Anchoring 5G in UK Ports

Understanding how to accelerate the roll out of 5G within the UK port sector

Findings from the 5G Smart Ports Collaboration
as part of the Department for Culture, Media and Sport's 5G Testbeds and Trials programme
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Image Credit: The Bristol Port Company

Contents

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Executive Summary

The port sector plays a critical role in supporting the UK economy, and the efficient and effective movement of trade through these locations is essential. As with other industrial sectors, digitalization is becoming increasingly important and 5G enabled technologies offer new opportunities to further enhance this efficiency and effectiveness.

However, the UK port sector can often be conservative in its adoption of new technologies. While 5G adoption is generally at an early stage, there is the opportunity for the sector to become more proactive in adopting this technology. This report explores in more detail what the opportunities are for 5G technology in the UK port sector, and the enablers and barriers to widespread adoption.

5G will overcome many of the current shortcomings with 4G and Wifi based applications, and we have identified a range of potential use cases for the port environment including:

- Health and safety
- Automation
- Tracking
- Drones
- Asset monitoring
- Data sharing
- Value adding applications

What is clear, however, is that any 5G deployment will need to bring together multiple use cases in order to justify the investment in the technology.

However, there are a wider range of barriers and enablers to wider adoption of 5G, which we categorise as:

- Investment decision making, which includes alignment with digital strategy, building the business case in light of existing investments and asset renewals and the availability of funds.
- Use case benefits, which are often seen as uncertain now but are likely to be significant as new use cases develop in the future.
- Implementation related, with technology readiness being a barrier but collaborative working acting as an enabler.
- Workforce concerns, including the skills and attitudes of the existing port workforce and recruitment challenges where the port industry needs to access new pools of talent.
- Government support, through financial measures as well as standards, spectrum availability and supporting skills development.

From this understanding of barriers and enablers, the UK port sector can work to adopt 5G more effectively. In doing so, sharing experiences, best practices and learning will further enhance understanding within the sector.

Introduction

Ports play a critical role in UK supply chains, supporting the international trade of both imports and exports. It is critical that goods move as smoothly and efficiently through ports as possible to ensure that supply chains do not become disrupted.

The past 30 years has seen a significant change in port operations, with technology playing an increasingly important role. Digitalization is becoming commonplace, with the latest generation of ports now being labelled Smart Ports. Figure 1 shows the evolution towards Smart Ports and their characteristics.

A key facilitator of this evolution has been the growth in web-enabled technologies, and increased capability of telecommunication networks to support this. The emergence of 5G offers new opportunities for ports to embrace digitalization, with increased capabilities for handling data allowing improvements to both physical and information flows. It is clear that the next 5 years will see investment in 5G increase significantly by both ports and the wider logistics sector.

As of 2022, the adoption of 5G within the UK ports sector is still at an early stage, with some initial use case trials funded both by the Department for Culture, Media and Sport (DCMS) as well as by the ports themselves. However, there is interest more generally within the sector, recognizing the opportunities the technology can bring.

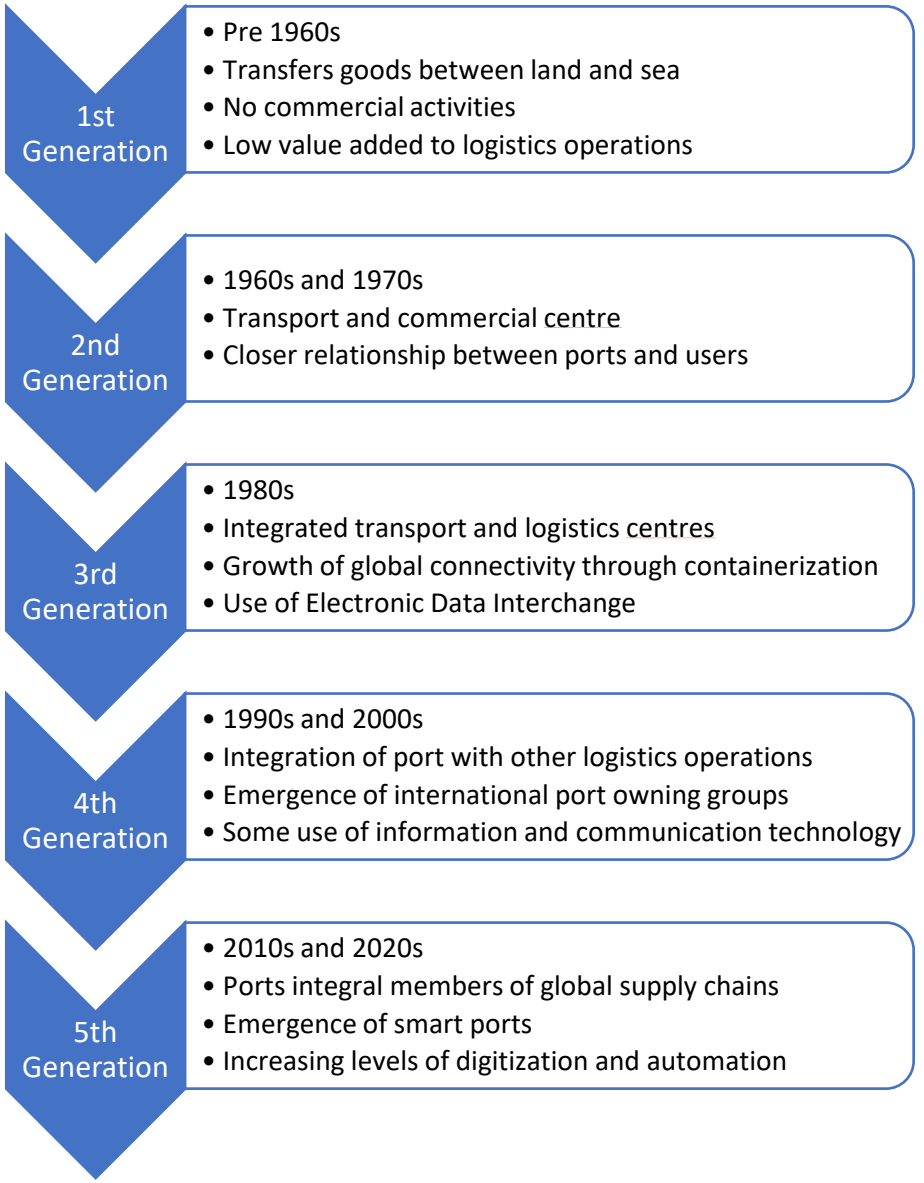


Figure 1: The evolution of Smart Ports (adapted from Molavi, Lim and Race, 2020)

This report results from a collaboration between two projects under the DCMS 5G Testbed and Trials programme, 5G Logistics and 5G Ports (more details on these projects can be found on pages 8 and 9). Building on experience within each project, the collaboration work has engaged with the sector more widely to examine what the opportunities are for 5G in the UK ports sector, as well as the barriers and enablers for wider adoption.

The aim of this report is to identify requirements for ports and their stakeholders to enable the wider deployment of 5G within the UK port sector. While recognizing that ports will compete to attract traffic, when deploying a new technology such as 5G there is also much to learn from each other's experiences. By identifying how ports can build the case for 5G deployment, the intention is to support this wider roll out, bringing benefits for the UK economy through more efficient and effective trade.

To inform our work, we have been speaking to UK port sector representatives, from small harbours to global gateway ports. These ports are at different points in the journey to 5G, from having initial thoughts through to investing in 5G technologies. Data collection has taken place during late 2021 and early 2022, and the report's content reflects our analysis of these discussions, rather than an industry-wide perspective on 5G deployment.

Why is 5G important for ports?

It is likely that 5G will see major deployment in the next 5 years within the logistics industry, particularly in support of wider moves towards digitalization and automation in the sector. This will enable companies to meet continually increasing demand for greater transparency and reliability in speed in the movement of their freight. Underpinning all of this is the need for communication networks to handle and process increasing amounts of data.

5G will provide the capability to do this, exceeding the capabilities of existing 4G and Wifi networks where wireless communication is required. The benefits can be considered in relation to:

- Volume – 5G networks will enable a greater amount of data to be handled when compared to existing wireless technologies. This will provide, for example, the capability for an increased number of sensors to be deployed around the port estate to allow the tracking of mobile assets and cargo.
- Velocity – Using 5G will provide a greater bandwidth for handling data, allowing it to be transmitted at a higher speed. In doing so, activities such as automation and remote working within ports becomes more feasible, especially for mobile assets which cannot have a fixed connection.
- Veracity – 5G can provide more reliable connections for data transfer, giving assurance that the flow of data will not be disrupted. This can support mission critical control activities and better quality video transmissions for the purposes of security or remote maintenance.
- Variety – 5G networks have the ability for network virtualization to allow different systems to use the same communication infrastructure. This reduces the need for multiple communication networks to be installed, while ensuring security is maintained between different users.

Ports around the world are now developing and testing 5G use cases that cover all stages in the movement of freight as well as in other functions supporting port operations. Figure 2 summarises these 5G use cases, as well as providing examples of ports which have trialled or deployed them. Use cases are very important as they create the value proposition from 5G.

The use cases demonstrate the capability of 5G to enhance various processes, including

- increased monitoring of freight, assets and environmental measures
- automation of processes to speed up flow and reduce the risk of accidents to port workers
- use of video, including coverage from tugboats and the use of drone based camera to enhance safety and security.

Beyond these use cases, there are other examples of port digitalization which would benefit from 5G adoption. This includes energy management within the port, autonomous vessels and using artificial intelligence for resource allocation.

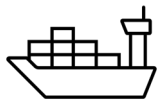
	Port Waters	Unloading	Storage	Transfer	Port Gate to External Site	Other Applications
						
Current 5G Use cases	• Tracking on barges and tugs • Streaming video from tugboats • Augmented reality to aid berthing	• Monitoring and managing equipment • Remote control of cranes • Detecting container damage	• Sensors to monitor cargo • Tracking containers and cargo • Added value cargo services	• Sensors to monitor cargo • Navigation of automated guided vehicles • Traffic control • Work allocation	• Sensors to monitor cargo • Tracking containers and cargo	• Remote site support using virtual and augmented reality • Monitoring environmental impacts • Security monitoring using drones • Health and Safety
Locations using 5G	• Antwerp • Livorno • Zeebrugge	• Felixstowe • Koper • Qingdao	• Bristol • Livorno • Southampton	• Felixstowe • Hamburg • Livorno • Piraeus	Bristol • Southampton	• Belfast • Bristol • Riga • Hamburg • Pireaus • Rotterdam • Zeebrugge

Figure 2: Existing 5G use cases within ports

5G Logistics

The 5G Logistics project is trialling the power of private 5G networks for supply chain efficiency, visibility and traffic management.

Led by the West of England Combined Authority, the 12-partner-strong consortium includes: the region's major port, The Bristol Port Company; academic facilities at the University of Bristol Smart Internet Lab and Cardiff Business School; Gravity, the new 616-acre commercial smart campus; automated drones solution provider, Unmanned Life; Bristol City Council and 5G private network businesses, Cellnex, ADVA, AttoCore and Airspan.

Set to complete in June 2022, the project trials three use cases:

1. **Geo-fenced asset tracking and condition monitoring:** Using 5G internet of things (IoT), goods containers and pallets are being tracked within the 5G testbeds – and between them, using a public network. This level of visibility is expected to become critical in a modern freeport scenario, where products can move customs-free between a central port zone and remote 'freezones' up to 45km away. The goods containers are also kitted out with sensors measuring temperature, light, humidity and more – and transmitting this data in real-time to a user dashboard.

2. **Automated drone surveillance and emergency response:** The project is using the reliability and bandwidth offered by 5G to test automated drone perimeter inspections and incident response at the port. Security for goods and workers is paramount in a port environment, which can span large areas and has an ever-changing landscape.

3. **Smart junctions:** The smart junction use case is exploring how 5G features such as deterministic low latency to mobile edge compute (MEC) and enhanced location services might shape future intelligent traffic system (ITS) architectures. Trials involve moving non-safety critical traffic optimisation features (normally running on-street), into the MEC. The trials also explore how vehicle location data could be used to improve algorithms to optimise junction efficiency for HGVs – common around ports.

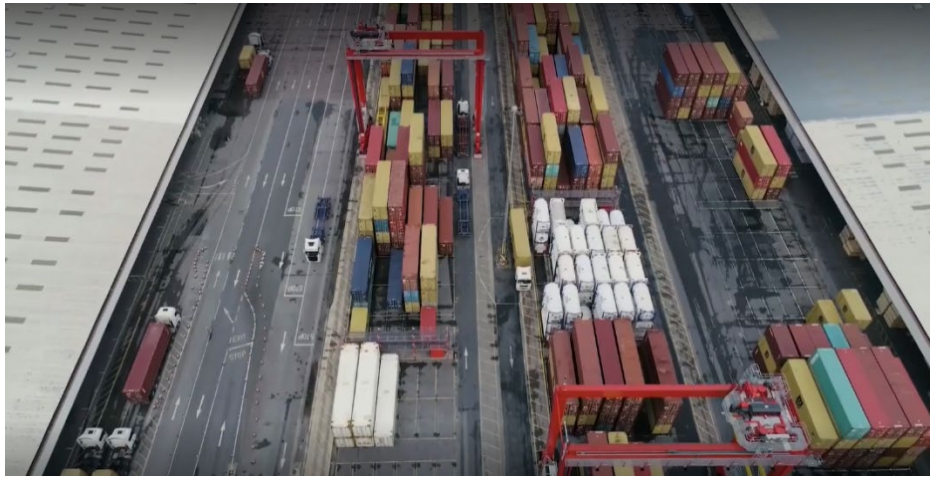


Image credit: The Bristol Port Company

5G Ports

This project at the Port of Felixstowe will use 5G Internet of Things (IoT) devices and predictive data analytics to reduce unscheduled downtime of cranes, to boost the productivity and efficiency of the operation of the port's ship-to-shore quay cranes. It will also show how the use of 5G technology, replacing fibre optical cable, will improve the performance of remote control yard cranes enabling the port to increase both efficiency and safety and develop new skills amongst its workforce. The project involves the University of Cambridge, Three UK and Bluemesh Solutions Ltd.

AI enabled predictive maintenance: Quay cranes are one of the most critical assets in a port, and their availability and efficiency of these cranes is often the determining factor in port productivity. However, cranes are prone to disruptions due to the extensive stresses and cyclic loading they experience during operations. Unexpected disruptions can lead to stoppages in loading/unloading operations, affecting turnaround times for vessels. This project is monitoring the condition of the critical components of the cranes using low-cost IoT sensors communicating via 5G technology. Artificial intelligence is employed to identify pre-disruption trigger events to guide the predictive maintenance strategy.

The project will demonstrate the effectiveness of AI using 5G IoT to improve the efficiency of quay cranes by reducing their downtime attributable to component failures and thereby increasing their availability and moves per hour.

Remote control of yard cranes: Remote control of assets is important to the Port for health and safety by removing operators from the quay and also to attract a wider pool of employees, including those with some disabilities, who are otherwise unable to work in certain roles on the Port.

5G provides critical latency and throughput capabilities needed to enable the crane critical operating systems to operate and to transfer the multiple CCTV feeds that the operator requires. This use case is testing high upload rather than download volumes and operating at less than 16m/s latency.

Image credit: Port of Felixstowe

Approach Taken

The focus of this work has been to understand what needs to happen to accelerate the use of 5G within the UK ports sector. In doing so, two main questions were posed:

1. What are the key operational challenges the UK port sector faces that 5G could help with? And how?
2. What are the enablers and barriers to investment in 5G?

The first of these questions recognises that, for 5G to be more widely adopted, it needs to help ports improve their current operations. It may be that use cases have yet to be fully developed, and so the question allows a breadth of opportunities to be identified.

The second question more closely examines how organisations may transition from being interested in 5G deployment to committing to investment.

To get industry opinions, a workshop was held with six representatives from organisations with active involvement in the UK port sector. This was complemented by six further interviews where participants were unable to attend the workshop.

In the workshop, a short presentation was given summarising the current use of 5G in the port sector globally and highlighting some of the potential opportunities offered. Information about the two collaborating DCMS-funded projects was also covered. An open discussion session was then held focusing on the two questions above.

For interviews, a similar approach was taken although the presentation element was adjusted to reflect the current experiences of the interviewee with 5G deployment in their organisation.

These covered a wide range of port operations including small, local government owned harbours, Trust Ports and large, multi-port owning groups. Geographically, participants had operations throughout the UK, with the port-owning groups having overseas operations too. Most participants were responsible for IT within the port although those from smaller ports had a wider range of responsibilities. In addition to port operators, participants included representatives from trade bodies as well as 5G technology and logistics providers.

In terms of experience with 5G, some participants were well along the path towards investing, either undertaking trials or going out to tender. However, many were still exploring potential opportunities and some were more cautious, knowing a little about 5G without fully considering whether it offered opportunities for their organisation.

The qualitative data from the workshop and interviews has been analysed by the team at Cardiff University, complemented by academic literature and trade press articles as appropriate.

Operational Challenges

In discussing the operational challenges for 5G adoption, much of the focus was on the potential **use cases** that could improve existing port operations. However, some challenges were also raised related to **management** and **technology** issues. These need to be considered before building a business case and considering the enablers and barriers. Each of these is now discussed in more detail.

Use cases

Through the discussions, a range of different use cases were identified which would take advantage of the capabilities of 5G (see Figure 3). While all of the use cases can be standalone examples, they can also support other use cases. The most frequently mentioned examples related to health and safety, automation and tracking of resources and cargo. There are often links between these use cases.

- **Health and safety (H&S):** The focus here is on keeping workers out of dangerous areas within the port, either by tracking their location or using automation. For dangerous, repetitive tasks, 5G and AI enabled robotics can help companies to prevent incidents while saving time and cost, as robots are capable of working in hazardous environments and alleviating strenuous tasks. While H&S was the most frequently mentioned opportunity, it was also recognised that tackling this issue alone may not justify investment in 5G.

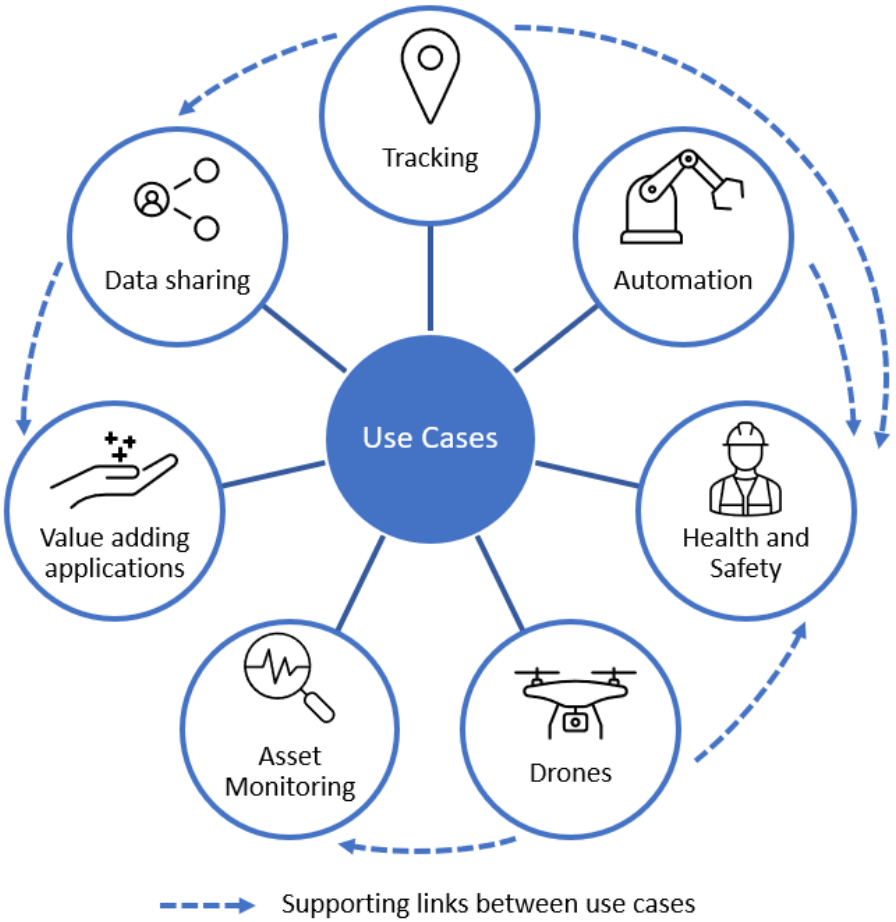


Figure 3: Potential 5G use cases in ports

- **Automation:** Enabling activities to be controlled remotely offers good potential, both for fixed and mobile assets. However, these use cases are likely to emerge in the medium term, given the

significant investment requirement and dependency on the existing technology maturity of a port.

- **Tracking:** To quote one participant, this would involve tracking "anything that moves", including workers, vehicles and cargo. Given that tracking capabilities already exist, use cases will need to exploit the enhanced value of 5G in terms of intensive real time and low latency connectivity at scale.
- **Drones:** These offer a range of different opportunities, including goods/items delivery, video monitoring from hard-to-reach locations (e.g. aerial views), servicing hard-to-access locations or enhancing security monitoring across the port estate.
- **Asset monitoring:** 5G provides the opportunity for monitoring the condition of port assets, such as cranes, to allow predictive maintenance and avoid unplanned unavailability of equipment – which can come at a high cost.
- **Data sharing:** Using and sharing data in (near) real time manner is increasingly important for port operators, providing the much needed end to end supply chain visibility to relevant stakeholders including shippers, logistics service providers, and government agencies such as customs clearance. 5G, as a critical supporting infrastructure, plays a significant role in this.
- **Value adding applications:** These use cases relate to opportunities for providing value adding services to the freight and/or passengers making use of the port. Currently, very few customer focused use cases have been adopted and more discussion on these came from the smaller ports. These ports may be tourist destinations or host cruise ships, and therefore opportunities exist for 5G use cases that can improve the visitor experience.

Elsewhere, use cases related to environmental monitoring within ports have been developed. However, discussions with participants indicated that current thinking related to use cases in other areas, while recognising there may be environmental benefits as a consequence.

Management

There was a general belief among ports regarding the importance of digital transformation, particularly in providing competitiveness while coping with uncertainties and disruptions such as Covid-19 and geopolitical turmoil. However, efforts and investments on digital technologies tend to be conservative. In particular, ports can be risk averse when it comes to experiments with and the trial use of emerging technologies, preferring to see investment elsewhere before investing in deployment.

For smaller ports, there are added challenges in having the resources and in-house expertise available for undertaking innovation, as management teams may be small with individuals having multiple roles within the port. Consequently, leading in innovation has a lower priority than other, and port management tends to focus more on operational activities.

This tendency to be risk averse then filters through into justifying the need for investing in 5G. For many use cases, investments in 4G and Wifi are generally seen as sufficient for current business needs and there are often substantial switching costs when transiting from legacy systems to new digital solutions. Interoperability as well as the redesign of IT infrastructure and restructuring of internal processes

and practices can be expensive, leading to less desirable efficiency gains. Therefore, the case for 5G investment is reduced unless there are wider strategic objectives to be seen as leaders in this technology. However, where 5G investments are more easily justified is in the development of new infrastructure within the port estate, where legacy systems are not present.

Technology

Participants identified that 5G may offer the opportunity to overcome some of the challenges they face with their current use of Wifi and 4G. In the case of the former, issues identified include the available bandwidth for handling increasing amounts of data, reliability of connections and security concerns. Another issue with Wifi was the presence of Faraday cages creating deadspots, as a result of the equipment and containers passing through ports.

For 4G, the main concern was network coverage. Ports are often in more peripheral areas and, while many of these now have reasonable coverage, there remain parts of the UK where 4G signals can be patchy, and for port operators in these more remote areas, this can lead to blackspots.

Despite these concerns, for many operators existing Wifi and 4G networks are sufficient for current operations, and may have redundancy to accommodate further growth. As noted earlier, this creates a challenge for justifying further investigations into 5G deployment.

There are also concerns about 5G coverage. Where ports deploy their own private network, there may be a large area of land to be covered with 5G and this leads to the need for significant investment. For some ports, a public or hybrid (public/private) network may be an alternative, but these then depend upon the coverage available. Solutions to overcome security concerns around public networks are now becoming available. 5G networks are currently more focused on urban areas, whereas ports are often away from these.

Enablers and Barriers

In considering the enablers and barriers to 5G adoption by UK ports, five general themes emerged: Investment decision making, use case benefits, implementation activities, workforce and government support. Within each of these, a range of enablers and barriers existed, as summarised in Figure 4. It should be noted that some barriers are becoming enablers as ports digitalise their operations, and these are shown with dotted arrows.

Investment decision making

These issues extend some of the earlier points made about management issues when discussing opportunities and challenges. The **digital strategy** of a port operator is significant, and is moving from being a barrier to being an enabler.

The ports and logistics sector in the UK is quite traditional in its outlook and, until relatively recently, had not significantly embraced the opportunities offered by digitalization. Where digitalization has now occurred, 4G and Wifi networks are normally sufficient to support this.

However, changes are coming as a result of various pressures and there is a greater recognition that ports need to embrace digitalization to improve operational efficiency and productivity, increase safety, reduce emissions, and improve sustainability. Ultimately, ports will need to adapt in much the same way as they have done over time in response to external pressures.

The **business case** for investing in 5G can also be a barrier to investment. Any decision needs the investment cost to be compared with quantifiable benefits and, currently, there are challenges with both of these. With the port sector often not leading on innovation, these uncertainties can then represent a barrier.

An initial barrier is the **availability of funding** for the 5G investment. Ports have finite resources, and it may be that other areas of the business are deemed more important for investment, particularly if they directly benefit the movement of cargo. Related to this, some participants directly identified the cost of 5G provision as a barrier.

Existing investments in 4G and Wifi can also represent a barrier, with participants already having these networks in place. Therefore, moving the whole port environment to 5G is difficult to justify, leading to a more incremental approach. However, the incremental approach can also then reduce some of the benefits that can be achieved.

What is seen as a way forward is to adopt a hybrid approach, whereby radio masts can support both 4G and 5G, with a switch towards the latter over time as required.

Another enabler for port operators is for 5G investments to **align with wider asset renewal cycles**. Much port infrastructure predates the internet era and therefore telecommunications equipment needs to be retrofitted. By contrast, new build facilities can include the physical infrastructure for 5G connectivity and may need wireless communication methods to be installed. In these situations, the justification for 5G can be stronger.

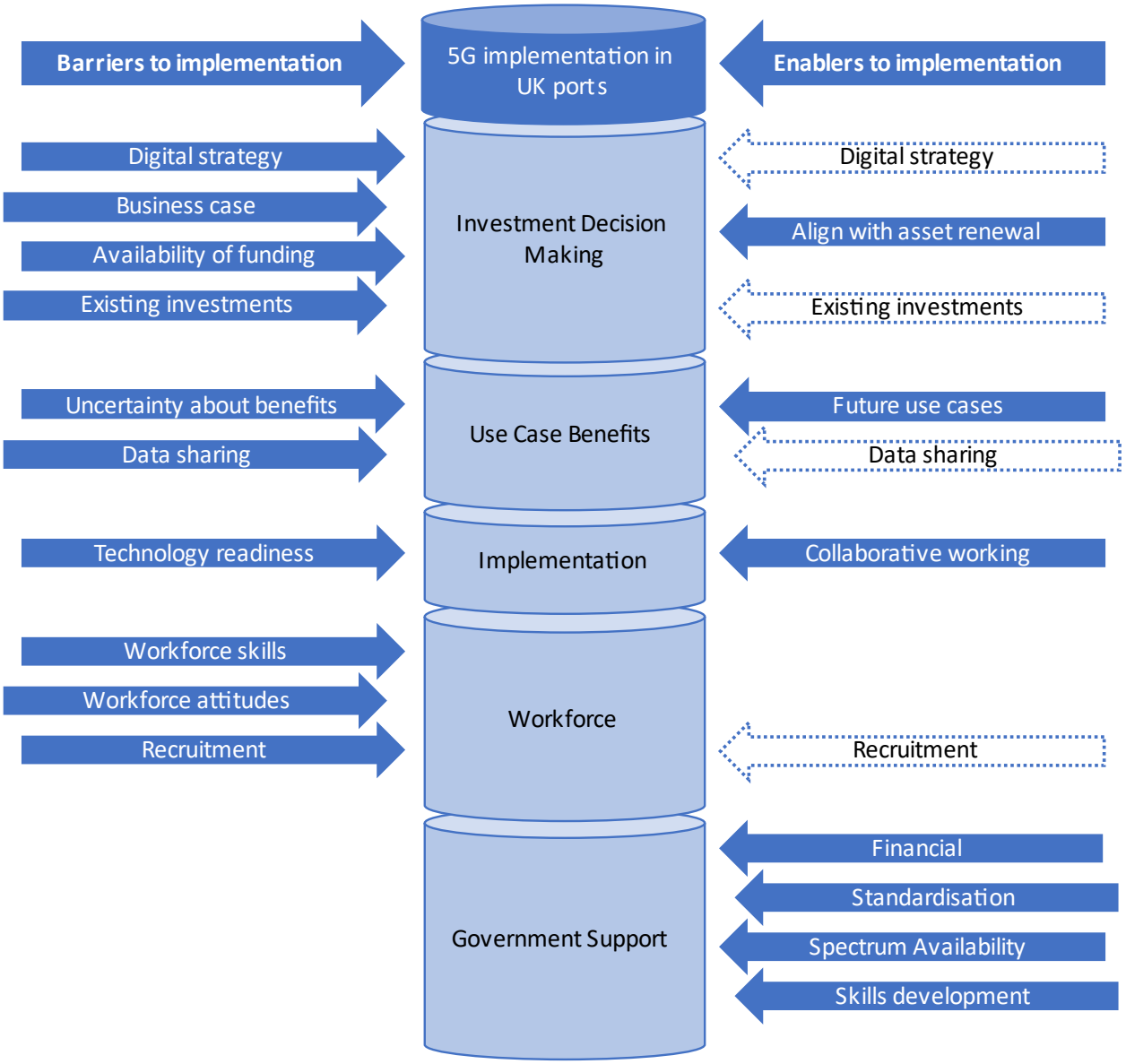


Figure 4: Barriers and enablers to 5G adoption in UK ports

Use case benefits

The other side of any 5G investment decision are the benefits that come from use case introduction. Although many believe ports would benefit from 5G deployment in general, there remains **uncertainty on the benefits** because of the early stage of deployment. Many of the use cases currently being developed are similar to existing systems and therefore the question is what 5G can do differently. It is likely that the biggest monetizable benefits will occur in use cases that improve processes within the ports, and will provide a foundation for H&S and environmental use cases. Multiple use cases are likely to be needed for 5G to be a viable commercial proposition for an individual port. The findings from the 5G Trials and Testbeds programme will be important in reducing the uncertainty for ports.

Seeing the opportunities and benefits that may emerge from **future use cases** is likely to be an enabler in the UK port sector. As one participant observed, investing in 5G is about "building for the future rather than today". Current trials will need to scale up and as use cases get implemented, new opportunities will emerge. The potential for greater coordination in port processes represents a significant opportunity that could be revolutionary if realized.

However, greater coordination is likely to require increased **data sharing** and collaboration. Current mindsets may limit the extent to which this can happen. There remains resistance in the port and logistics sector with data sharing – a common barrier found in other industries too. Thinking is shifting towards a more collaborative culture in the ports' ecosystem, for instance as evidenced by the developments of port community systems around the world.

Implementation

Turning to the implementation of 5G networks, a common observation was that current **technology readiness** was a barrier to wider adoption. Off the shelf solutions are not widely available and, given the complexities of 5G deployment, operators lack confidence that a network can be set up to deliver what is expected. There are also issues with the availability of devices able to connect to 5G networks. Over time, this barrier should reduce as availability improves.

Conversely, **collaborative working** and knowledge sharing between a wide range of stakeholders was seen as an enabler for 5G deployment. This includes network providers, use case developers, government (both national and local) and, particularly for smaller ports, the wider community. In doing so, a better understanding of 5G capabilities and opportunities can be developed, increasing the likelihood of successful deployment. Equally, sharing experiences within the port sector more widely further enhances this.

Workforce

There was much discussion with participants around various workforce issues relating to the deployment of 5G, with three particular barriers emerging: workforce skills, workforce attitudes, and recruitment.

Digitalization within ports has changed the **workforce skills** requirements throughout the port, from offices to the quayside. A substantial proportion of that workforce would not be considered early adopters of new technology, and therefore barriers exist in introducing digital working practices. From the discussions, some ports

have been more successful in this transition than others, providing opportunities for shared learning.

However, deployment requires not just new skills but also changes in **workforce attitudes** towards technology. Existing working practices can be embedded and organisational inertia can be a barrier to digital innovations. Terminology used by technology providers may be poorly understood. There may also be nervousness amongst the workforce that digitalization may lead to job losses. Participants also noted that ports can be highly unionised, and therefore trade unions can play an important role in supporting deployment.

Several issues relating to **recruitment** were also identified. As with other areas of logistics, ports have an aging workforce and one with a high turnover of people. However, attracting new and younger workers to the industry can be challenging as it is perceived as a traditional and manual sector. It may be that opportunities created by 5G, such as automation and virtual reality, may change this perception.

Recruitment to support digitalization is creating new challenges, with roles such as developers now being sought by ports. This is a new employment market for ports, and one where they are competing against employers who may be seen as more attractive due to the nature of work or geographical location. Ports are having to adapt to these new labour markets and changes accelerated by the pandemic, such as hybrid working, can facilitate this.

Government support

Finally, government support was seen as an important enabler in delivering 5G more widely in the UK port sector. The most commonly discussed issue was **financial support** through grants and project funding to reduce the financial risks associated with innovation. Government support enables use cases to be implemented in a test environment, enabling them to reach a technology maturity level from where commercial adoption can take place. It was recognised that financial support can only go so far and there will be a need for the UK port sector to take on more of the financial risk over time, once an appropriate maturity level is reached.

Beyond this, several other areas were identified where government support would benefit the deployment of 5G:

- **Standardisation**: this will be required to enable use cases to work with each other and with existing systems. While government can play a supporting role here, there are also opportunities for port industry bodies to facilitate this.
- **Spectrum availability**: ensuring that ports are able to get licences for private 5G networks in a timely manner.
- **Skills development**: as noted above, workforce issues are a challenge for and government support to people into the ports industry would be welcomed.

One challenge identified with this is where responsibility lies within government departments as the issues cut across a range of responsibilities, and with national, devolved and local administrations.

Conclusions and Recommendations

Digitalisation has influenced the port sector significantly during the past decade. It is clear that the adoption of 5G within the port sector represents the next step in wider digitalization of the industry. The opportunities that it can unlock represent a step change over existing technologies. Therefore, it is essential that the UK port sector expands its use of this technology.

There is a clear appetite for 5G adoption by ports both large and small, with a wide variety of potential use cases being identified. This is despite the industry often being seen as risk averse when it comes to innovation and not wishing to be the first adopters. 5G will bring the capability to handle large volumes of data, connect large numbers of devices and bring a high degree of latency, all critical in enabling port based use cases.

As more ports look to adopt 5G, so a variety of barriers have emerged and these will need to be overcome into the future. However, there is already evidence that some barriers are becoming enablers as the UK port sector increasingly focuses on digitalisation. This will help to accelerate the pace of the transition to 5G.

Based on the findings outlined earlier, the following recommendations are suggested:

- Ports need to identify a portfolio of different use cases with clearly articulated value which link to their overall business strategy. For larger ports, these are likely to be within the port estate and can rely solely on private 5G networks. However, for smaller ports, there may be opportunities from using or providing a public 5G service as well, particularly in more remote areas.
- There needs to be flexibility in the deployment of 5G networks with ports, so that they can adapt and expand over time. It is clear that a 'big bang' approach is challenging to adopt for ports and therefore using technology that has both 4G and 5G capabilities offers a progressive evolution. This applies to both the radio network and the hardware, the latter in particular being a constraint on adoption. This also enables ports to explore different use case possibilities and acquire a deeper understanding of how 5G should be best deployed to maximise its value. This then informs later, large-scale deployments.
- In considering the roll out of public 5G networks, there would be benefits from a faster deployment to more rural areas where ports (and other industries including tourism) may be able to exploit the capabilities offered more quickly, avoiding the lack of 4G coverage and providing access to directly using 5G. This would require a shift from providing coverage based on population centres.
- Adoption of 5G requires a collaborative approach that focuses on processes, technology and people. There is evidence that the first two are already happening successfully in the UK port sector, but people issues remain. In changing workforce attitudes and for the effective upskilling of digital literacy, there is a need to engage with trade unions effectively.
- More generally, the port sector needs to work together in sharing experiences, best practices and learning from 5G deployment, as this will reduce many of the current uncertainties and therefore make the business benefits clearer. This will also help to develop a larger market for use cases and hardware, creating wider benefits

within the market. Port industry trade associations can help to facilitate this.

- Working together across the sector will also be effective in addressing the issues raised around skills and the attractiveness of the industry to new recruits, particularly in new areas of expertise such as IT solution developers. Ports are competing with other industries for this talent and presenting a wider view of the opportunities across the sector will help career pathways to emerge, even if these are across different ports.
- Continued government support is required across the above recommendations. Financial support through initiatives such as the 5G Testbeds and Trials Programme help to offset the risks and can encourage collaborative working. Funding for skills development, such as through Apprenticeships, can help bring in new talent. Beyond financial support, government can also facilitate adoption through planning regulations as well as spectrum standardisation and access. A challenge, however, is bringing together multiple government departments and a UK port strategy could be a means to achieve this, combining digitalization with existing port policy developments such as freeports.

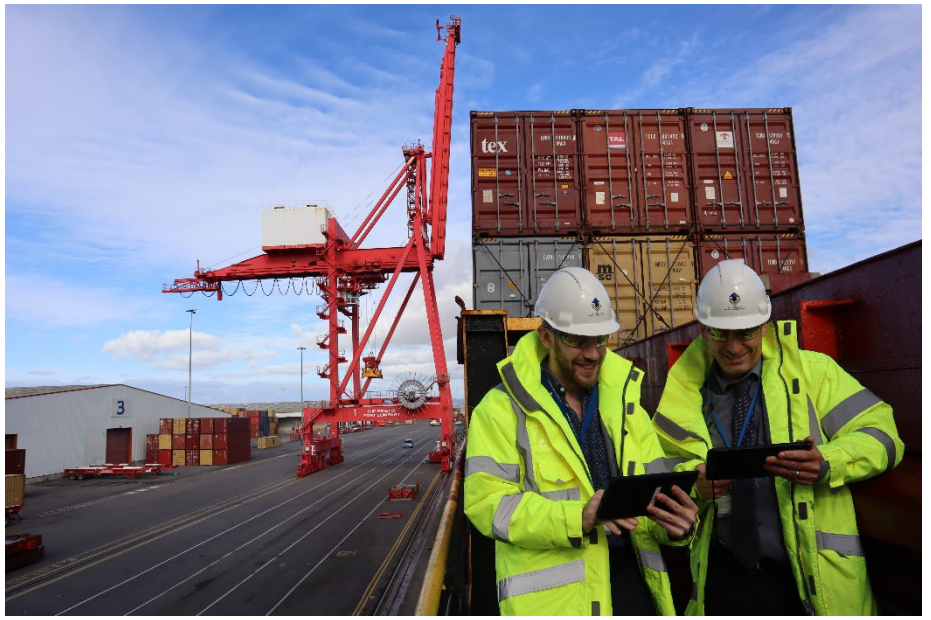


Image credit: The Bristol Port Company