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# UK Ports of the Future

## A vision and roadmap

# Contents



# 1. Introduction

# 1.1 Background and motivation

As an island nation, ports are critical for the UK to remain competitive in global trade. Ports are essential multi-modal transport hubs, vital to the effectiveness and resiliency of our national logistics networks and supply chains, and to the success of the industries on which they rely. Approximately 95% of UK international trade is transported through ports. As such, the efficiency and resilience of port processes is of paramount importance to the national interest. This has been highly demonstrated through the current COVID-19 pandemic. Furthermore, the importance of UK ports to the nation will continue to grow given the upward prediction of trade going through ports as outlined in Figure 1.

Digitalisation and decarbonisation of the complex processes and interactions through ports offer the potential to improve our logistics and supply chains, making the UK a world leader in port technology that has measurable impact well beyond the boundaries of the port. The need to adapt and grow the maritime sector is highlighted in the Maritime 2050 strategy to maintain the UK position as a world-leading maritime nation.

Whilst there is much talk internationally around smart ports, it is not clear what makes a port 'smart' and where the opportunities truly exist for the UK. Current published material is largely technology-led, and there is no clear transition plan for stakeholders in this sector to leverage individual efforts across UK ports. Globally, most ports have historically been risk-averse, resisting investment in new technologies. While this is now changing, there is still a lack of clarity on what the port of the future should look like for the UK and where impactful opportunities in digitalisation and decarbonisation exist slowing investment and reducing opportunity.

This report presents the key outputs of the Transitioning to Smart Portsproject which delivered an industry validated definition and blueprint for the UK Ports of the Future that will:

- define the key challenges and opportunities that will inform next steps to accelerate and leverage growth in the sector.
- help solve **real-world challenges** in multimodal logistics through ports
- inform the next steps in delivering a transition and intervention plan to ensure the UK ports remains competitive and meet future customers' needs with **efficient and resilient logistics networks**
- expand our global maritime technology **export opportunities**.
- highlight **cross-sector opportunities** for businesses to enter new maritime markets
- drive **wider logistics** innovation through implementing new port technology solutions as multimodal transport hubs.



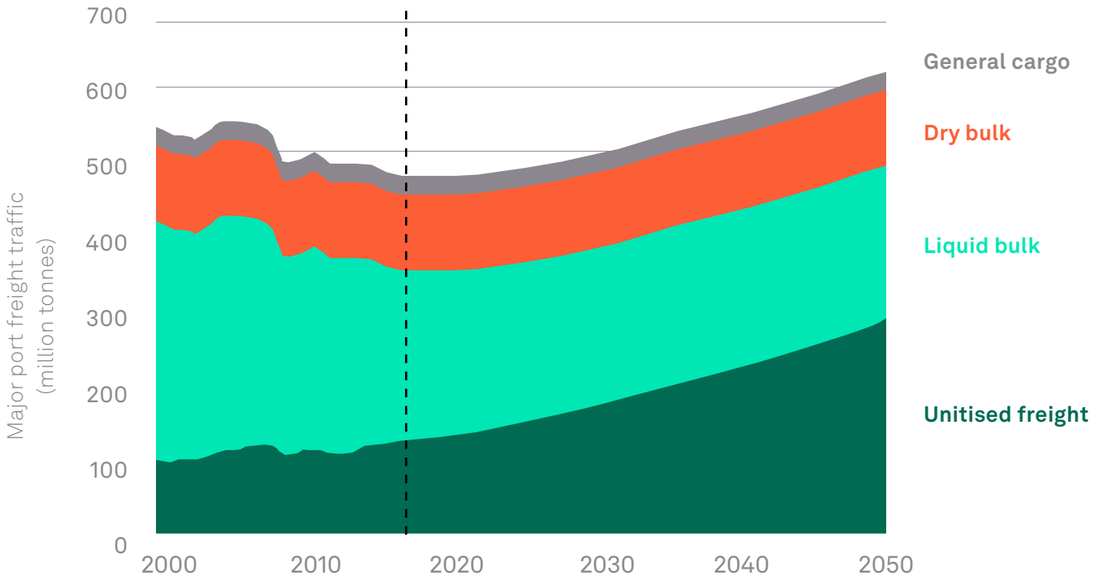



Figure 1 Total port freight tonnage 2000 - 2050[1]

1. https://globalmaritimehub.com/wp-content/uploads/2019/01/port-freight-forecasts.pdf

# 1.2 Approach and activities

The applied project approach was based on the following three key principles:

1. While the "Smart Port" term has been around for a while, there is no consistent definition of what a Smart Port is, where the term is usually associated with a push of specific technologies and solutions. Therefore, a **challenge-led approach** has been adopted in this project, building a good understanding of the challenging facing the industry currently and in the future. This is then followed by developing a set of recommendations and identifying relevant solutions to address the challenges. This approach:
   - develops a realistic blueprint that takes current and future challenges into account
   - identifies solutions that are fit for purpose, aligned with challenges faced by the UK industry
2. Recognizing the role of ports as multimodal transport hubs, a **whole logistics-chain approach** was adopted to enable wider logistics innovation and realization of the efficiencies in the end-to-end movement of people and goods.
3. Taking a **collaborative approach** to the definition of the challenges and recommendations through wider engagements with the different stakeholders across the maritime and logistics industries. This approach helps in getting a more realistic picture of the industry and supports gaining buy-in to the identified recommendations

Table 1 provides a brief description of the conducted activities throughout the project in the May-November 2020 period.

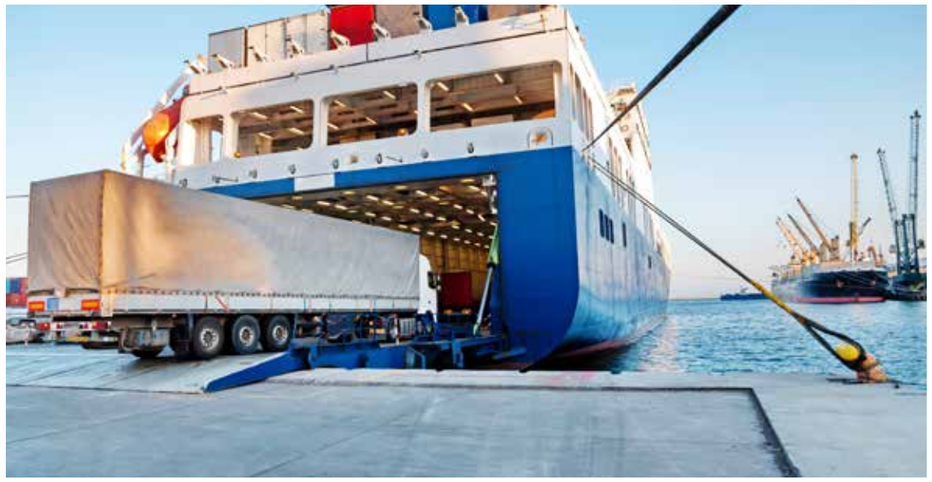




Table 1 - Overview of conducted project activities

| Task | Description |
|---|---|
| **Definition** | This task defined the different challenges, potential opportunities, and associated recommendations in the ports and logistics chain, and constituted of three key activities:<br>• **Research** – a desk study to establish global knowledge and market opportunities, capturing lessons of relevance to the UK.<br>• **Stakeholder identification** – to capture the key stakeholders across the whole logistics value chain. The output of this activity is outlined in Figure 2<br>• **Stakeholder engagement** – this was mainly through one-to-one interviews with 130 individuals across many relevant organisations as outlined in Figure 3. The interviews were semi-structured around 4 main topics: challenges, potential solutions, barriers to solution adoption, and recommendations for overcoming the barriers.<br><br>The task defined over 100 different challenges facing the industry and captured a set of over 100 recommendations. |
| **Analysis** | Analysis and ranking of the identified challenges and recommendations were conducted in this task. The ranking was based on the impact of each challenge and recommendation, and the number of stakeholders who identified it. |
| **Validation** | This task validated the analysed outputs of the Definition task with the industry. This was conducted through two workshops bringing together representatives from relevant organisations. Over 40 attendees in the two workshops used online tools to feedback on the top 25% of the identified challenges and also engaged in small groups discussions to analyse further the high-priority challenges and identify potential ways forward. The attendees also provided their view on the vision of ports of the future. |
| **Reporting** | This task brought together all the defined challenges, potential solutions and recommendations as well as the outputs of the Validation task into a vision and roadmap for UK Ports of the Future which is detailed in this report. |

Figure 2 Stakeholder identification

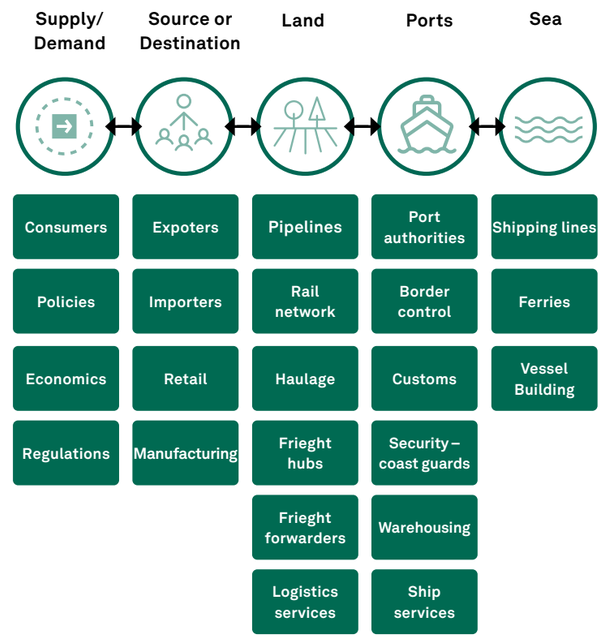
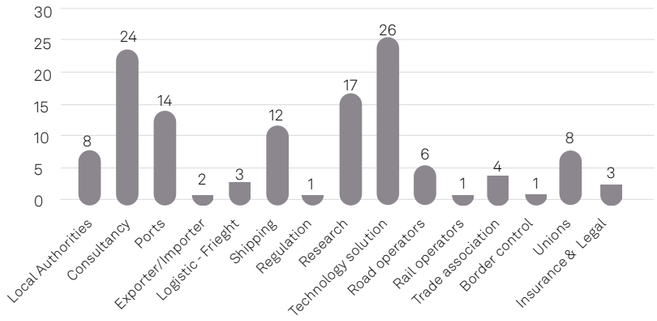



Figure 3 Grouping of interviewed stakeholders



# 1.3 Technology perspective

The recent few years have brought significant technological advances in sensing, computing, communications, and data analytics; leading to the transformation of many sectors including maritime and logistics. Some of the relevant technologies to maritime and logistics are briefly presented below:

- **Internet of Things** (IoT) is a system of connected objects with unique identifiers and the ability to transfer data between each other over a network independent of human interaction[2]. IoT allows real-time monitoring and insights into how a system is working and how individual components are performing. Implementing IoT therefore enables automation of processes that required real time information, reducing labour costs and waste.

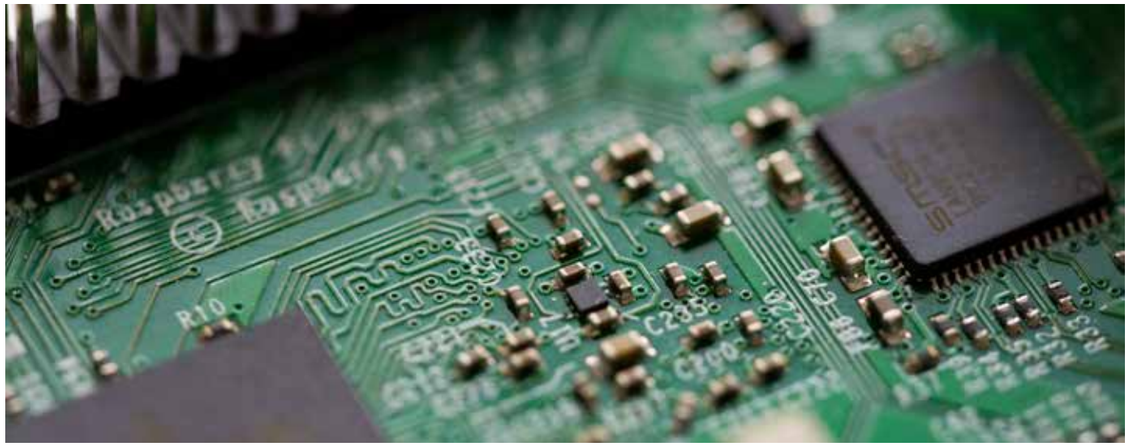
- **5G** refers to the 5th generation mobile network, which is promising higher peak data speeds, ultra-low latency, greater reliability, larger network capacity, and increased availability[3]. Given these significant improvements, 5G is set to open many new use cases and support many other innovations such as Augmented Reality and autonomous operations that will require greater amounts of data to be transmitted reliably with low latency and higher speeds to ensure safe operation[3].

- **Cloud-based systems** allow network access to a shared pool of configurable computing resources such as processing power and storage[5]. The exceptionally large storage capacity of cloud systems enables large volumes of data to be collected, stored and accessed in real-time supporting faster and more informed decision making. Cloud computing also allows compute power and data storage to be available when required, rather than installations having to be designed and costed to meet the maximum projected demand.

- **Virtual Reality (VR) and Augmented Reality (AR)** - VR is a simulated 3D environment in which a human can be immersed and interact with digital representations of physical objects, either existing or in the design phase. AR is a method of adding virtual elements, items or information onto the physical world in real-time[6]. Applications of VR and AR include training through accurate and safer learning environments, maintenance and inspection, and shipbuilding and design review[7].

2 https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT
3 https://www.qualcomm.com/invention/5g/what-is-5g
4 https://www.ship-technology.com/features/5g-in-shipping/
5 https://seanews.co.uk/features/shipping-and-maritime-industry-powered-by-cloud-computing/
6 https://reader.elsevier.com/reader/sd/pii/S2405896317324291?token=50C14636CA506A8EFC73846714C0D339C6BF3210FE585F2ACDB4202F6F9488F8967D0457E02384669AD429F06B2152D9
7 https://seanews.co.uk/features/augmented-reality-in-shipping-and-maritime-industry/





- **Digital Twins** are virtual representations of an object or system. Sensors are used to measure the real-world conditions of the system that it is replicating, and the data is then processed to enable for remote real-time monitoring [8]. Digital twins provide a virtual testbed for trialling new processes and conditions without having the risks of implementing it in live conditions which could have safety implications or financial consequences[9].

- **Artificial Intelligence (AI) and Machine Learning (ML)** - AI is a discipline concerned with building smart machines capable of performing tasks that typically require human intelligence[10]. ML is a branch of AI that is associated with developing algorithms that allow computer programs to automatically learn and improve through experience. There are vast existing and future applications of AI and ML notably in autonomous systems.

- **Blockchain** technology provides an immutable digital record of transactions which has been duplicated and distributed across an extensive network of computer systems which make up the 'blockchain'[11]. This revolutionary technology provides a high level of transactional transparency making it very difficult to commit fraud. There are blockchain applications in the port industry which have the potential to improve stakeholder interoperability, the reliability and speed of data exchange, processing time of documentation and the cost of transactions.

These technologies have many potential applications in the maritime and logistics sectors and can lead to cost savings and improved efficiency, safety, and resilience. The application of these technologies in the ports sector is usually associated with the Smart Ports term in the literature.

This report is not specifically focusing on the application of these technologies in the sector. Rather, the key focus is on understanding the challenges facing the wider industry, including ports at different technology maturity levels, and provide recommended solutions to these challenges. Such solutions cover a range of aspects including technology as well as policies, regulations, standards, processes, and people and culture related interventions.

7 https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/#4e1aa32c2e2a
9. https://eandt.theiet.org/content/articles/2020/01/seven-ways-seaports-are-adapting-to-modern-challenges/
10 https://builtin.com/artificial-intelligence
11 https://www.euromoney.com/learning/blockchain-explained/what-is-blockchain

# 1.4 Strategy and Policy perspective

The Department for Transport (DfT) has published in 2019 the "Maritime 2050: navigating the future"[12] document which defines the UK maritime strategy. It recognises the need for the UK to adapt and grow its maritime sector to maintain its position as a world-leading maritime nation. The document sets out ten strategic ambitions which sit across seven high level themes: UK's competitive advantage, environment, infrastructure, people, security, technology, and trade. The Maritime 2050 strategy addresses smart ports specifically, with a vision of ports being digitalised and integrated across the wider supply chain and logistics system; making use of a wide range of technologies to deliver safety and efficiency improvements across the system and delivering regional benefits such as boosting productivity and growth. This report builds on this vision, focussing on specific opportunities based on validated challenges.

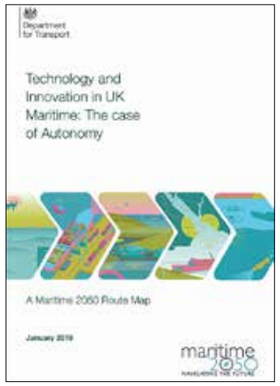
The Technology and Innovation Route map for Autonomy was published alongside the Maritime 2050 strategy in January 2019, making the case for maritime autonomy, with a focus on four key themes: (1) developing and future-proofing UK **infrastructure**; (2) understanding the **skills** requirements for the future and how this will affect employment; (3) the **technologies** which will shape the sector; and (4) working to create the **regulation** and environment which promotes and fosters innovation in the sector.

The Clean Maritime Plan sets out the UK ambition to be a global leader in zero emission shipping, with the UK having successfully captured significant share of the economic, environmental and health benefits associated with this transition by 2050. The Clean Maritime Plan defines the pathway to zero-emission shipping, through a combination of onboard and offboard technologies. Essential to achieving these goals will be in understanding and defining solutions for infrastructure related challenges at ports that will support the transition to zero emission domestic and international shipping.

This report supports the Governments maritime ambitions, specifically across the Maritime 2050 Strategy and Clean Maritime Plan where digitalisation and decarbonisation of shipping are key themes across several stated priorities, including:

- **Clean maritime** - This report has taken a whole logistics chain approach to this challenge, considering the systemic zero emissions transport challenges through ports as multi-modal hubs, capturing the challenges and potential solutions for ports from an infrastructure perspective in supporting the transition to zero emissions shipping.

- **Greater maritime integration with rail and road** - The Maritime 2050 Strategy recognises the importance of considering the maritime sector in its wider systemic context of UK transport systems as part of the road and rail infrastructure and creating a more integrated system. This study has taken a whole logistics chain approach, engaging with challenge owners and stakeholders considering the whole journey of people and goods across multiple transport modes through ports. The project has identified specific challenges such as the optimisation of rail and road connections, supporting wider transport decarbonisation through ports and the potential of increasing coastal shipping as part of an optimised transport system.



- **Enhancing the attractiveness of UK's regional maritime clusters** - Through identifying and validating clear industry challenges and strengths, this report supports the stated Maritime 2050 ambition of strengthening our maritime cluster offer. We have engaged with over 130 stakeholders across the maritime and logistics industries to understand specific regional challenges and opportunities as well as broader challenges and initiatives to support growing our maritime clusters, such as culture, investment and systemic inefficiencies.

- **Strengthening our position as a maritime innovator** - Maritime 2050 states a strategic ambition to strengthen the UK's place as a maritime innovator through maximising our strengths across technology focused academic institutions, SME's and global businesses. We have engaged with technology developers and stakeholders to understand the challenges in accelerating the adoption of new technologies and unlocking new opportunities for technology developers. More broadly, the project identified and validated specific industry and systemic challenges across stakeholders to strengthen the case for technology and process innovation that will both stimulate opportunities for solutions providers and build a stronger argument for investment for stakeholders.

Other relevant maritime priorities such as delivering the **Technology and Innovation Route map for Autonomy** and the **Port Air Quality Strategies** are supported by clearly defining opportunities in these areas. Furthermore, the project outputs support wider DfT initiatives such as the Future of Freight program, the Future of Mobility Grand Challenge and revitalising coastal communities.

12 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/872194/Maritime_2050_Report.pdf

# 1.5 Report structure

The remainder of the report starts by defining a common vision for UK ports of the future in Section 2 which is developed based on the Definition, Analysis and Validation activities outlined in Table 1. The route to realising the defined vision is outlined through four focus themes for future ports: Digitalisation, Decarbonisation, People, and Holistic collaboration. The associated benefits, challenges, and proposed recommendations for each of the four themes are discussed in Sections 3, 4, 5, and 6 respectively. Section 7 presents a roadmap of the different recommendations over the short, medium, and long terms; along with a set of concluding remarks.

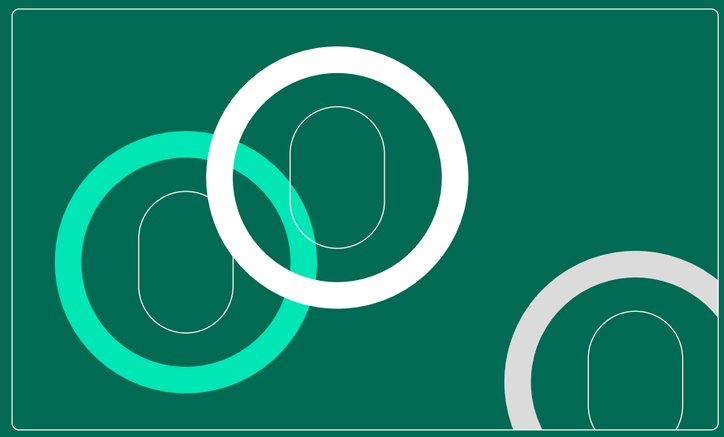




# 2. The vision for UK ports of the future

Ports in the UK come in different shapes, sizes, ownership models, business and revenue models, and vary in the goods they handle and services they offer. The statement of “every port is unique” is very true in the UK and is widely quoted. However, the principal functions and fundamental operations of ports are largely similar (an interface between sea transport and land transport and operations).

The outlined vision in this section builds on the core similarities between ports and aims to highlight the common needs and objectives of the industry in the UK. This vision was developed in a workshop activity that brought together different stakeholders in the ports industry as well as the whole logistics chain.



# 2.1 The vision

The vision for the UK ports of the future is they are ***efficient enablers for UK sustainable economic growth***. This is realised by ports being ***Connected, Digital, Green***, and ***Economic activity hubs***.

a) ***Connected***: this is in (1) the physical sense through the provision of strong transport links into land; (2) the digital sense through reliable communication provision serving sea and land operations through wired and wireless (land and satellite based) technologies; and (3) the community sense through strong links with the local communities supporting the local social, economic and environmental objectives; as well as stronger links with the logistics value chain.

b) ***Digital:*** where ports make the most of technological and data advancements to improve their operations and support the efficiency of the end-to-end movements of people and goods. This is a broad feature applicable to ports at different technology maturity levels and ranges from the digitisation of basic processes to the use of the latest advances in sensing, data processing, and automated decision making and operations.

c) ***Green***: where (1) ports operations are carbon neutral and have no negative impact on the surrounding environments at land and sea (air, water and land pollution); and (2) ports enable the decarbonisation and emission reduction of land and sea transport where they support and encourage the use of green alternative fuels and efficient operations.

d) ***Economic activity hubs***: where ports bring a range of value-added services in addition to being efficient multi-modal transport hubs. This feature builds on each port strengths and potential. Examples of such activity hubs include:

1. Green energy generation and distribution hubs,
2. Goods manufacturing, value adding and distribution hubs,
3. Vessels diagnosis, repairs, and engineering hubs

The above examples are not comprehensive, and each port will need to build on their own advantages and potential.

# Roadmap to ports of the future

Figure 4 – The vision and relevant features of UK future ports

**1**

**Ports of the future are**

"Efficient enablers for UK sustainable economic growth"

**2**

**This is achieved by ports being**

| | |
|---|---|
| **Connected** | in the (1) **physical** sense through strong transport links; (2) **digital** sense through reliable communication service; and (3) **community** sense with strong links with the local communities and the value chain |
| **Digital** | making the most of tech and data advancements to improve their operations and support the efficiency of the end-to-end movements of people and goods |
| **Green** | where (1) ports operations are carbon neutral and with limited negative environmental impact; and (2) ports support the decarbonisation of land and sea transport |
| **Economic activity hubs** | bringing a range of value-added services in addition to being efficient multi-modal transport hubs. This feature builds on each port unique and local strength. |

**3**

**Which enables ports to realise**

- **Enhanced competitive position**
- **Improved efficiency**
- **Enhanced safety**
- **Improved resilience**
- **Enablers of decarbonisation**

# 2.2 The expected outcomes of realising the vision

Realising the defined broad vision brings a wide range benefits to ports as well as to the wider logistics chain while supporting the UN Sustainable Development Goals. These benefits include:

i. **Enhanced competitive position** - through all the defined features in Figure 4 where UK ports maintain and enhance their competitive position whether locally, regionally, or internationally.

ii. **Improved efficiency** - through the Connected and Digital features enabling the stronger digital and physical links with the logistics chain and the use of advanced technology and data applications.

iii. **Enhanced safety** - through the Connected and Digital features enabling opportunities for the use of technological advancements to increase situational awareness and improve safe operations

iv. **Improved resilience** - building on all the defined features in Figure 4 to improve the resilience of ports against naturally occurring and manmade problems (pandemics, climate change, terrorism, theft, goods supply/demand variability, etc.)

v. **Enablers of decarbonisation** - through all the defined features in Figure 4 where ports are not just achieving their Carbon and air quality targets, but enabling others across the logistics value chain to realise their decarbonisation targets.



# 2.3 The route to realising the vision

Realising the defined vision requires a collaborative effort from different stakeholders from the Ports, Transport and Logistics industry, Technology solution providers, Academia and Research, and the Government. The future ports vision and associated features are further broken down into a set of focus themes as depicted in Figure 5. This is to identify the required activities for realising it.

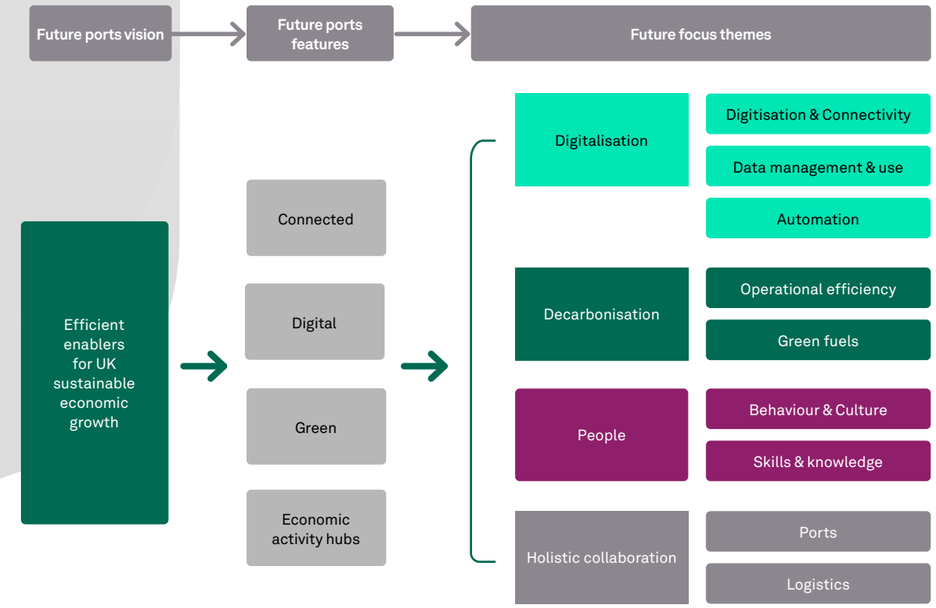
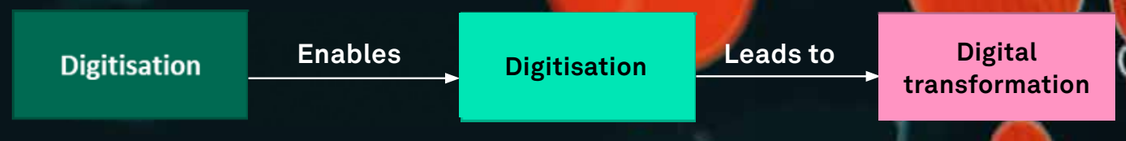



Figure 5 – The defined focus themes for Future Ports to enable the realisation of the vision

Each of the outlined focus themes is explored further in the following sections in terms of the associated challenges, relevant solutions, and recommendations for a way forward.

# 3. Digitalisation




Digitalisation can be defined as the process of becoming a digital business; this will include using digital technology to make existing processes more efficient and may include using digital technologies to change a business model and provide new revenue and value-producing opportunities[13]. The implementation of the digitalisation process leads, as an outcome, to what is referred to as digital transformation. On the other hand, digitisation is the process of converting analogue inputs/outputs into a digital format; this can include, for example capturing data from the environment, machinery, buildings, or equipment. Digitisation does not automatically lead to digitalisation, but any process of digitalisation must first have a well-considered process of digitising the relevant aspects of a business or operation.

Ports contain a multitude of dependant processes across a diverse range of stakeholders, with many of these processes still being carried out using paper-based systems. Digitalisation of these complex processes can offer opportunities for efficiency improvements across the logistics chain. Digitalisation of ports and logistics will allow the identification of weak points in the chain, predict future events based on historical trends, establish optimisation options, and model new ways of working or the impact of new technology prior to investment. Ultimately, digitalisation is an enabler of potential cost reduction, minimising organisational waste, reducing risks, and optimising processes across multiple actors. Digitalisation is at the heart of the Government's Maritime 2050 strategy, with an aim for the maritime sector to be "digital by default", ensuring greater connectivity and supporting better business decisions.

A set of digitalisation challenges and opportunities have been defined in this project which are grouped into a set of three topics:

1. Digitisation and connectivity
2. Data management, use and associated processes
3. Automation

Automation is considered as a separate topic in this report given the strong interest in it in the maritime and logistics industries. People and Culture is a key factor in ensuring that the digitalisation process leads to successful digital transformation. This is covered in detail in Section 5.

13 https://www.gartner.com/en/information-technology/glossary/digitalization

# 3.1 Digitisation and Connectivity

Advances in technology and manufacturing capabilities have led to significant developments in sensing, computing, and communications systems, which have made digitisation more accessible than ever from a technological standpoint. Digitisation has the potential of making data more accessible, offering new levels of interrogation and efficiency in how we capture and store information.

Ports (and logistics organisations more broadly) have been increasingly digitising analogue inputs/outputs such as paperwork for goods, weather data, safety incident data, process performance metrics, traffic movements and personnel records. Technology developments such as IoT sensors and 5G may offer the potential to build an even greater view of processes and operations at and through ports. The digitisation of inputs or processes has the potential to deliver benefits such as efficiency improvements or cost reduction, for example through having a more effective and accessible route to capture and interrogate data when compared with manual data collection processes. Furthermore, digitisation is an essential foundation to realising the potentially greater benefits of more holistic organisational digitalisation. The Maritime 2050 strategy has identified digitalisation as "crucial to the future of maritime".

Below are the key challenges around the digitisation in the ports and logistics industries which have been captured through engagement with the relevant stakeholders:

1. **Inefficiencies due to paper-based activities** - there are many ports and many parts of the logistics industry still reliant on paper-based and generally analogue processes. This is attributed to:
   - Many smaller ports are still using non-digital processes, for example using whiteboards for planning and scheduling various operational aspects. This brings inefficiencies and missed opportunities for understanding challenges and improving operations through data capture and analysis. Such ports are challenged by limited IT resources and budgets to invest in digitisation.
   - Some regulations still require physical papers for checks such as customs.
2. **The business case for digitisation** - the business case for increasing sensing capabilities or investing in data utilisation is not always clear to some stakeholders leading to data availability issues. This is essentially due to a lack of understanding and established use cases and guidance of the wider benefits of digitalisation. The impact of this challenge is evident by:
   - Limited adoption of sensing technology for monitoring assets and goods movements within ports.
   - Limited visibility of goods movements through the value chain due to inconsistent implementation of tracking technology
3. **Poor wireless connectivity in port**s - technological advances such as fibre optic wired connectivity, 4G, 5G and high-speed, lower cost satellite communications have led to the world being more connected than ever before. However, despite the numerous applications and benefits of wireless connectivity at ports both for people and devices, many stakeholders have reported poor connectivity within ports and surrounding areas.



## Recommendations

The following recommendations are proposed in relation to digitisation and connectivity:

### A1. Framework and incentivisation for digitising paperwork

There is a need for the Government and relevant authorities to investigate and consider how to further enable the use of digital checks and potentially mandate it if possible, through a staggered approach.

### A2. Supporting digitisation of ports

This is to support the early adopters of ports digitisation solutions and the advocates within ports. Industry and funding organisations should consider funding small demonstrator projects to help quantify the benefits of digital technologies and demonstrate the value; building confidence for ports and connected stakeholders to invest. This can be followed by industry and relevant associations to consider developing a common data platform or enabling framework for smaller ports to reduce some of the financial burden of the digitalisation journey.

### A3. Building the digitisation business case

To support the industry to invest more on digitisation and deploy connectivity technologies (e.g. 5G and satellite communications), industry, potentially through commercial collaboration models, and funding organisations should consider activities that:
Highlight the role of digitisation in optimising operations and adding value from the perspectives of the different stakeholders, and its role as the enabler and initial step towards digitalisation.

- Support the development of the digitalisation business case and associated benefits
- Support digitisation and connectivity pilots and demonstrator projects to help build the underlying evidence for the business case

# 3.2 Data management, use, and associated processes

Advances in digitisation and connectivity are leading to an ever-increasing generation and transmission of high-quality data, including cargo movements, weather, high-definition video feeds, equipment condition and operational data. Coupled with advances in computing, data storage, cloud-based systems, advanced signal processing and data analytics techniques; this brings the potential for realising the wide range of benefits of digitalisation to the maritime and logistics industries. The data generated through increasing digitalisation should also be considered as offering new commercial and value creation opportunities for the owners of the data and, importantly, the generated insights and analytical methodologies. Examples of potential applications and associated benefits include:

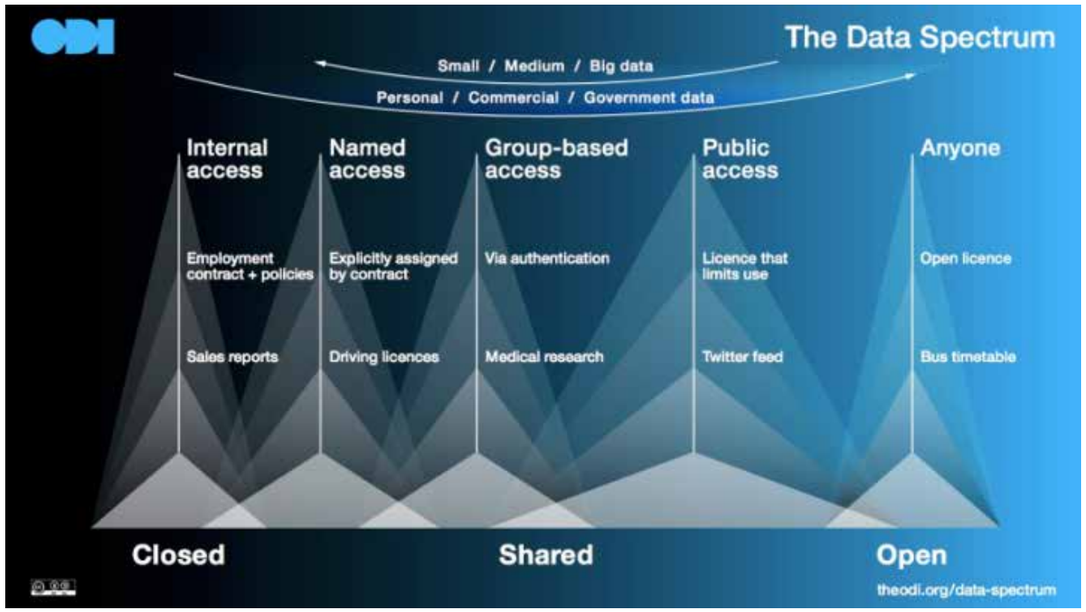
- Fusion of data on tides or weather through connected sensors with other available data sources to support planning and scheduling decisions
- Insight derived from data on equipment condition and performance to inform maintenance optimisation and scheduling, risk management, and process optimisation.
- Digitalised and centrally accessible operations planning and scheduling systems to ensure accurate and up to date information is available when and where required
- Live information on the condition and flows of the road and rail network to support optimisation of cargo movements and bookings for onward travel of people and goods; enabling importers and exporters to confidently plan operations and contingencies
- Historic and real time data on environmental emissions of mobile plant linked to operational data to identify emissions reduction opportunities
- Better mathematical modelling techniques for the physical world enabling a greater level of insight to be derived from relatively limited or varied data sources (e.g. monitoring of vibration and temperature in gas turbines for predictive maintenance schemes).
- Use cases for Distributed Ledger Technologies (DLT) to address challenges on data trust and providing an immutable record of digital transactions.

While the fusion of multiple data sets has the potential to bring more insights, this needs to be considered in the data accessibility context (Closed, Shared, Open) as outlined in the Open Data Institute (ODI) Data Spectrum [14]. Closed data include financial, personal and commercially sensitive data; Shared data include data shared across organisations through defined contracts and authentication processes; and Open data refer to data accessible to anyone through open licenses.

Realising the full potential of data-enabled applications and services in the industry is associated with many challenges explored through this project including:

14 https://theodi.org/about-the-odi/the-data-spectrum/






1. **Lack of a common approach to data** - data is often described as the new currency and like any currency it must be suitably exchangeable across different parties. Currently there is no standard and agreed way across the ports and the logistics chain to capture and share different datasets. This covers data formatting, access, and data modelling. This challenge sometimes leads to inefficiencies through ports, having to respond to multiple requests for the same information, and stifling collaboration amongst ports on addressing some of the common challenges.

2. **Poor data quality** - while different datasets are available, they are not always offered to the relevant stakeholders in the required quality level. Data quality covers data accuracy, consistency, completeness, and timeliness.

3. **Limited use of available data** - in many cases the full potential of available data is not utilised to improve insight and decision making. Data is generated and used for specific applications in a siloed approach, hindering the potential of driving intelligence from the integration of multiple datasets within the same organisation or across organisations.

4. **Limited investment in digital infrastructure** - realising the potential of digitalisation needs a digital infrastructure that enables reliable, secure, and standardised access and use of data within and across organisations. This will help in breaking the silos and demonstrating the art of the possible with data. However, this is currently hindered by the limited investment in such infrastructure in the private sector, and while support for capital investment is relatively accessible in the public sector, continued funding for maintenance and operation is limited. This is a potential challenge for authorities given the trend towards the 'as a service' models widely used for digital platforms.

5. **Limited application of digitalisation processes** - despite the availability of data in some cases, the associated processes are not fully utilising such data where manual human activities are still required (e.g. sending status updates by emails as opposed to through an API).

# Recommendations

The following recommendations are proposed to support the utilisation of data-related digitalisation interventions:

## A4. A common approach to data

There is a need to consider the standardisation of data, and system interfaces across ports, as well as standardisation of logistic system interfaces, data and models used by ports and land/sea transport companies. This also includes defining agreed data quality standards across the logistics chain. To deliver an effective common approach, it will likely be necessary for multiple industry partners to work for mutual benefit across sectors, potentially through industry associations or an impartial third party. If established, the Innovation Platform (recommendation C3 in this report) may be considered a useful vehicle to facilitate this recommendation. A common approach to data is further explored in Section 6.

## A5. A case for better use of data

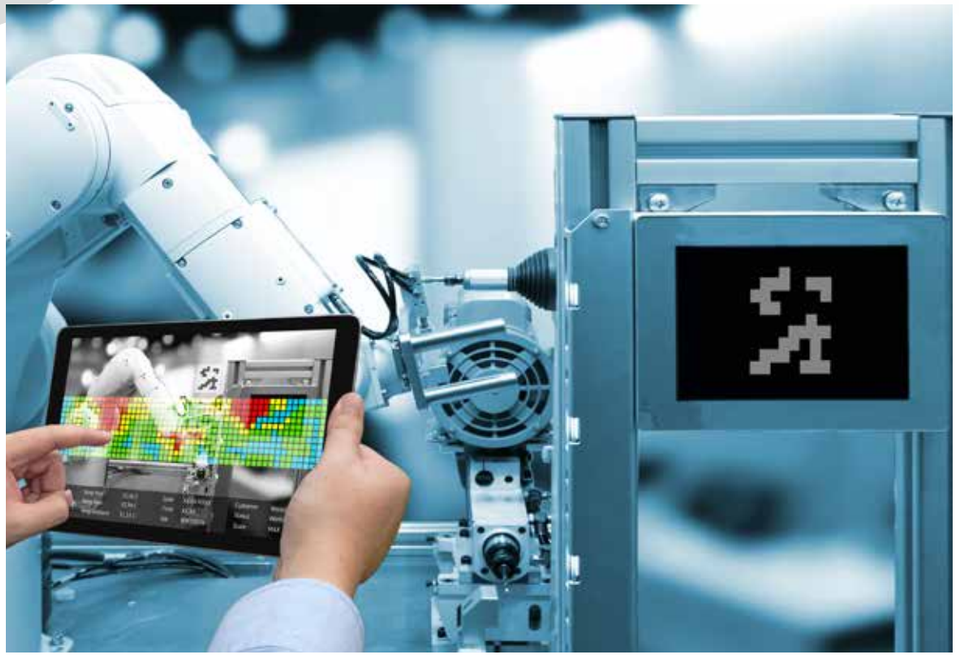
There is a need to develop a better understanding of the current and potential future data landscape and opportunities across ports and logistics and where this data may offer the potential to develop solutions that deliver positive impact to challenges across the logistics value chain. This should be done both at the port level and across the logistics value chain to realise systemic benefits that deliver value to individual organisations, likely requiring joint working across industry partners, industry associations and/or impartial third parties recognising the commercial sensitivity of some data sources across organisations. If established, the Innovation Platform (recommendation C3 in this report) may be considered a useful vehicle to facilitate this recommendation by:

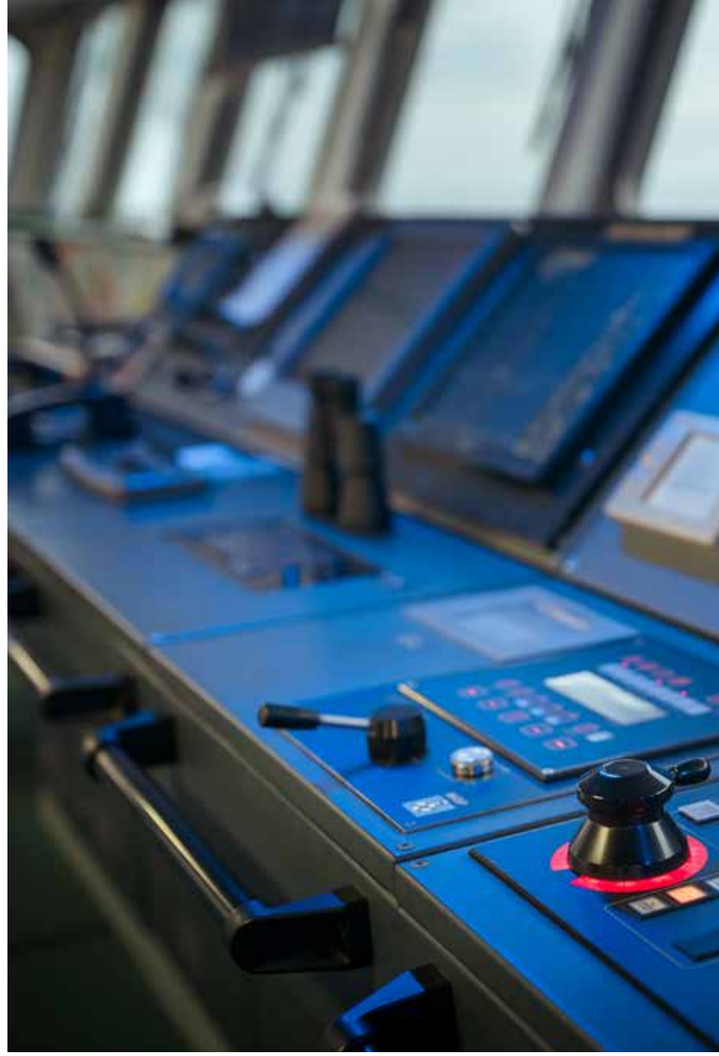
- Building a comprehensive list of existing data across the value chain through a data discovery exercise
- Developing a set of use cases associated with specific current and future industry challenges and linked to existing and/or easily captured datasets. Such use cases can include sharing certain non-commercially sensitive data across the ports and the logistics chain
- Running a set of pilot data analytics projects that demonstrate the value of data utilisation
- Supporting the industry digitalisation journey through learning and knowledge sharing as further explored in Section 5.2.

# 3.3 Automation

There are varying degrees of automation, autonomy and remote control that can be applied across the maritime, ports and logistics network. It is important to define the terms used when discussing automation. *Automation* is the removal of human effort from a system carrying out a task or process within defined boundaries with specified parameters e.g. an autopilot system on an aircraft or a robotic production line. *Autonomy* is the removal of human effort from a system that can competently respond to unexpected changes e.g. a collision avoidance system or a fully self-driving car. *Remote Control* is when the human retains control of the system but is physically separated from it.

Varying degrees of remote or autonomous control have been trialled or deployed at ports, including automated docking systems, autonomous cranes, and remote-controlled mobile plant. Automation or remote control may be beneficial in some cases from a safety perspective, by removing human operators from hazardous environments. In the UK, the Maritime and Coastguard Agency has carried out extensive work on leading the Maritime Autonomy Regulation Lab (MARLab) to develop the autonomous technology regulatory framework, identifying challenges and researching the data landscape and requirements to accelerate the safe development and adoption of autonomous technology.





Autonomous technology and systems may also provide a greater level of assistance for tasks and present an opportunity for skills in the workforce to be focussed in higher value areas through automation of lower value processes. Efficiency gains and cost reductions can also be realised through autonomy, remote control, and combined solutions where human operators can remotely control autonomous systems in certain situations.

Besides ports and logistics operations, ports of the future will need to interact safely and efficiently with vessels and vehicles having varying degrees of autonomous functions visiting and transiting the port. Autonomous technology in maritime is a key technology trend, where use cases for navigation, collision avoidance, and docking are being increasingly explored and developed. Further, the growth of Connected and Autonomous Vehicles (CAV) such as self-driving vehicles, HGV platooning and drones presents both challenges and opportunities across port operations.

A wide range of challenges around automation across the value chain have been captured. The key challenges are as follows:

1. **Capturing the autonomous vessel market** - whilst the UK has carried out extensive work in the area of autonomous vessel development and testing, European and International competitors are advancing and capturing market share at considerable pace. In the UK, government investment in autonomous vessels is relatively low compared to that for road autonomy where the UK has a globally leading position.
2. **Challenging operational environments** - autonomous vessels will be challenged by mixed operation with manned vessels, extreme weather, and port approach. They are likely to present potential risks for other water users in the port area such as leisure users.
3. **Limited adoption of autonomous vessels** - there is an anticipated scaling up and adoption gap of autonomous shipping from pilots, trials, and sea operations such as subsea surveys. This could be due to vessels autonomy benefits not seen as very high compared to their cost. Furthermore, the regulations, certification, and supporting infrastructure are lagging behind the autonomous vessels technology.

# Recommendations

Relevant recommendations for government and the industry have been proposed as follows:

## A6. Build on UK strengths

There is a need to develop a strategy for the UK to ensure a leading role in the international vessel autonomy market, with focus on UK strengths. This needs to build on existing activities such the "Promoting the UK's world-class global maritime offer: Trade and Investment 5-year plan 2019"[15]. Examples of UK relevant areas of strength are Artificial Intelligence, hydrography, communications technology, autonomy legal and liability insurance, and certification and assurance of autonomous systems. The Government and appropriate innovation funding organisations should consider ensuring that robust support for the UK maritime technology ecosystem is put in place to help realise the economic benefits to the UK in capturing a significant share of this growing global market.

## A7. Support autonomous vessel testing

Industry, the Government and regulatory bodies should ensure that the UK retains, and strengthens, it's place as a prime region in which to test and develop autonomous vessel technology through initiatives including:

- Continuing development of innovative and agile UK autonomous vessel testing regulations following the conclusion of the MARLab project
- Provision of insurance and liability guidelines
- Evaluation and communication of the safety improvements and cost savings of vessel automation
- Increased cross-sector knowledge exchange (e.g. automotive and aerospace autonomous systems development) as recommended through the MARLab project

## A8. Develop a gradual vessel automation adoption plan

Industry and regulators should work closely to ensure a safe and efficient transition to increasingly autonomous ships and systems. This should support the transition from small scale trials and smaller vessels to larger and more safety critical use cases. Activities could include:

- Considering coastal shipping as a trail blazer for maturing autonomy and automation technology and demonstrating viable business and operating models
- Continuing to engage with International Maritime Organisation (IMO) in relation to global autonomy testing and adoption
- Considering segregation of autonomous and non-autonomous traffic to mitigate impact of mixed operation environment
- Investigating the use of technologies to improve situational awareness of automated vessels, such as drones, to account for their distance and manoeuvring
- Considering changes to vessels Automatic Identification System (AIS) requirements for leisure activities to improve their visibility in a future mixed operation environment


15 Marine 5-year plan (publishing.service.gov.uk)

# 4. Decarbonisation

The term decarbonisation is used loosely in this report to refer to all emission related aspects including the reduction of carbon emissions and greenhouse gases, as well as the emission of other gases and particles such as Nitrogen oxides and Particulate Matter which have a more local impact on air quality and health.

The UK was the first nation to publish a national Clean Maritime strategy following the 2018 IMO agreement to reduce greenhouse gas emissions from shipping 50% by 2050. The Clean Maritime Plan sets out the environmental roadmap to deliver on the Maritime 2050 ambition that the UK "Lead the way in taking action on clean maritime growth enjoying economic benefits from being an early adopter or fast mover".

The stakeholder engagements and the project analysis have identified two broad routes to realising the government and international decarbonisation targets: (1) operational efficiency; and (2) alternative fuels and power trains for land and sea transport. The former is looking at improving the operational efficiency of the existing fleet (on land and at sea) as well as logistics operations and processes that can reduce fuel consumption and/or emissions. The latter includes interventions like the electrification and the use of other fuels that are known to reduce the carbon footprint of the industry and its impact on local air quality. The two routes of interventions have different advantages and disadvantages and are considered to complement each other. The challenges facing each route along with a set of associated recommendations are discussed in the following two sub-sections.

# 4.1 Operational efficiency

Improving the operational efficiency of existing fleet as well as logistics operations and processes have the potential to reduce fuel consumption and/or emission. A wide range of interventions exist in this category such as the shift to more sustainable transport modes (i.e. modes with low CO2 emissions per tonne of goods moved), reducing unnecessary journeys, and minimising idle running emissions (e.g. reduce port entry waiting times of HGVs and vessels).

Operational efficiency issues with impact on decarbonisation and air quality have been captured through this project. The key identified issues are outlined below along with their relevant stage within the journey:

1. **At sea: Optimum vessel speeds** - Vessels can optimise their speed to ensure arrival at ports in the most fuel-efficient way reducing emissions. However, in some cases the lack of available berths at ports or tidal constraints can lead to vessels waiting for berths for hours and possibly days. Such delays lead to avoidable emissions waiting for berth and the need to sail at higher speeds on the onward journey to make up for lost time.

2. **At Sea/port interface: Variability of vessel arrival time** - Vessels can be late (or early) arriving at ports due to, for example, delays at previous stops, vessel faults, and weather conditions. This variability is often not communicated in a timely manner to all the relevant stakeholders and can lead to disruptions to ports operations as well as to the land transport system. An example is HGVs being held at ports waiting for vessels to arrive.

3. **At port: Cargo allocation within port** - The arrival and departure of cargo in ports does not follow a defined order, that is the first cargo in is not necessarily the first cargo out. It is challenging for some ports to know in advance when cargo is leaving the port leading to inefficiencies in the goods handling process and associated fuel consumption within ports. An example is the inefficient staking of containers.

4. **At port/land interface: Ports related traffic congestion** - Freight traffic in and out of ports can cause congestion in the ports surrounding areas sometimes due to required access time to ports. Many consulted stakeholders have highlighted that many ports have a limited focus on road transport in terms of supporting the development of infrastructure, systems, and processes. This leads to unnecessary fuel consumption and emissions from HGVs.



# Recommendations

Recommendations have been proposed to improve the operational efficiency from the decarbonisation perspective. It is important to highlight that many of the recommendations defined in Sections 3 and 6 provide operational efficiency and are linked to the decarbonisation topic.

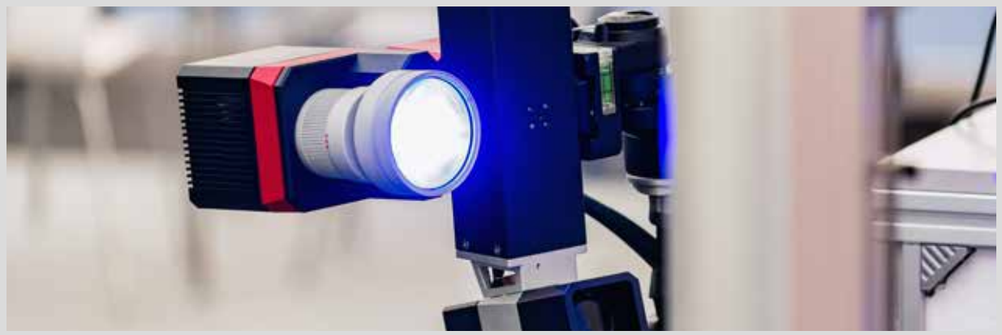
## B1. Data capture of port-related traffic

There is a need for a better understanding of the bottlenecks in port-related road freight and causes of associated congestion. This can be facilitated by the collection of different datasets such as waiting times of HGVs and vessels outside and within ports and HGV congestion linked to ports disruptions due to equipment failure or vessel delays. Discussions with stakeholders through this project has established that this would be most effectively achieved collaboratively between ports local and regional authorities, and national operators with potential opportunities to accelerate beneficial impacts (to port, port users and region) through commercial collaboration across more than one port. This will help understand the root causes of some of the congestion issues and help ports and both local and national authorities introduce targeted interventions to alleviate such congestion and associated environmental impact.

## B2. Optimising vessels interface with ports

Ports and port users should consider joint initiatives to optimise the interface with vessels, this recommendation is associated with two key aspects:

- ***better data sharing between vessels and ports and other relevant stakeholders*** - this is to improve the overall end-to-end journey efficiency and includes the sharing of berth availability data to enable vessels to optimise speed; as well as sharing of vessels location and journey disruptions with ports and other stakeholders. The industry needs to agree data sharing and quality (timeliness, accuracy, and completeness) standards. This topic is further explored in Section 6.
- ***development of predictive technology*** – this covers predictions on tide, weather, berth availability, required ports resources, vessel arrival times, and ports processing times. Accurate predictions of these elements will significantly enhance the operational efficiency of the whole logistics chain and subsequently support the decarbonisation targets.



# 4.2 Green fuels

Greener alternative fuels are currently being explored for goods transport in sea and land. These include Electricity, Hydrogen, Ammonia, Liquefied Natural Gas (LNG), and Biofuels. Each of these fuels bring advantages in terms of emissions but also has associated challenges. The lack of a clear future fuel winner is halting the wide adoption of any of these fuels and there seems to be a supply and demand waiting game. This section explores the challenges associated with alternative fuels adoption as identified through the stakeholder engagements and presents a set of recommendations for a way forward. The key identified issues in relation to alternative fuels are broadly classified into **Demand challenges** which refer to the use, or lack of, use of alternative fuels and **Supply challenges** which covers the generation and distribution of these alternative fuels.

## Demand challenges:

1. **Lack of certainty on the winning fuel** - referring to the Hydrogen Vs Ammonia Vs others question which is especially challenging for international shipping given the need for wider consensus on the fuel(s) of the future. This creates a first mover anxiety and stalls the adoption of new fuels by the shipping industry and relevant infrastructure investments by ports and other stakeholders.

2. **Long life of vessels** - the average life of vessels is in the range of 30 years limiting the adoption of new technologies and fuels and increasing the anxiety of adopting the 'wrong' fuel.

3. **High cost of alternative fuels** - this includes both the upfront (engines - systems - storage) and ongoing costs for shipping lines (additional required storage space and different bunkering needs given the low density of some alternative fuels). This is coupled with perceived limited financial benefits. The same challenge, high cost against perceived low returns, is witnessed in the land transport as well as in ports operations equipment (e.g. tugs, workboats, and forklifts). This is coupled with limited incentives for greener vessels in the UK.

4. **The split-incentive** - this refers to the ownership and operational model of international shipping where the ship owners who commission the ship building are not the operators of these ships and hence do not always consider fuel saving or alternative fuel technologies that can increase the ship building cost even if they lead to lower whole-life costs.

5. **Low oil prices** - reducing the financial benefits of alternative fuels.

6. **Global nature of decarbonisation** - climate change is a global issue and introducing any national CO2 emission restriction will only shift the problem. On the other hand, air quality is a local issue that needs relevant interventions.

## Supply challenges:

7. **Limited supply of alternative fuels** - this is related to the current supply levels of fuels such as Hydrogen and the different types of biofuels which are unlikely to satisfy the potential demand of the maritime and logistics industry especially for high-demand applications such as Hydrogen for large container vessels.



8. **Understanding of operational challenges** - there is a lack of a deep understanding of the potential operational challenges of using the alternative fuels in the UK maritime industry. This sometimes leads to over- or under-estimation of these challenges.

9. **Supporting regulations and standards** - Some of the existing regulations around alternative fuels may complicate their adoption (e.g. the need for alternative power source in vessels). There are also gaps in the standards associated with some fuels.

10. **Limitations of the supply chain** - this covers aspects such as:
    - the ageing infrastructure in ports and electric network limitations for electric charging provision for land and sea transport. Shore power demands can be highly variant with cruise ships, for example, putting high pressure on the grid for specific times.
    - challenging requirements for the storage and distribution of some alternative fuels such as Hydrogen, Ammonia and LNG
    - the historically limited government funding or support available for the maritime sector and in supporting the clean maritime transition

# Recommendations

The following recommendations have been defined to alleviate some of the challenges and to help define a way forward with regards to the adoption of greener alternative fuels:

## B3. Support short- and medium-term interventions

There are interventions that can support the decarbonisation targets while the future fuel picture becomes clearer. These include industry investing in hybrid vessels/vehicles and retrofitting solutions that can enhance the efficiency of existing vessels and/or reduce their carbon footprint and emission impact. An example is post-emission solutions which are likely to support achieving decarbonisation and emissions targets in the short and potentially medium terms. To provide a clear and manageable transition to a net-zero future, there is a need to define shorter-term, stepped and achievable decarbonisation targets and associated guidance, regulations and standards for these solutions as well as funding trials and demonstration projects to de-risk investment in the technologies.

## B4. Support relevant Research and Development (R&D) and demonstration activities

The Government and industry need to support a range of R&D activities that can speed up the adoption of alternative fuels. These activities include:

- R&D on potential alternative fuel topics such as advances in battery technology to support the electrification of small vessels; and onboard vessel Hydrogen generation which can alleviate many of the port infrastructure and on-vessel storage challenges
- Investigation of potential methods such as adopting modular designs to support flexible vessels architectures that enables plug-and-play flexibility to address fuel uncertainty and enable adoption of alternative fuels while waiting for the global winner
- Fill the current knowledge gaps in the decarbonisation risks (e.g. new fire hazards) and risk modelling scenarios (e.g. impact of two LNG-fuelled ships colliding)
- Investigation of potential business and financing models to support vessel decarbonisation
- Develop a good understanding of the full environmental impact of the different alternative fuels including by-products of their generation, distribution, and use
- Investigation on the whole life costs and benefits of alternative fuels from the perspectives of different stakeholders. This will help develop the business case for decarbonisation investments from both the public and private sectors

## B5. Support regional and international activities

Industry and regulatory bodies should continue to strengthen their close working relationships and influence with the IMO and regional organisations to address the need for any regulations that can influence the supply and demand of green fuels

## B6. Start small and local

The waiting game for the future fuel is likely to continue for the next few years, highlighting an opportunity for more localised UK-specific activities whilst the global picture becomes clearer. This recommendation covers different aspects including defining suitable vessels, routes, fuels, and ports, among others for a local plan. An important initial step is to segment the market and define tailored routes to UK decarbonisation including potentially making the distinction between domestic and international shipping. The potential local decarbonisation factors include:

- ***Vessels and routes*** – focus on the decarbonisation of small vessels and short trips. Examples include work boats, coastal shipping, and service vessels for the offshore industry. This will:
  - avoid the wait for the global green fuel winner. Even if the used fuels are adopted internationally, satisfying the short-trip small vessels needs can provide a local and sustainable market for these fuels.
  - minimise the requirements on the supply network – small vessels are unlikely to require huge amounts of energy; and the short trips will reduce the need for large onboard fuel storage or heavy batteries.
  - reduce any potential conflicts in terms of international standards.
  - reduce the associated retrofitting/adaptation costs in the case of the small vessels compared to the large ones.
- ***Fuel*** - Electricity and Hydrogen present two good options to investigate, at least from the UK perspective:
  - they can be generated from renewable sources, and can take advantage of the UK offshore renewable energy strength.
  - green Hydrogen generation from offshore wind can act as an energy storage solution.
- ***Ports*** – given the above fuel approach, starting with ports around offshore energy generation will build on the existing supply and port-energy generation relationships and existing infrastructure

## B7. De-risk the decarbonisation investment

This applies to the whole energy generation, distribution and use value chain and aims to address some of the challenges around the high upfront investment cost and perceived long-term return on investment. Ports may benefit from considering the renewable energy generation and distribution potential based on regional strengths (e.g. tidal, wind or solar) to explore potential new revenue streams across the logistics value chain. More broadly, industry associations may play a strong role as knowledge exchange partners in exploring potential solutions for decarbonisation and investment challenges that will be common throughout the sector. If established, the Innovation Platform (recommendation C3 in this report) may be considered a useful vehicle for ports, cross-sector stakeholders and shipping organisations to engage with in support of these recommendations. Recommendations to be considered include:

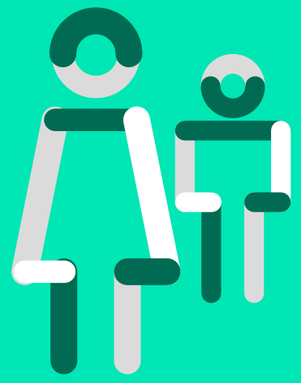
- Developing ports into energy generation and distribution hubs to minimise the pressure on the energy supply chain. This includes supporting ports in shore power provision and renewable energy generation.
- Bringing the decarbonisation of land transport and port operations into the mix. By becoming green energy suppliers to both sea and land transport, ports will be able to de-risk the infrastructure investments.
- Supporting ports, shipping and logistics i ndustries to trial and adopt greener vessels and vehicles. Funding organisations should consider supporting these initiatives through incentives, grants, and funding.

# 5. People

Whilst advances in technology present opportunities to enable a stronger, more competitive, connected, and resilient future for our maritime and ports sector, the sector would not function without highly skilled and experienced people. The Government's Maritime 2050 Strategy sets out a vision for a diverse and rewarded workforce, setting the global example and leading on maritime welfare. It is therefore essential the people working throughout our maritime and logistics sectors are a core consideration of future strategy and investments.

Maritime 2050 states that "the process of enhancing innovation will be vital to the whole sector's success". As a central hub in a wider system of systems, impactful innovation through ports must be approached in a collaborative and holistic way to accelerate transformation and realise mutual benefits. This highlights the need for a new mindset in the industry that embraces changes in technology, processes, and business models and supports collaborations among the wider sector to realise a multitude of outcomes that enhance efficiency and the UK competitive edge as examples.

The stakeholder engagement and analysis activities have identified two broad people aspects that are essential to the realisation of the identified future ports vision: (1) Behaviour and culture; and (2) Skills and knowledge. These two aspects along with their associated challenges and recommendations are discussed in the subsections that follow.

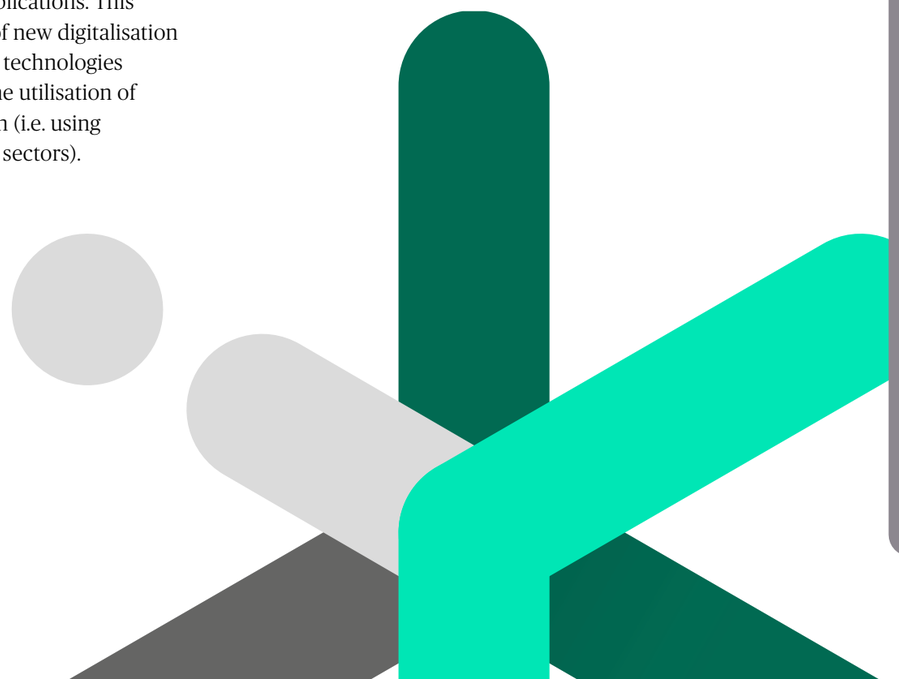


# 5.1 Behaviour and culture

The successful realisation of the decarbonisation and digitalisation agendas and the Maritime 2050 vision necessitates changes in operations and processes that impact existing stakeholders. Such change to pre-existing methods, practices, and conventions is likely to face resistance especially when is associated with perceived threats. Furthermore, new technologies and processes can also lead to undesired behaviours.

The engagements throughout the project have highlighted behavioural and cultural challenges in the maritime and logistics industries including:

1. **Closed and conservative industry** - the maritime industry is historically conservative and risk averse, needing full confidence before investing in solutions. A race to be second, not first, can slow innovation and collaboration. The industry is also not always viewed as very accessible for start-ups, SMEs or businesses with new technologies looking for new potential applications. This stifles the adoption of new digitalisation and decarbonisation technologies and processes and the utilisation of horizontal innovation (i.e. using learnings from other sectors).
2. **Reluctance to share data** - from stakeholders that may be used to better understand challenges or collaborate on solutions. This can be due to lack of trust, perceived GDPR concerns, governance, and reputational risk.
3. **Competitive Collaboration** - whilst the UK has a successful and vibrant competitive ports sector, there are opportunities for effective collaboration to enable and accelerate transformation for mutual benefits e.g. in establishing common frameworks, de-risking investment, adopting best practice and building on lessons learnt in other organisations. It is understood that growing collaboration should not impede competition, and there are non-competitive themes such as safety where collaboration is likely to achieve wider benefits and workable models for commercial collaboration can be explored.





# Recommendations

The recommendations below are proposed to potentially overcome some of the identified behaviour and culture challenges:

### C1. A national Innovation platform

There is a need for developing a platform, through single or multiple organisations, that can address some of the cultural challenges through:

- getting the different multi-sector stakeholders together to discuss common challenges and agree solutions – potentially through collaborative effort
- bringing together problem owners and solution providers from different sectors
- developing programs to attract SMEs and start-ups into the sector through targeted marketing and education activities
- supporting accelerator programs, partnerships programs, and pilot projects
- investigating the behavioural and cultural issues preventing data sharing and highlighting the mutual benefits

To ensure a collaborative and cross-sector approach, this innovation platform should be:

- suitably engaged across the wider systems infrastructure
- not directly associated with a specific region or sector organisation such as a port
- impartial to funding allocation and not directly responsible for funding decisions

### C2. Learning from other industries

to bring learning from successful innovative technology and data stories and successfully transformed organisations within the industry and from other industries. This is expected to bring a new mindset and help move the industry from being happy to be second in the race to change and innovate. If established, the Innovation Platform (recommendation C3) may be considered a useful vehicle to facilitate this recommendation.

# 5.2 Skills and knowledge

A skilled and knowledgeable workforce is the key enabler of the future digital, connected, and green ports. Current and future technologies and processes are highlighting the need for new skillsets within the maritime and logistics industries. Associated challenges include:

1. **Current and possible future knowledge gaps** - there are wider knowledge gaps in parts of the industry especially in relation to the 'why?' and 'how?' When it comes to new technologies and processes.

These include:

- lack of knowledge on all the benefits of digitalisation, where to start on the digitalisation journey, and available solutions
- lack of a clear definition of 'smart port' and a supporting route map. While solutions need to be fit for purpose, the Smart Ports agenda is highly dominated by a handful of internatonal ports
- limited knowledge about the impact of cybersecurity threats and how to be protected from cyber attacks

2. **Skills and training gaps** - these are associated with:

- concern of jobs lost due to increasing automation of vessels and port operations and the wider economic impact
- limited skills - for hybrid and new fuel engines as examples
- attracting new talent and skills to the Maritime industry is difficult as it can be seen as an old fashion industry
- ports are too busy with daily work limiting upskilling opportunities and gaining awareness of the technology solutions landscape



# Recommendations

The recommendations below are proposed to potentially overcome some of the identified challenges:

### C3. A national Innovation platform

There is a need for developing a platform, through single or multiple organisations, that can:

- support the industry digitalisation and decarbonisation journey through learning and knowledge sharing. This includes providing guidance on the uses, benefits, issues and wider impact of relevant technologies and innovations from a neutral perspective
- focus on a challenge and impact driven approach to being "Smart" with clearly defined wider and regional benefits to build consensus and broader support
- identify and share relevant learnings from international leading ports as well as from other sectors
- investigate current and future skills needs and develop a roadmap for the industry including standards and processes for learning

### C4. Attracting and developing the right skills

Building on and supporting the work of the Maritime Skills Commission established by the DfT and Maritime UK, the industry needs work to attract the right skills through:

- more public engagements and campaigns to highlight the importance of the industry and the different possible roles
- attracting the relevant skills from other sectors covering junior and leadership roles
- more investment on the existing workforce to be ready for the upcoming digitalisation and decarbonisation changes

# 6. Holistic collaboration

In order for the end-to-end people and goods journeys to be as efficient as possible, all the stages of such journeys need to be efficient in themselves but also importantly connected and integrated with the other stages. Ports are multi-modal transport hubs at the very heart of international trading. As such, ports are an intersection across a wide range of domestic and international stakeholders, influenced by the globalised trading system and impacted by events both locally and overseas. Given the complexity of ports-related logistics and the wide range of involved industries and stakeholders, there is a need for wider multi-modal and multi-sector collaborations. This is seen as an important enabler to achieve the wider digitalisation and decarbonisation targets within the transport sector as a whole and beyond and support the future ports and wider logistics efficiency and competitiveness aspirations.

The 'Holistic collaboration' term, in the context of this report, refers to aspects that needs wider considerations and include elements related to both the decarbonisation and digitalisation agendas. It covers two main aspects: (1) **Holistic ports view** which looks at collective ports challenges and recommendations and (2) **Holistic logistics view** which covers wider issues associated with the optimisation of the wider logistics network and operations. The proposed recommendations are defined as enabling initiatives to supporting beneficial collaboration across multiple organisations. Further work is required to outline the approach to realise the intended benefits which require a buy-in from all the relevant stakeholders.

# 6.1 Holistic ports view

Collaboration across ports on common challenges, and potential solutions is expected to bring wider economic, financial, and environmental benefits for the ports as well as their supply chain. Many of the challenges and opportunities related to digitalisation and decarbonisation can be addressed by ports at an individual level. In addition to opportunities on an individual basis, there are significant opportunities to reduce solution development and implementation costs, reduce investment risk in new technologies and enable wider systemic benefits across logistics organisation through increased collaboration across ports within the existing competitive model. The challenges that may benefit from a holistic ports approach are grouped in two topics: **Digital operation**, and **Resilience.**

## Digital operation

Ports are unique in many aspects including their geography, hydrography, size, way of interfacing with hinterland, and operation models. However, they have many common activities and processes such as managing vessels traffic in and out of ports, loading and unloading of goods and managing their ports assets. Many of these activities and processes now have some elements of digitisation, or are expected to have in the future, resulting in the use of digital tools and generation/consumption of data. This highlights the need for ports to collaborate on developing standards and data models that support the digitalisation of their operations. Such collaboration can have different flavours but is currently hindered by challenges such as the wide range of technology maturity levels across ports leading to staggered demand for technology and data solutions and in many cases bespoke and closed systems.

## Resilience:

Building resilience against environmental, process, supply chain, and economic shocks is a common objective for ports. The impact of climate change as well as the current COVID-19 pandemic and the anticipated impact of Brexit are examples of such shocks. Common port challenges relevant to resilience have been identified through the stakeholder engagement activities and include:

1. Ageing port infrastructure
2. Limited space available at some ports, putting pressure on port operations and creating a challenge for considering warehousing and manufacturing
3. Relevant regulations and complexity of gaining ports planning permissions (e.g. dredging and expansion). Some relevant planning agencies are under-resourced which can lead to significant processing delays
4. Lack of considering ports as significant national infrastructure
5. Lack of long-term certainty in trade demand to support investment decisions for ports and shipping



# Recommendations

Below are recommendations which can potentially bring wider multi-port benefits in digital operation and address some of the associated challenges:

### D1. Common data standards

Define common standards and agreed methods for capturing, modelling, formatting, processing, and storing port-related data. These standards should be workable across the industry, with the potential for industry and industry associations to collaboratively lead on this initiative. Such standards are intended to:

- help drive the wider market for data-enabled solutions
- avoid closed and vendor-locked solutions
- not necessarily require sharing of data and is an initial step towards more collaboration
- develop future commercial exploitation opportunities for data and insight holders (such as ports or authorities) through increasing standardisation and adoption of common terminology and methodologies

### D2. Common digital system architecture

Define common digital systems architectures with standard interfaces that support plug and play solutions. These architectures and interfaces should be workable across the industry, with the potential for industry and industry associations to collaboratively lead on this initiative. This would enable:

- ports to gradually and efficiently improve their technology maturity through the deployment of sub-systems that are compatible with a wider standard systems architecture
  - the technology solution market, especially SME's, to provide specific sub-systems or functions as opposed to a complete end-to-end system. This stimulates market growth and opens the maritime market to small and innovative solution providers, and avoids lock in to inflexible systems

### D3. Multi-port digital collaboration

Establish a set of use cases and applications for multi-port digital collaboration. This could include the procurement of shared digital assets and solutions as well as use cases for sharing non-commercially sensitive data. As a recommendation designed to support collaboration that delivers mutually beneficial value, we consider that an industry led approach, supported by an impartial third party and/or industry associations would be beneficial to releasing the potential benefit of this initiative.

The following are recommendations which can potentially support ports in becoming more resilient and address some of the associated challenges:

### D4.Develop ports as economic activity hubs

Bringing a range of value-added services and helping ports to diversify income sources, building on ports features and different strengths whilst improving resilience to future international trading developments. It is recommended that this be pursued as a collaborative initiative between regional stakeholders (e.g. authorities, manufacturers, supporting service providers etc.) and ports. Potential activities include:

- goods processing and value-added manufacturing
- bases for remote operations for other sectors such as offshore energy
- green energy generation, distribution, and consumption hubs
- vessel repairs and engineering
- Leveraging the Freeports initiative, designing individual Freeport operational concepts for regional impact to deliver maximum economic benefits

### D5. Support ports infrastructure upgrades and expansion

Through funding and regulations given their importance and significance to the resilience of the overall UK logistics value chain. It is recommended that industry, Government, and relevant funding organisations work to define cases best approached with self-funding and cases that may have a national impact or broader scope benefitting from other avenues of support.

### D6. Improve ports infrastructure resilience

By investigating and identifying the common threats that impact ports infrastructure resilience (e.g. rising sea levels and cyber-attacks) and developing a clear risk mitigation plan. This may require industry engagement with regional and international bodies to address some of the global threats.



# 6.2 Holistic logistics view

Taking a holistic view of the end-to-end movement of goods and people through ports leads to a better understanding of the systemic efficiency opportunities and challenges, and helps create new value or reduce costs and environmental impacts. This has been emphasised throughout the project stakeholder engagement activities, highlighting the importance of taking a wider systems level view to the decarbonisation and digitalisation agendas. This section presents the challenges, and proposed recommendations, captured through the project which require this holistic view and a collaborative approach between multiple actors across the logistics value chain to address them. The relevant decarbonisation and digitalisation challenges are:

1. **Lack of clarity on ownership of problems** - who should invest or change to address challenges. In some cases, the beneficiaries of freight optimisation interventions are not necessary the ones paying for the solution. There is a large number of stakeholders in the ports and logistics industries and limited methods of wider coordination and few forums.
2. **Efficiency of container shipping** - Space within containers is not always fully utilised. It is estimated that 24% of transported shipping containers are empty resulting in 122 million tonnes of carbon dioxide emitted every year by shipping empty space[16]. Underlying causes include the lack of coordination between exporters and importers to share space and limited facilities of cargo redistribution. Furthermore, some cargo and packaging is not designed for efficient container shipping.
3. **Limited shift to sustainable modes of transport** - The shift from road to rail and water transport will reduce the emissions of freight movement. However, rail and water freight modes have struggled to compete with road transport due to the latter's flexibility, competitive price, and ability to cover the end-to-end land journey. Furthermore, rail freight suffers from limited capacity with priority to passenger services, and a limited electrified network. Despite the wide understanding of the environmental benefits of modal shift, there is little support to the sustainable modes in terms of available capacity and price competition.
4. **Increasing demand for fast goods delivery** - Some goods owners and freight forwarders are sometimes pushing for quick deliveries and this could be to reduce uncertainties in the logistics chain and to avoid delays. This leads to increasing the environmental impact of shipping by limiting opportunities for consolidating different shipments and the use of slow but more sustainable transport modes. Furthermore, early arriving cargo maybe kept at ports for longer reducing ports storage capacity.
5. **More focus on the long-term decarbonisation targets** - Government focus more on the long-term decarbonisation targets, not on short term interventions on existing vessels and vehicles. There is a lack of a clear 'what happens if we do nothing' to show the urgency and importance of acting now to achieve the long-term decarbonisation targets.
6. **Limited visibility of the end-to-end goods movement** - limiting the understanding of the impact of disruptions on the whole logistics chain and relevant wider multi-modal optimisation interventions.

16 https://www.strategic-packaging.com/download-whitepaper-the-empty-space-economy

# Recommendations

The following recommendations are proposed to potentially address the identified challenges:

### D7. Sustainable end-to-end logistics

The conducted research in this project has highlighted the important role of the goods owner to improve the logistics operational efficiency as they are (1) the ultimate client who can drive the right behaviour through the logistics chain, and (2) set or influence many of the logistics decisions that can define the transport route, mode and schedule. Therefore, there is a need to highlight the impact of such decisions on the environment and influence goods owners' decisions to address some of the inefficiencies in the logistics chain. This recommendation may require collaboration between cross-sector industry associations at a high level, with industry engaging directly with goods owners. Example of interventions that can be considered are:

- ***Consideration of night-time goods delivery*** – this helps hauliers to reduce pressure on the road network and on entry/exit of ports.
- **Consideration of reducing demand for faster delivery of goods** – this can encourage the use of slower and greener transport modes such as coastal shipping and inland waterways
- ***Consolidation of container shipping*** – this is by combining goods from different importers or exporters to improve the utilisation of containers

### D8. Environmental monitoring and reporting

There is a need for developing a collective framework for the emissions monitoring and carbon reporting for the whole industry. This helps in developing targeted policies to achieve the national decarbonisation targets. Such a framework, potentially facilitated by the Government or regulatory bodies, can improve how technology is used to have confidence in emissions monitoring, deploy sensing in economic way, and subsequently reduce emissions through specific intervention.

### D9. A national Innovation platform

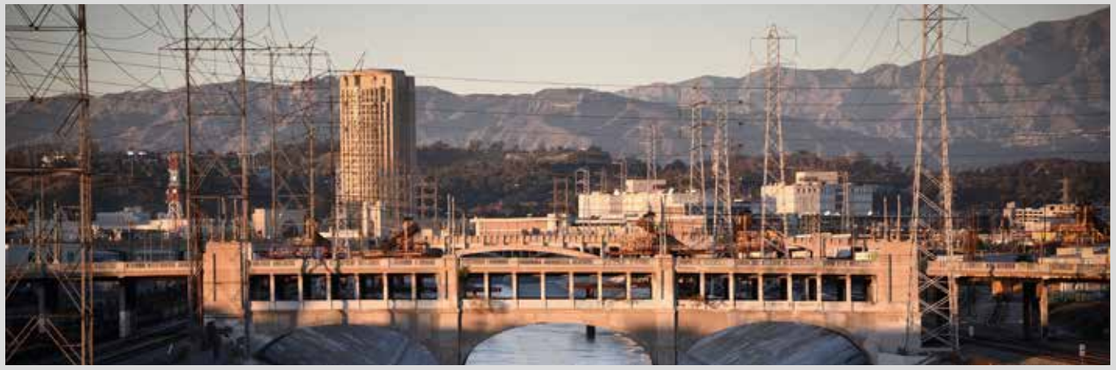
The need for developing a platform, through single or multiple organisations has been identified in recommendations C1 and C3 (Section 5). The role of this platform in the holistic logistics context is to act as a neutral convener of the different stakeholders across the ports and logistics industries and relevant associations to discuss the wider challenges and agree solutions. This includes getting unions, operators, road and rail operators, goods owners, freight forwarders, relevant industry associations, and authorities around a table to discuss technologies, processes and associated challenges and solutions.

### D10. Common data standards and system

Similar to the case for ports in Section 6.1, there is a need to:

(1) define common standards and agreed methods for modelling, formatting, and transmitting data between the different stakeholders across the logistics value chain. This will enable the industry to talk the same language when it comes to data and enables the adoption of more universal data solutions; therefore, stimulating the market and enabling economies of scale

(2) define a common digital systems architecture with standard interfaces between systems deployed by different stakeholders across the logistics value chain. Defining and adhering to a set of common interfaces between subsystems will enable flexibility and interoperability.



This will be the first step towards better sharing of data across the logistics chain, which will improve the understanding of the end-to-end freight movements and enable more accurate freight movements analysis and predictions. These common standards, architectures and interfaces should be workable across the industry, with the potential for industry and industry associations to collaboratively lead on this initiative along with Government support.

### D11. Shift to more sustainable modes

Despite the known environmental benefits of moving cargo by rail and water (coastal shipping and inland waterways), there is limited shift towards these modes which can be attributed to financial, efficiency and operational factors. The interventions below are suggested to improve the adoption of these modes:

- ***Improvement to the interface of the rail network with ports*** - There are great examples of increased rail mode share due to investments in rail connections to some ports. There is a need to highlight the benefits of such interventions to build the business case for wider improvements
- ***Develop a strategy and plan for coastal shipping*** – coastal shipping has the potential to address challenges in road and rail capacity, local congestion, achieving emissions reduction targets through more efficient journeys compared with current freight flows. Furthermore, it provides a good route to some of the vessel automation and decarbonisation interventions.

There is a potential for the relevant industry organisations and associations to collaboratively lead on these initiatives along with Government support.

Realising the required modal shift requires more wider interventions highlighted through the project stakeholder engagements. These interventions require coordination and planning across wider sectors and government departments as, in addition to maritime, it links to road and rail transport at the national and local levels as well as the energy and environment sectors. Such broader interventions include, as examples:

- *Investment in rail electrification (or other fuels) for the rail freight network*
- *Improvement to the capacity of the rail freight services*
- *Improvement to the modal interchanges of rail and water freight with road freight transport*
- *Improvement to the strategic road network and connections*

# 7. Next steps and concluding remarks

# 7 Next steps and concluding remarks

The project defined a vision for the UK ports of the future in the context of four focus areas (Digitalisation, Decarbonisation, People, and Holistic Collaboration). This was defined through research, wider stakeholder engagements, and analysis. For each of the four focus areas, associated industry-validated challenges and recommendations to alleviate these challenges and support the delivery of the vision were identified and discussed in more detail in Sections 3-to-6. The proposed recommendations are outlined in Table 2 below in a short-, medium- and long-term order.

A set of key short-term activities have been highlighted in Gold in Table 2. These are expected to deliver quick demonstrable value and/or build the foundations to key follow-on activities across the four focus areas:

- **Digitalisation**: through (1) building the foundation for a data-driven industry through defining commonly agreed standards and terminology for data and architecture for digital systems; and (2) identifying and developing challenge-led data use cases that build on existing data and infrastructure assets and can quickly demonstrate value.
- **Decarbonisation**: through (1) building the foundation for the adoption of green fuels through a UK-specific domestic green fuels plan, and a strategy for coastal shipping; and (2) supporting the delivery of the 2050 decarbonisation targets through agreeing nearer term achievable decarbonisation milestones along with supporting activities.
- **People**: starting by establishing a central Innovation Platform through single or multiple organisations to: (1) build the learning and knowledge sharing foundation that underpins both the digitalisation and decarbonisation agendas; and (2) act as a neutral convener of problem owners and solution developers, and support innovation programs.
- **Holistic Collaboration**: starting by building a better understanding of the common natural and man-made threats to the resilience of ports.

The industry is going through a transitional phase with a wide range of current and planned activities in the digitalisation and decarbonisation space. The great engagement response witnessed in this project from the stakeholders, and the high-level of enthusiasm felt from both problem owners and solution providers are great evidence for the positive and strong momentum in the industry. It is very important to build on this to translate the proposed recommendations into a program of impactful projects and initiatives. Below are two key activities proposed to take the recommendations in this report to the next level:

(1) **Define champions** - the report has provided suggestions of possible leaders, at a high-level, for each of the proposed recommendations in Sections 3-to-6. A key next step is to define and agree champions or owners for each recommendation along with collaborators, and a clear plan. This needs to be broadly discussed and agreed with the relevant stakeholders

(2) **Monitor progress** - to keep the vision and associated activities alive, there is a need to develop a structure for monitoring progress against delivering the vision. This also requires a wider consensus across the relevant stakeholders



Table 2- The proposed recommendations to realising the Ports of the Future vision for the short, medium, and long-term

| Short-term | | Medium-term | | Long-term | |
|---|---|---|---|---|---|
| Investigate the need for new regulations to enable the digitalisation of logistics paperwork and customs (A1) | ● | | | | |
| **Support knowledge sharing on the benefits of digital solutions to ports through promotion of case studies (A2) (C2)** | ● ● | Fund small digitalisation demonstrator projects to help demonstrate value, and build confidence in digital solutions (A2), and build the evidence to support business cases (A3) | ● | Consider developing a common data platform for smaller ports to reduce some of the financial burden of digitalisation and expedite adoption of solutions (A2) | ● |
| Support developing the digitalisation business case (A3) | ● | | | | |
| **Define a common terminology, approach and standards for port-related data (D1), and agreed data quality standards (A4)** | ● ● | Define a common terminology, approach and standards for the logistics chain data (D10) (A4) | ● ● | | |
| **Define common interface and requirements for digital port systems architectures that support plug and play solutions (D2).** | ● ● | Define common interface and requirements for digital systems architecture between systems deployed by different stakeholders across the logistics value chain (D10) | ● ● | | |
| **Conduct data discovery to identify existing data within ports and the logistics value chain; to develop relevant use cases linked to current and future industry challenges (A5)** | ● ● | Run a set of pilot data analytics projects that demonstrate the value of data utilisation (A5) (B2) and share learnings across the industry (C2) (C3) | ● ● ● | | |
| Define and promote a set of use cases and applications for multi-port digital collaboration (D3) (C2) (C3). | ● ● | Run a set of multi-port digital collaboration pilot projects (D3) and share learnings across the industry (C2) (C3) | ● ● | | |

● Digitalisation ● Decarbonisation ● People ● Holistic Collaboration

| Short-term | Medium-term | Long-term |
|---|---|---|
| Develop a strategy for growing export for maritime autonomous technology to ensure a leading role in the international market building on the UK cross-sector strengths (e.g. AI, certification, assurance) (A6). | Support autonomous vessel testing by developing the relevant national testing regulations and guidelines, and evaluate and highlight benefits of autonomy (A7); and engage with IMO in relation to global regulations (A8) | |
| Consider using sea exclusion zones and infrastructure to mitigate impact of mixed operation environment (A8) | | |
| **Develop a strategy and initiatives to support coastal shipping given its potential to address challenges in road and rail capacity, achieving emissions reduction targets (D11), as well as its potential for being a trail blazer for adopting autonomy and automation (A8)** | | |
| Develop better understanding of the bottlenecks and root causes of port-related congestion and associated environmental impact through analysing existing port-related road traffic data and identify data gaps (B1) | Develop an action plan to fill gaps in required data to improve understanding of port-related congestion (B1) | Introduce targeted interventions to alleviate port-related congestion and associated environmental impact (B1) |
| **Define nearer term achievable decarbonisation milestones and associated regulations and initiatives to support the delivery of the 2050 decarbonisation targets (B3).** | | |
| Support the nearer term decarbonisation interventions through funding trials and demonstration projects and developing relevant standards (B3). | | |
| Support R&D and demonstration activities of alternative green fuel for maritime (B4) | | |
| Develop a collective framework for the emissions monitoring and carbon reporting for the whole ports and logistics industry, to support developing targeted policies to achieve the national decarbonisation targets (D8). | | |

| Short-term | Medium-term | Long-term |
|---|---|---|
| **Develop a plan to define UK-specific domestic green fuel adoption activities, which includes defining suitable vessels, routes, fuel, and ports (B6); while continue the regional and international engagements to influence the global green fuel direction (B5)** | Build the business case for the defined UK alternative fuel plan and support development and trials with defined stakeholders (B6). | Develop an adoption plan for national green fuels building on the lessons learnt from the local trials and international developments (B6) |
| De-risk the investment in decarbonisation solutions by supporting ports, shipping and logistics industries to trial and adopt greener vessels and vehicles (B7) | De-risk the decarbonisation investment by developing ports into energy generation and distribution hubs to both land and sea transport (B7) | |
| **Develop a central Innovation Platform through single or multiple organisations to support learning and knowledge sharing across the industry, support innovation programs, and acts a convener of problem owners and solution developers (C1), (C3), (D9)** | | |
| Build an educational and best practice program to bring learning from successful innovative technology and data use cases and successfully transformed organisations; to support successful approach to innovation in the sector (C2) | | |
| Attract and develop the right skills for the industry based on current and future challenges (C4) | | |
| | Develop ports as economic activity hubs - bringing a range of value-added services and helping port to diversify income sources, building on ports features and different strengths (D4). | |
| **Investigate and identify the common threats that impact ports infrastructure resilience (e.g. rising sea levels and cyber-attacks) and develop clear mitigation plans (D6).** | Support ports infrastructure upgrades and expansion through funding and regulations given their importance and significance to the resilience of the overall UK logistics value chain (D5) | |

Digitalisation Decarbonisation People Holistic Collaboration

Digitalisation Decarbonisation People Holistic Collaboration

# 8. Acknowledgements

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