AI and autonomy can also be placed in developing safe practices for building ships; AI can analyse large amounts of data and detect anomalies and potential safety hazards regarding shipbuilding and maintenance practices.

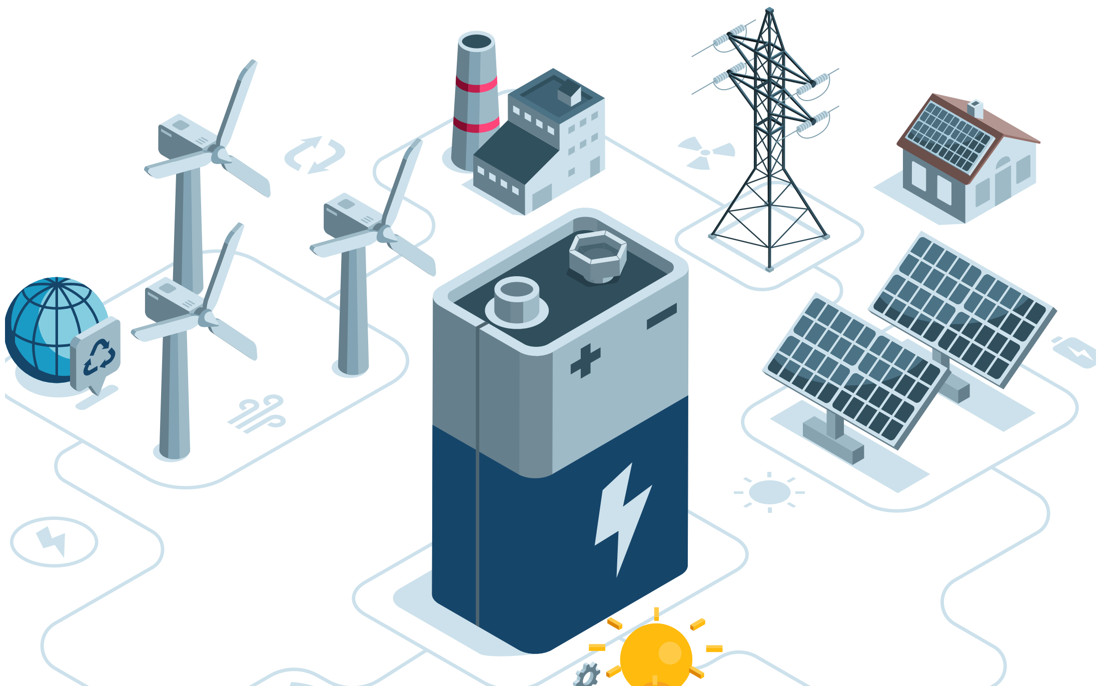
The investment in these advanced research skills applying to disruptive technologies will enable the UK to address emerging challenges and seize opportunities, ultimately benefiting the existing and emergent members of the country's maritime shipbuilding industry. Undoubtedly, investment in automation is crucial.

Decarbonisation

Decarbonisation has long been a central theme in the shipping industry, so, unsurprisingly, this report will recommend an intensified emphasis on decarbonisation strategies. The intent behind this recommendation is not merely to reiterate the focus but to underscore the necessity of enhancing and transforming current approaches to decarbonisation, ensuring that they align with evolving industry standards and the urgency of environmental concerns. The UK must improve its strategy to compete and move beyond other nations. Improvement in strategy and development of greener ships will come from design changes and green propulsion systems utilising alternative fuels such as hydrogen wind and electric alternatives. Regarding greener ships, fuel cells represent a disruptive technology challenging current conventional powering approaches for ships. They offer one of the most apparent pathways to harness the UK's research capabilities. This aligns seamlessly with the UK's shipbuilding agenda, which strongly emphasises innovation and sustainability, in line with initiatives such as the Net Zero by 2050 and the Clean Maritime Plan. Furthermore, there is a growing global interest in such technologies, making it imperative to continue in-depth analysis and innovation. Given the scope of fuel cell research, several unanswered questions and areas regarding optimisation, safety, and logistics exist, which require our focused attention to meet these ambitious emissions reduction goals.

Alternative fuels and clean energy are other possible areas for UK investment. There are ambitious environmental targets for shipping, and it is easy to support the concept of investigating alternative fuels and clean energy, such as hydrogen, ammonia and methanol. Nuclear technology once garnered significant interest, particularly in the 70s and 80s, but that interest has somewhat waned due to the introduction of alternative approaches and technologies. Nevertheless, nuclear power remains a viable option for ship propulsion, particularly the adoption of small modular reactors. Therefore, the UK can lead in refocusing on nuclear technology and reassessing its viability for modern ships. Revisiting the use of nuclear power could potentially complement the UK's expertise in nuclear regulation and decommissioning and general knowledge of the nuclear sector. However, it's essential to acknowledge that the feasibility of such a shift remains uncertain and would require thorough evaluation.

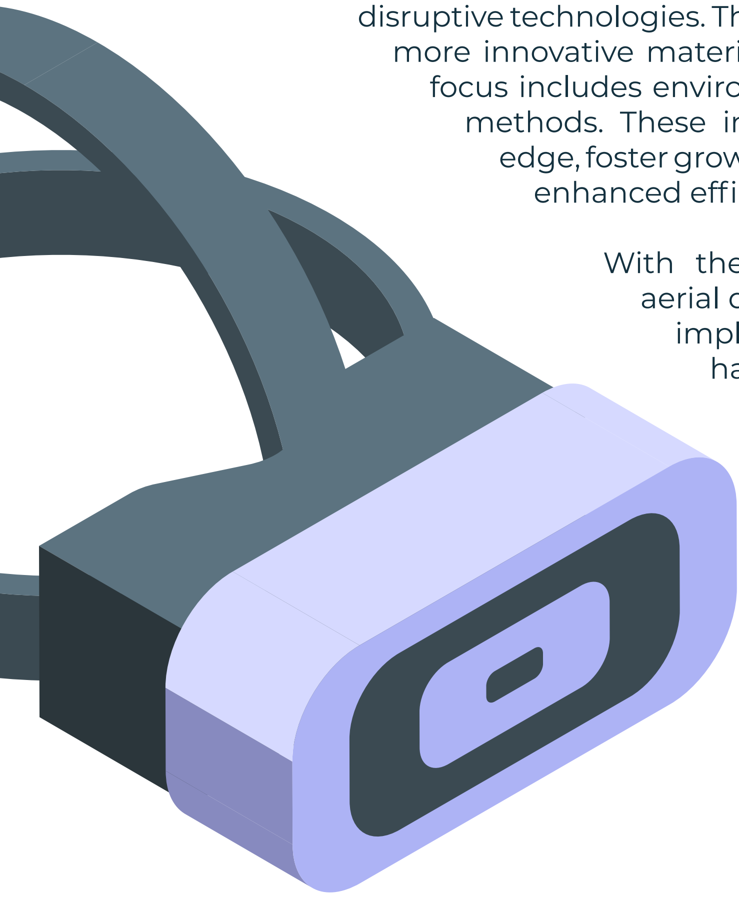
The UK is actively investing in carbon capture projects related to shipping, demonstrating a keen interest in this technology. Therefore, the recommendation is to continue research and investment in carbon capture, provided its efficacy and viability are maintained.



Digital And Innovative Technologies

Investing in higher-level research skills for disruptive technologies is crucial for the UK's maritime shipbuilding industry. It drives innovation, competitiveness, and sustainability. Disruptive technologies like digital manufacturing, AI, and IoT enhance processes, attract global customers, and align with eco-friendly practices. Such investments future-proof the industry, ensuring adaptability to emerging trends. Collaboration and knowledge exchange accelerate innovation, while economic growth and job creation result from embracing these technologies. Investing in research skills for disruptive technologies is a pivotal step towards industry transformation, global leadership, and long-term success.

Investing in research skills is vital for the UK's shipbuilding industry to embrace disruptive technologies. These technologies can revolutionise the sector with more innovative materials, greener practices, and efficient designs. The focus includes environmental sustainability through cleaner fuels and methods. These investments maintain the industry's competitive edge, foster growth, streamline operations, and lower costs through enhanced efficiency and productivity.

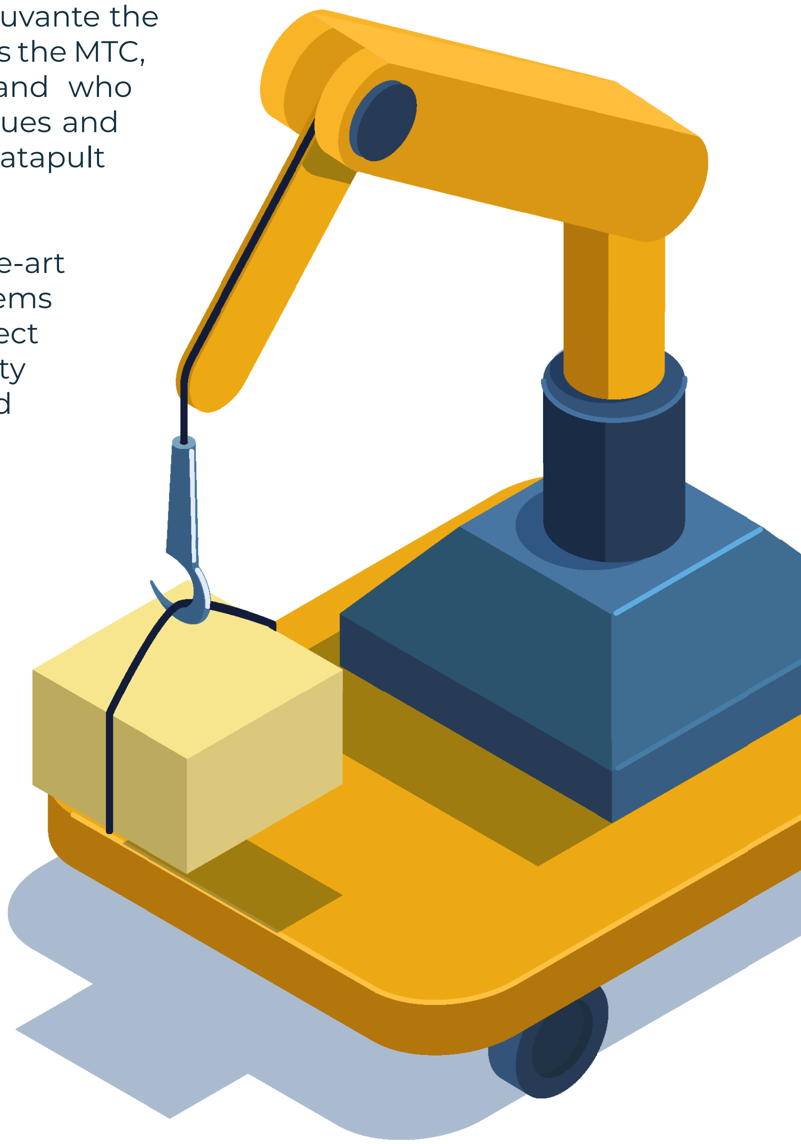


With the ever-changing and evolving development of aerial drone technology, the UK can quickly develop and implement tailored drones to inspect and identify hazards. Finally, robotic and automated systems can enhance safety within shipbuilding. Robotic technologies can allow builders to be free from hazardous areas. Alongside the proposed implementation of these technologies, VR/AR can be used to manipulate these technologies and enable workers to be safe and free from hazards. VR/AR can also be used to enhance the training of workers as it can play a range of scenarios without the risks being in place in the real world and works as a great alternative to purely theoretical training.

Manufacturing And Supply Chain

The shipbuilding process involves various elements like suppliers, factories, and transforming raw materials into usable resources on a global scale. Creating a resilient shipbuilding process means adapting to market fluctuations and natural disasters. Strengthening the shipbuilding supply chain is crucial for efficient ship production. The supply chain is a communication network connecting companies, factories, suppliers, and resources. Its main objectives are swift responsiveness, flexible production, cost-effectiveness, and minimal excess inventory. These improvements benefit all parties involved, enhancing shipbuilding efficiency and sustainability. The overarching goal is to strengthen shipbuilding's sustainability by optimising these connections. This includes integrating key shipbuilding technologies with supply chain concepts such as efficiency, adaptability, eco-friendliness, and crisis management. Presently, the shipbuilding industry requires innovative approaches to streamline operations and supply chain management. This will drive profitability and ensure the well-being of individuals and the environment; alongside the supply chain aspect, the UK will need to invest in manufacturing, particularly Industry 4.0.

The UK has already begun to improve and rejuvante the manufacturing industry with examples such as the MTC, the National Manufacturing Institute Scotland who specilise in advanced manufacutring techniques and is supported by the UK government and Catapult Scotland.



Manufacturing a complex, state-of-the-art Maritime 4.0 and 5.0 requires supporting systems to manage a full-scale construction project effectively. Coming to grips with such complexity involves supporting an industry-specific and enterprise-breadth system that can handle such a unique manufacturing process. Thus, supporting project management and supply chain processes is critical.

The transformational technologies integral to Industry 4.0, from AI and machine learning to 3D printing and digital twins, are poised to play a pivotal role in Maritime 4.0. Effectively capitalising on the potential of these technologies will require a comprehensive digital transformation process. Because of the complexity of the projects, it requires a digital shift to a more integrated environment. The size of their operations will require UK ship manufacturers and naval organisations to move towards a more integrated environment to fully take advantage of the efficiency, visibility, security, and sustainability benefits of Maritime 4.0 in an increasingly digitised sector.

HOW CAN WE ACHIEVE THIS?

The UK's maritime sector is crucial to the country's economy. The rich history of shipbuilding across the UK drove the development of marine departments in leading regional universities. These universities (collaborating widely with other UK and international partners) continue to hold high global standing in maritime research and education, even whilst the regional shipbuilding industry base has significantly declined and adapted into new markets such as offshore energy. Meanwhile, these regions' industry sectors continue to be embedded with skills and knowledge ideally suited to renewed shipbuilding, shipping and related industry activity.

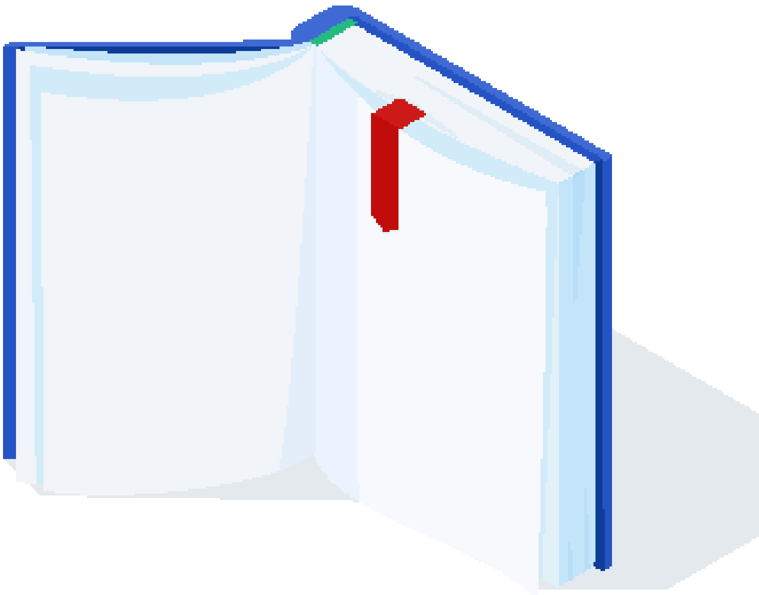
To revitalise UK shipbuilding and global competitiveness in maritime, it is vital that the industry can effectively leverage the research capacity of this regional network of universities and allied institutions. This report highlights areas including the enhancement and critical investment into the UK's shipbuilding facilities, which are vital to the success of the UK's shipbuilding strategy and need renewed industry-academia collaborative research to drive productivity and competitiveness of UK industry. Leveraging this academic resource by UK industry will, in turn, promote the standing of UK institutions for internationally leading academic research, innovation and impact in the global maritime sector. This is the virtuous circle of enhanced industry-academia collaboration, with successful international examples such as the EEA Research and Innovation Platform for Waterborne Industries.

Underpinning this requires a rejuvenated maritime workforce that needs enhanced knowledge, skills development and training, ranging from core shipbuilding competencies to radical new areas such as autonomy and AI. UK universities, working closely with industry, can provide better leadership in this area to benefit throughout the skills range and attract talented people into the maritime sector. High-level knowledge can be exchanged through educational mechanisms such as doctoral training. There is a growing demand (currently outstripping supply) for graduate-level professionals in the maritime sector, which can be better met if university capacity grows through aligned research activities. Universities can also better influence core workforce capacity by expanding degree apprenticeships and linking to the broader network of tertiary education providers such as colleges and training academies.

KEY RECOMMENDATIONS

National Collaborations And Partnerships

Support national and regional networks to grow and maintain strong collaboration between academia, industry, and government. Encourage broad objective industry-academia partnerships to enable long-term sharing of knowledge and resources, including people (refer to key recommendation: Skills Development and Training). Learn from example models of good practice internationally, such as MARIN (Netherlands) academic partnerships. Utilise platforms like the National Shipbuilding Office (NSO) to act as central support for these partnerships. Build on existing regional hubs and networks to foster partnerships and extend to universities, with examples of good practice including MarRI-UK, the Liverpool Freeport, Maritime UK Solent, NOF, and National Manufacturing Institute Scotland. Widen maritime industry collaboration with broader networks, for example, the AMRC, the National Robotarium and MRC Catapults, to exchange knowledge and translate research findings into practical applications for shipbuilding.



Research Funding And Incentives

Adapt current funding models from UKRI and Government agencies to combine and work better for collaborative industry-academia research in maritime fields associated with shipbuilding. These can meet both the shorter-term development needs of the industry (examples are Innovate UK Clean Maritime Demonstration Competition with timescales typically 6-12 months) with routes to longer-term outcomes of fundamental research and impact from universities (examples are EPSRC responsive grants with timescales typically 2-5 years) and other programmes such as UK SHORE and the Department For Transport: Zero Emission Vessels and Infrastructure. Recognise the differences in how projects are resourced in industry compared to academia to remove barriers to effective collaboration through research funding. For example, by resolving the difficulties of people resourcing short-term projects effectively within universities. Provide specific grants and incentives to support projects on AI, automation, sustainable practices, and decarbonisation linked to core shipbuilding outcomes. Continue support of network programmes like MarRI-UK and UK SHORE.

Research Funding And Incentives Continued

Alongside the other funding recommendations, it is crucial that the ESPRC and UKRI recognise and implement Maritime Engineering as a priority theme, promoting new research incentives for the topic area and investment into key themes of research in these areas.

Skills Development And Training

Invest in high-level workforce development programmes to equip professional engineers to develop knowledge stemming from research in future aspects of shipbuilding and maritime, particularly in areas such as AI, automation, sustainable practices, and digital technologies. This also enables academia to access industry practice through researcher-in-residence programmes. For instance, the Data-Centric Engineering (DCE) programme, building upon the strong foundations of the long-term strategic partnership between Lloyd's Register Foundation and The Alan Turing Institute, can be applied to the UK shipbuilding sector to enhance the speed and safety of design and system implantation. Short-term skills development includes specific skills training, industry-academic conferences, CPD programmes, MSc programmes (such as the Marine Technology Educational Consortium) and apprenticeships. Longer-term specialist maritime education, which provides an ideal mechanism to foster industry-academic partnerships, includes doctoral programmes such as EngD, PhD and MPhil. Demonstrating the value of skills development to industry is essential, using examples of excellent practice in the international sector, such as DNV's university relations programme, and support from government schemes such as the China Scholarship Council. Reduce financial barriers to study doctoral programmes in the UK, recognising that current UKRI stipend levels fall well below typical graduate salaries in the maritime sector.

PhD
Doctorate of Philosphy
3-4 Years

EngD
Doctorate of Engineering
4-5 Years

MPhil
Masters of Philosphy
1-2 Years

Entrepreneurship and Commercialisation

Create an environment that encourages and supports entrepreneurship and the transition of research outcomes into marketable products and services for the shipbuilding sector. Facilitate technology transfer, protect intellectual property, and involve industry partners in technology development. Promote universities' world-leading facilities and expertise to early-stage product development, including a range of internationally leading experimental and computational facilities across UK institutions.

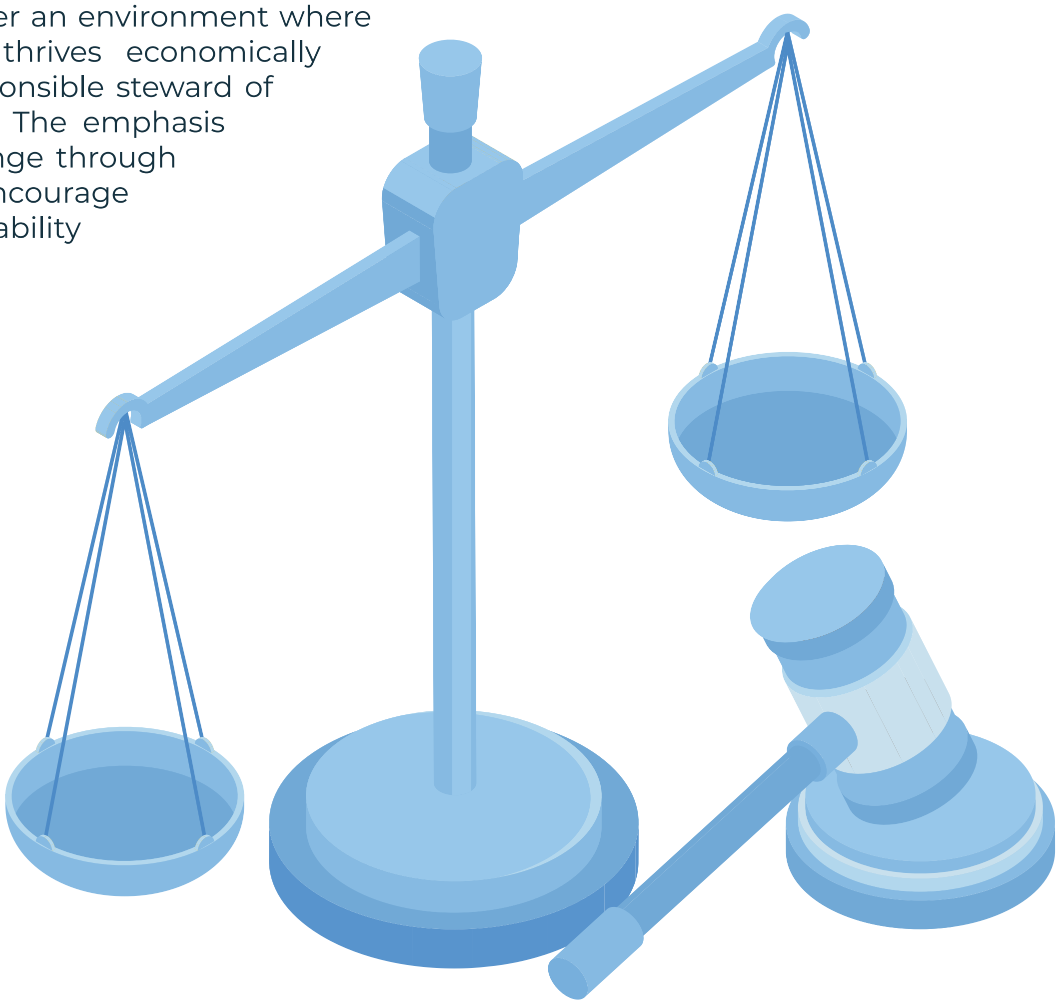
Focus on Niche Technological Expertise

Develop specialised expertise in workboats, walk-to-work, autonomous, and short-range vessels. By concentrating our efforts and resources on these specialised domains, we can carve out a distinctive edge in the market. Adapt successful practices from related industries like aerospace and automotive to shipbuilding challenges. These industries have demonstrated remarkable advancements in precision engineering, materials science, and design methodologies, all of which can be adapted to address shipbuilding challenges. By leveraging cross-industry knowledge transfer, we can accelerate innovation and elevate the quality and efficiency of our shipbuilding endeavours.

Policy Incentives and Regulations

Advocate for policies incentivising adopting new technologies, sustainable practices, and digitalisation in the maritime sector. Ensure supportive regulatory frameworks to promote cleaner fuels, energy efficiency, and environmental responsibility. These regulations will be pivotal in steering the industry towards a more sustainable and environmentally friendly future.

By combining policy incentives with robust regulatory structures, we can foster an environment where the maritime sector thrives economically and operates as a responsible steward of our planet's resources. The emphasis here is on driving change through policy incentives that encourage innovation and sustainability in the maritime sector.



Emphasise Shallow Continental Shelf Solutions

Prioritise research and development for vessels suitable for shallow continental shelves for sustainable resource and energy developments. These unique environments present challenges and opportunities, making them a niche area where we can excel. Adapt successful practices from other countries to gain a competitive edge. By learning from their experiences and adopting best practices, we can accelerate our progress and gain a competitive advantage in designing and deploying vessels ideally suited for shallow continental shelf applications.

Shipbuilding for Regional Growth

Promote the adoption of shipbuilding as a catalyst for regional economic growth. Encourage regional and devolved governments to collaborate with their academic and industry partners in revitalising underprivileged areas that possess the space, heritage, and expertise in shipbuilding. This initiative could revolve around developing port-side infrastructure to support advancing the next generation of offshore wind farms. This encompasses investments in Walk-to-Work vessels, alternative propulsion technologies, alternative fuel bunkering and shore-to-ship energy facilities, and port redevelopment for manufacturing and logistics purposes. In this context, the UK Government can align regional development funding with its energy strategy and leverage private sector investments for offshore wind development.

Implement Robust Methodology and Logistics

Establish robust ship design methodologies, incorporating digital technologies like Building Information Management (BIM). BIM can significantly streamline and enhance ship design efficiency, resulting in more precise and cost-effective outcomes—Optimise supply chain logistics for efficient component delivery. By implementing state-of-the-art logistics strategies, we can ensure the timely and cost-effective procurement of components, contributing to the overall success of our shipbuilding projects.

Shifting Mindsets of Young Adults

Creating educational and professional interventions for young adults to encourage them to get into the shipbuilding industry. By looking at the current options and paths available to young adults and creating specialist interventions such as educational courses, modern apprenticeships and even, study for work schemes to shift a young adults interest into shipbuilding and maritime engineering.

SECTION 5

CONCLUSION

This report is a building block or stepping-stone for the NSO, and the UK has much work to do to rejuvenate the shipbuilding industry. To summarise this report, however, the UK has several leading research areas listed below.

The UK is leading in developing specialist vessels and underwater vehicles – particularly drones. The UK has a relatively leading position in investigating and developing green fuel sources, strongly emphasising hydrogen-based systems and IoT for enhanced decarbonisation. Finally, the UK has an influential role in developing autonomous systems for both the design process and integration within ships, achieved through support tools such as optimisation techniques used in CAD, CFD and FEA platforms.

Although leading in the research areas mentioned above, the UK lags behind other nations in several domains. Whilst the UK has a strong autonomy research, it lags behind countries in Asia who are leading in the use of AI and automation. The UK needs to catch up in decarbonisation such as sustainable development, exploring the use of advanced and alternative propulsion systems and alternative fuel cell technology compared to the EEA.

To ensure the UK remains abreast and leads, the following research areas need investment to help drive the UK forward. The UK can invest and become competitive in integrating innovative technologies such as drones, VR/AR and AI automation for several themes, such as design, safety, supply chain and even decarbonisation. But for the UK to become more competitive, there needs to be significant investment and support for rejuvenating shipbuilding yards in and around the country. This can be achieved through the retro-fit of ports and dockyards by implementing cleaner fuel sources, advanced manufacturing techniques and equipment and developing enhanced lifecycle management techniques to help reduce costs, reduce and mitigate potential delay and ensure that we are developing ships right the first time. Some examples of ports ideal for retrofitting are Glasgow, Liverpool and Plymouth.

Finally, the UK can achieve enhanced competitiveness in several ways, and recommendations are listed in Section 4. However, listed below are some examples of how the UK can do this such as:

1. **Promote National Collaboration & Partnerships**
2. **Support and Enhance Research Funding & Incentives**
3. **Upskill the UK workforce by implementing innovate skills**
4. **Promote Entrepreneurship & Commercialisation**
5. **Create and Implement supportive & incentive policy & regulations**
6. **Implement Robust Methodolgies and logistics**
7. **Shifting Mindsets of Young Adults**

APPENDIX A

Research Outputs By Topic (UK v World)

The following table outlines the UK's contribution to shipbuilding* research against the world

***Some topics have been searched solely on the overall topic and not in a shipbuilding context to understand the wider picture, these have been marked by an asterix.**

TOPIC	UK	WORLD	UK'S SHARE PERCENTAGE
AUTONOMY	204	2,444	8%
DECARBONISATION*	259	23,583	1%
DESIGN	428	13,857	3%
DIGITAL	279	1,394	20%
FACILITIES AND CAPABILITES	116	197	59%
FUTURE SHIPBUILDING	60	184	33%
MANUFACTURING*	1235	225,004	1%
MARKETS	11	143	8%
SAFETY	93	5,801	2%
SHIP TYPES	136	5,444	2%
SUPPLY CHAIN	98	1,244	8%

PLEASE NOTE THE NUMBER OF PAPERS PRODUCED IS NOT A TRUE REFLECTION OF THE RESEARCH BEING CONDUCTED AND WHO THE LEADING COUNTRIES ARE

THE UK'S ACADEMIC CAPACITY & CAPABILITY FOR SHIPBUILDING REPORT
Published By MarRI-UK
Funded By The National Shipbuilding Office

Conducted By
The Alan Turing Institute
The University of Liverpool
Liverpool John Moores University
University College London
Newcastle University
The University of Southampton
The University of Strathclyde

Edited By
Ian Edgecomb
Tahsin Tezdogan
David Hitchmough
Yi Huang
Thomas Fitter
Simon Benson
James Murphy
Cammy Acosta

MarRI-UK Research & Innovation

National Shipbuilding Office