Maritime Technology and Research
https://so04.tci-thaijo.org/index.php/MTR
Research Article

The potential of 5G in commercial shipping

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Article information
Received: February 7, 2021
Revised: April 4, 2021
Accepted: April 7, 2021

Keywords
5G,
Automation,
Autonomous ships,
SMART connectivity,
Unmanned vessels,
COVID-19

Abstract
The buzz about 5G technology has been going on for a few years now. The technology, even before its inception, has had its fair share of controversy, with concerns over its influence on the environment and national security. Recently, some conspiracy theories branded 5G as the primary cause of COVID-19. As the technology develops, one realizes that 5G has many positives and enormous potential in the field of mobile communication. To tap this potential, 5G is being simultaneously developed by many companies globally. Unlike earlier generations of mobile communication, 5G offers numerous benefits when adopted in the maritime domain. Hence, technologically advanced nations are experimenting with the use of 5G in shipping, ports, and shipbuilding. While the understanding of the 5G technology is still at the nascent stage for most of us, this article aims to discuss the potential of 5G in commercial shipping by discussing the pros and cons associated with this technology. The article overall aims to provide a start point for future work and studies on the use of this technology in the maritime industry, and by no means is considered a 'one-stop' solution to the problems of commercial shipping.

1. Introduction

The shipping industry is the oldest mode of transportation known to humanity. However, this industry has not been able to achieve its full economic potential due to a variety of reasons that are diverse and cover a large spectrum of issues that vary from the vagaries of Mother Nature at one end to simple human errors at the other. In order to minimize the impact of these issues, various technological advancements, such as the mechanization of ships, automation, GPS navigation, the use of advanced materials, and protective marine paints have been made over the years to become a part of the industry. Such technological advancements, and many more, have allowed greater exploitation of ships in harsh weather conditions, with poor visibility, for longer durations, in restricted space, and with hazardous cargo, all without compromising the safety of both men or material at sea. While the shipping industry has been slow to adopt these disruptive technologies, owing to their high costs, the same industry has seen an improvement in its revenue generation every time a new technological advancement has been adopted (IHS Markit, 2020).

Today, ships are no more 'independent', 'forgotten', 'left to themselves', or 'responsible for their upkeep and maintenance at sea' entities, but part of the 'complex network of global cargo movement' that operates seamlessly on the seas as one of the most important modes of

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transportation, moving nearly 80 % of the global trade by volume, and nearly 70 % by value (UNCTAD, 2018).

All these developments have been possible as a result of advancements in science and technology, especially in the field of electronics and communication, that have changed the way ships operate. This has brought us to a point wherein complete automation, both on and off the ship, is looming large to become a reality. One such area of advancement that is changing all this is the field of 'connectivity', which has the potential of enabling other emerging technologies by providing unhindered, faster, and high-quality data and voice communication with low latency periods. Like earlier instances, the use of this disruptive technology will help the shipping industry to realize some of its unrealized economic potential.

So far, the shipping industry has relied on wired connectivity of ship-borne electronics for safety and reliability. This form of wired connectivity, while being safe and reliable, cannot be supported remotely, thereby necessitating a need for greater human involvement in ship operations, making the entire process slow, inefficient, time consuming, prone to errors and, at times, unsafe for the operator itself. In addition, such wired connectivity has disallowed percolation of automation into the shipping industry, thereby keeping the industry devoid of the possible economic gains. Today, advanced technologies like 5G are helping the industry to migrate from wired to a completely wireless connectivity and create a much safer working environment for the operator through higher automation. It is now possible to connect equipment within a ship without a maze of wires. Providing 'virtual' access of ship-borne equipment to maintenance teams in harbor for defect monitoring and analysis is no more a dream, and neither is monitoring the health of cargo onboard at sea in real-time from anywhere in the world. Similarly, it has become simpler to avoid accidents in restricted waters, with all this made possible because of technologies such as 5G. Such disruptive technological evolution is helping to revolutionize the global shipping sector and, hence, global trade by cutting down on both transit and port time due to improved navigation systems and efficient cargo handling systems in ports. This will, in the long term, be extremely beneficial for the shipping sector, to help cut down shipping emissions palpably and achieve decarbonizing of the shipping industry to a great extent (Agarwala, 2020).

So, what is this 5G that is set to change the maritime domain to an extent that has not been witnessed so far? Can this 5G really bring automation to the shipping industry? How will 5G change the working in and with the shipping industry in the future? What are the areas in the shipping industry that will see the change? Questions such as these, and many more, are what is intended to be addressed in this article.

Accordingly, in order to address these, and many other unknowns, the article will begin by providing a brief historical background of the major technological developments that have occurred in the shipping industry, before explaining what 5G technology is. It will then discuss the potential this technology has in the commercial shipping industry by analyzing its envisaged applications. Having discussed the potential, the article will then discuss the advantages accruedand the pitfalls that are likely to be encountered by the commercial shipping industry if this technology is used.

2. Background

Even though the shipping industry has been slow to adopt technological advancements, it has maintained a steady pace since after the first Industrial Revolution, but with a consistent lag with their terrestrial counterparts. The steam engine that was developed as part of the First Industrial Revolution in the 1700s and experimented on small inland crafts was used effectively on ocean going ships only after the 1850s (Lovland, 2007). This opened the doors for further mechanization of ships, and advancements in communication technology for better communication between Owners, Charterers, and the Master (North, 1958). Developments of the 1900s were adequately supported by the development of metallurgy to help strengthen ocean going ships and increase their carrying capacity and speed (Harley, 1988). Next to follow was the use of electric power onboard ships as part of the Second Industrial Revolution (Skjong et al., 2015). The World Wars to follow helped develop electric propulsion systems on ships (Paul, 2020) and power system solutions due to varying power requirement by various electronic systems onboard. Since then, technological developments have moved at a blistering pace, improving navigation, communication, and safety by leaps and bounds to help save the lives of hundreds of seafarers as part of the Third Industrial Revolution.

As technology developed, studies showed that the future technological developments that would shape the future of the commercial shipping industry would either be driven by internal competition or by adopting already existing mature technology from other sectors (GMTT2030, 2015). Accordingly, the Fourth Industrial Revolution to follow began building on the Third Industrial Revolution by blurring the lines between physical, digital, and biological spheres. As a result, many of the disruptive technologies that are being developed by other sectors as part of the Fourth Industrial Revolution, such as Artificial Intelligence (AI), Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Blockchain technologies, and many more, as seen in **Figure 1**, and which are anchored in the digital domain, are likely to have a major impact in defining the future of commercial shipping. While some of these technologies have a direct use for activities on a ship, such as monitoring onboard equipment, identifying and predicting potential issues, remote operations, movement of ships, etc., others are primarily of use as a link between ships and the shore for better logistic management and secure financial transactions. However, what remains common between these and all the digital disruptive technologies being developed is that they all need high data speeds with high latency to be effective. Realizing the need for greater data speeds and latency, and the limitation of the existing wired connections on ships, 5G technology is being developed which will eventually be the backbone for all data transfers and seamless operations. It thus becomes essential that we understand what 5G technology is and the potential it has for revolutionizing the commercial shipping industry.

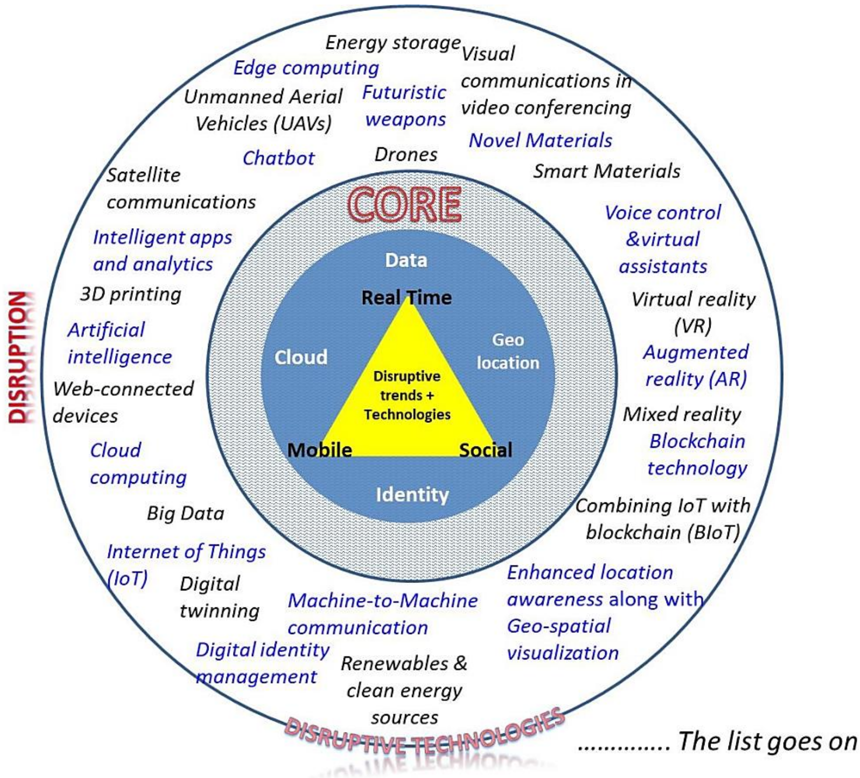

Figure 1 Some disruptive technologies specific to the maritime domain (Source: Agarwala, 2021).

3. Understanding 5G

5G is the fifth generation of mobile technology and is super-fast. It can achieve multi-Gbps (Gigabytes per second) data speeds with ultra-low latency (time required to deliver a data package) by using higher frequencies of electromagnetic waves when compared to the fourth generation (4G). This feature provides networks with greater reliability and availability, along with a massive designed capacity to deliver data at a rate of 20 Gbps and downloads at 7.5 Gbps. In addition, the connection density (the number of devices that can be connected simultaneously in a square kilometer) for 5G is much higher than that of 4G, at close to a million as against a mere 100,000 for 4G (Notwell, 2017). The enhanced capacity with low latency allows for a much greater uniform user experience, with limited loss of signal. This thus allows for enhanced connectivity between people and things (machines, objects, and devices), making ‘smart’ functions, such as autonomous vehicles, virtual reality, augmented reality, etc., feasible. In return, it helps establish greater autonomous activities, with efficiency and sustainability at its core. **Figure 2** shows the multifaceted dimensions 5G aims to address.

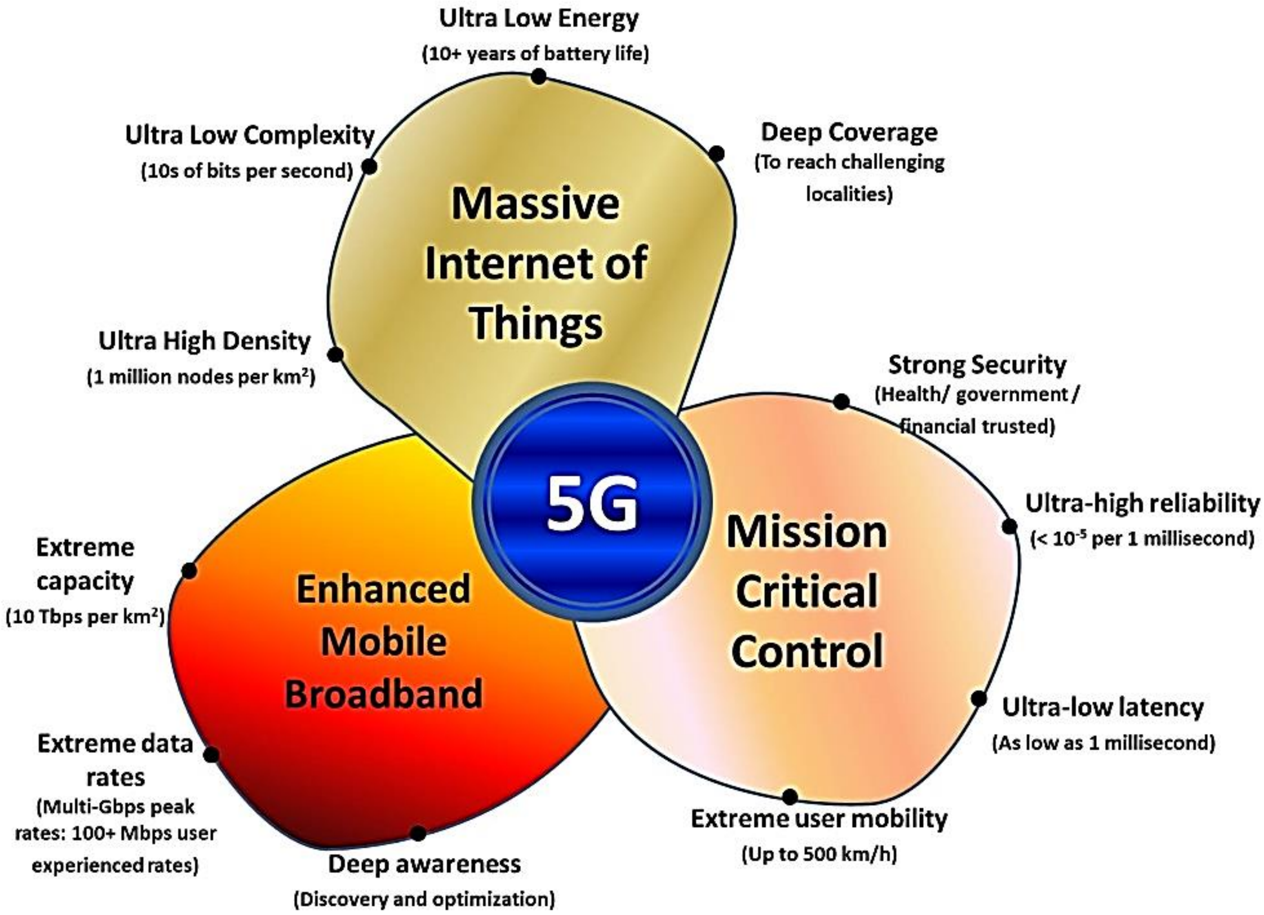

Figure 2 Multiple facets 5G will address (adapted from Qualcomm, 2016).

Since 5G is still developing, a variety of versions are available. These include the low-band (frequencies below 1 GHz); the mid-band (frequencies 1 - 10 GHz); and the high-band (frequencies between 20 - 100 GHz). All these are incompatible and perform differently from each other. Of these, the low- and mid-bands have been used by earlier generations of connectivity and are now being used by 5G with limited success. The high-band has not been used so far, due to the non-availability of miniaturized antennas and hand-held power processing devices. With the availability of these devices becoming common, they can now be used for providing high speeds and greater bandwidth. This requires the use of many smaller, lower power base (2 - 10 Watt) units in place of the earlier 20 - 40 Watt units. These smaller base units, using a more efficient coding OFDM (Orthogonal frequency-division multiplexing), are able to provide 30 % better speeds in the larger bandwidth that is available.

5G technology did not evolve overnight. As the word indicates, it is the fifth-generation wireless technology. 1G delivered analogue voice, 2G introduced digital voice and SMS, 3G allowed the availability of data and, hence, web browsing to be added by bringing data speeds from 200 kbps to a few Mbps, and 4G brought in broadband data, with speeds to a few hundred Mbps much greater than 3G. Now, 5G is aimed at providing enhanced mobile broadband that can support digitalization[†] through the use of VR (Virtual Reality), AR (Augmented Reality), AI (Artificial Intelligence), IoT (Internet of Things), critical IoT (which includes wireless control of industrial processes, remote medical surgery, automation of a smart grid, transportation safety, etc.), and many more. In addition, 5G has the capability to connect to a number of devices simultaneously, due to the available bigger channel and lower latency.

4. 5G in the Shipping Industry

Such developments indicate the potential usage of 5G in the commercial shipping sector. While logistics handling and surveillance have a larger role to play in harbors and port areas, 5G also has a huge potential in applications onboard vessels in transit. However, to limit the scope of this article and avoid it from becoming unwieldy, due to the vast scope wherein 5G can be exploited, we limit the scope of this article to just commercial shipping, and not its utilization in ports and harbors.

It is important to mention that commercial ships are floating platforms that move or are geo-spatially positioned while being electronically and technologically complex. They function as floating cities, with all the necessary amenities available to the crew onboard. Accordingly, to execute the basic principles of ‘float’, ‘move’, and ‘perform’, a number of electronics are used. The use of these electronics onboard ships is in line with the advancement in technology available, so as to make the life of the seafarer simpler while maximizing profits by lean manning, thanks to automation. Since electronics have the ability to ‘speak to each other’, if configured with the right generation of technology, most of the onboard electronics can be connected to a single console that may either be manned on the platform itself or be remotely accessed by operators and maintainers from their offices on land. It is here wherein the use of 5G technology for floating platforms can be, and is being, experimented with.

While technologies such as 5G will eventually change the way we communicate, work, think, operate, and do our business, it will also provide avenues for increased revenue from new sources with reduced operational cost. As bonding and dependence with the virtual world increases, remaining disconnected for long is unacceptable. Guests on cruise ships want to be online to share their joy with others, read about the next port of call, connect with their loved ones, watch online and OTT (over-the-top) content, etc. (Norli, 2019). All this has so far been possible with the internet being made accessible on ships at sea using cellular services at sea. 5G technology is now helping enhance this experience and making it seamless (Lund, 2019).

It is imperative to mention that, though disruptive technologies such as 5G can be experimented with, their actual use, however, requires enabling rules and regulations based on international governance in line with the currently accepted norms. Since this technology has the

[†] *Digitization* and *digitalization* are different terms that are mistakenly used as synonyms. *Digitization* means taking analogue information and encoding it into binary format (using *zeroes* and *ones*), so that computers can store, process, and transmit such information, whereas *digitalization* is an ambiguous term, which means a way in which many social domains are structured or restructured around digital communication and media infrastructure.

ability to change communication between person to person, person to machine, and machine to machine, these rules are considered essential (Agarwala, 2021).

It is important to mention that, since the 5G technology is still in the nascent stages of development, it is primarily being experimented with on the shore by Logistics Service Providers (LSP) and by some 'smart' ports across the world (Port of Hamburg, Port of Singapore, Port of Hamburg, Port of Shanghai, Port of Los Angeles, etc.) for material handling and financial transactions, with limited experimentation of this technology on ships. In recent years the use of this technology in 'smart' ports has increased and has been used for activities such as remote pilotage, video surveillance, and remote control of cargo handling facilities to address labor issues such as the availability of trained manpower and harsh working conditions. However, the use of 5G in ports is considered beyond the scope of this article and will not be discussed any further. This said, in order to support greater port efficiency, some of the LSPs have been experimenting with equipping containers with IoT capabilities to monitor goods in transit and for better handling when in harbor. One such company, CMA CGM, a French container carrier company, is investing in furthering such smart containers. With numerous containers on a ship, the need for 5G technology to support such proliferation of connected devices is considered essential, as this cannot be handled by the currently-used 4G/ LTE technology. Such efforts by the LSPs will ensure a speedy implementation and utilization of 5G on ships.

This notwithstanding, the use of 5G technology on commercial shipping platforms is possible in numerous fields, and can be broadly broken down into various sectors, as seen in **Figure 3**. Let us look at each of these sectors to get a flavor of how commercial shipping is set to change in the future due to this disruptive technology.

Figure 3 Areas of use of 5G in commercial shipping (Source: Authors).

4.1 Engineering

Ships, like any other mode of transport, need power for propulsion and for other ancillary equipment, making engines an integral part of a ship. In earlier times, these engines were 'fed' with fuel (coal) manually. As times changed, and diesel engines were introduced, the number of people required in the engine-room department reduced. However, since the engines and their ancillaries, including sensors, had moving parts, manual intervention for the recording of reading and maintenance was essential. Over time, this need, too, was circumvented by the introduction of electronic sensors and higher electronic components. This allowed remote operations and monitoring of engineering equipment from areas away from the engine room, and at times away from the bridge itself.

Though *remote operations* have been an integral part of commercial ships for many years now, with the availability of 5G, the number of devices that can be simultaneously connected is on the rise. Furthermore, with higher latency available, the reliability of these connected devices has increased.

The other usage area of 5G in engineering is that it now allows the engineering components of a ship to be connected to the shore, where maintenance teams can undertake designing, prototyping, and predictive analysis of the ship components in a cost-effective manner. Such an analysis is possible by creating virtual replicas of physical entities on board called *digital twins* (Shaw & Fruhlinger, 2019). These replicas allow the collection of data from physical systems using smart sensor components that are enabled by cloud-based technologies that are now possible to be used on ships due to the availability of 5G technology (Spirent, 2019).

Digital twins also permit the testing of complex systems where physical access was earlier restricted. By monitoring the performance of critical components, such as engines, rudders, propellers, control systems, hull integrity, etc., and with designers and component manufacturers having access to the real-time data of a component, an early diagnosis of an emerging problem is possible, along with efficient inspection and scheduled maintenance operations (DNV-GL, 2019; Ship Technology, 2017). On the operational side, this would help reduce down-time, reduce onboard manpower, reduce the maintenance costs of moving original equipment manufacturer (OEM) representatives, and provide better logistic management for spare ordering and delivery by ship-owners. On the design side, such digital twins will help improve the design of shipboard engineering components and address recurring technical issues in follow-on designs. In the long run, confidence in digital twins will help in the realization of fully autonomous ships (Safety4Sea, 2019), and all this is possible with the availability and use of 5G technology on board ships.

4.2 Safety

Cargo safety is an integral and important part of commercial shipping. This, in turn, is directly associated with vessel safety, which is related to the trim and ballast management system to ensure the immersion of the propeller and to ensure hull girder flexure. This aspect assumes higher importance due to the Ballast Water Management (BWM) Convention and Guidelines of IMO (MEPC 72) (IMO, 2019). Accordingly, through a continuous monitoring system both by operators and regulators, the appropriate enforcing of BWM guidelines would be adhered to, which is possible using 5G enabled clouds. Furthermore, in heavy seas, using 5G-enabled ballast management systems that are autonomous, a higher and more accurate control of BWM can be achieved, thereby ensuring higher structural safety of a ship. As automation progresses, and ships become autonomous, the need for ballast would reduce, as the space available will be better utilized for cargo rather than for living spaces. This would reduce the requirement of compensating ballast but would increase the need for timely and limited ballast to ensure both structural flexure of the hull girder and stability of the ship (Hurst, 2017), thereby increasing the dependency on technologies such as 5G for automatic control.

4.3 Autonomous shipping

Typically, crew cost constitutes 30 % of the operational cost of vessels. Autonomous vessels offer the possibility to cut these costs entirely. Therefore, autonomous shipping and digitalization in the maritime transportation sector using Internet of Things (IoT) sensors enabled by 5G makes great economic sense (CB Insights, 2018). Using maritime 5G, ships can be remotely controlled from shore by operators both for navigation and for maintenance, thereby reducing the cost of having a crew on board at sea (Onag, 2019). Such automation would help in better fuel optimization, safer navigation, reduced marine accidents, and saving human life from the perils of the sea. In addition, maritime 5G can be used in remote operations and during search-and-rescue operations for real-time communications and accurate positioning. This said, all this would be feasible at sea only with the requisite supporting rules and regulations by the IMO, which currently are still being debated (Riviera, 2019), as the areas of concern are numerous (Safety4Sea, 2019a) and with little unanimity.

4.4 Communication

Maritime communication is one of the principal areas that will benefit immensely from the adoption of 5G and related technologies. Ships currently use the maritime ‘Very Small-Aperture Terminal’ (VSAT) (Mobilsat, 2019) satellite enabled system and the International Maritime Satellite (INMARSAT [date unknown]) system for voice and data communication. With the future deployment of 5G satellites in space, maritime communication is likely to undergo a significant transformation (Safety4Sea, 2019b).

As of today, the VSAT and the INMARSAT provide the required communication bandwidth at sea, with the network speeds limited to a few hundred kbps. However, as digitalization is increasing on floating platforms, communication at sea is likely to witness a demand for high-speed data transfer to collect data from vessel-mounted sensors and provide ‘video on demand’ for training and maintenance purposes. Such demand can be supported only by 5G technology, with its higher data transfer rates and latency. By deploying satellites in low earth orbits (500 to 2,000 kilometers) this requirement can be met by maneuvering the satellites in a coordinated manner to achieve data transfer rates of close to 1 Gbps (Orange, 2019).

4.5 Navigation and Maneuvering

The UNFCC Paris Agreement has set an ambitious target of limiting the global temperature rise to ‘below 2 °C’ by 2050. Accordingly, the IMO has mandated GHG emission reduction by ships to 50 % by 2050, with a reduction of CO_2 emissions by 40 % by 2030, and 70 % by 2050 (Agarwala, 2020). In order to achieve these targets, the World Shipping Council (WSC) has recommended a reduction of speeds by ships at sea to reduce emissions. Similarly, to improve the regulations for emissions, the IMO has mandated the collection of emission data by ships. Both these requirements can be conveniently met by using automation and sensors using 5G-enabled cloud services that can be monitored from shore. Such data will enable shipping companies to guide captains and chief engineers in real-time to choose the most fuel-efficient route, as well as in identifying optimal speeds and engine configuration along each leg of the journey (Hannemann, 2019).

Developing the use of 5G for autonomous navigation; an autonomous navigation platform that allows ships to set a course to a destination on their own using a Lidar (Light detection and ranging) sensor connected to a 5G network has been developed by SK Telecom and Samsung Heavy Industries (Manners, 2019). Though presently used on a 3.3-metre long-ship, it shows the feasibility of using 5G for autonomous navigation. Similarly, Super Radio, a start-up in Norway, and Telia Norge AS are working on using LTE, Wi-Fi, and 5G massive MIMO[‡] communications to prevent collisions and enable smooth operations both at sea and in harbor (Buckholm, 2019). Since

[‡] Multi-input and Multi-output

5G is being used, the data available will be real-time and will enable quicker communication due to shortened latency periods.

4.6 Cargo handling

In order to improve the efficiency of commercial shipping, cargo handling both on ship and in port needs to be made more efficient. Such an efficiency improvement on board would reduce the level of fuel consumption and, hence, ship emissions, thereby reducing operating cost for the owner. Furthermore, while the ship is in operation, factors such as longitudinal/transverse hull strength monitoring, loaded mass and discharged mass using draught survey method, liquid level reading of cargo, monitoring temperature and humidity of cargo and refrigerated space and containers, and monitoring of load forces and strain on ship stacking system can be undertaken using 5G-enabled sensors to ensure both the seaworthiness of the ship and the worthiness of the cargo being carried (Remella, 2019).

Another area where 5G can be used for cargo handling is by establishing communication with the port prior to arrival for the loading and unloading manifest to allow the team on board to be prepared for quick and planned unloading and loading, thereby reducing time in harbor and, hence, increasing the availability of the ship to the owners (The Maritime Executive, 2019).

4.7 Cargo monitoring

Today, cargo moves mostly in containers. Currently, some of these containers carrying critical cargo may be provided with sensors or refrigeration that are monitored and controlled by the ship's crew while the owner of the cargo remains oblivious of the state of the cargo until it reaches its destination. With the availability of 5G, this is likely to change, as real-time monitoring and managing of the cargo in transit will now be possible by creating private IoT networks, with 5G as the backbone. These networks can then be connected via satellites for offshore connectivity and shore-based networks when in range (Telecom26, 2019). This would provide updates on temperature, humidity, and 'g' forces on goods to allow corrective actions to be taken if needed and insurance claims to be made (Wheeler, 2020).

4.8 Cellular services at sea

Until the early 1980s, the sailor at sea could not use his/her cell phone, as there was no cellular service available at sea. To cater for the growing 'cruise tourism' market, and to ensure that guests are connected while at sea, 'cruise line packages' were made available to guests using their own cell phones. With the needs of guests at sea increasing from mere mail and telephony to data sharing, chats, OTT, and movie watching, to name a few, the need for higher bandwidth and higher speeds are becoming essential. In order to meet this requirement, 5G technology provides a suitable way ahead by allowing cellular, IoT, and Wi-Fi systems to work simultaneously (Gibson, 2017).

4.9 Training

Training of the existing workforce and new blood to handle future operations is as important as the actual operation of ships at sea. As technology advances, and technological changes evolve on board ships, it is essential that the man-on-the-ground is made familiar and comfortable with the new equipment before being put at sea to minimize marine disasters. Virtual training platforms using immersive environment technologies such as VR and AR are being used for training both, existing and future engineers and crew alike. Such platforms use 5G technology to exploit the advantages of latency-free, real-time, high speed, data transfer and immersive user interaction. Several such virtual training sessions have been conducted over the last couple of years as technology demonstrators and have proven 5G technology as a reliable method of training. These technology demonstrator sessions involved aspects such as Maritime Safety Education using VR

Technology (MarSEVR), Ship Engine Safety Education VR (ShipSEVR), and Crane Simulator and Fire Safety On Board (Markopoulos & Luimula, 2020).

5. Downside of 5G in commercial shipping

In the preceding discussion, we have seen the various avenues where 5G can be used in the shipping industry and the changes it is set to unleash in the world of shipping. However, there are some downsides that one needs to be aware of to understand the full potential of this technology. These include:

(a) 5G technology is currently in its nascent stages of development and has not reached the scale where it can run optimally. It is believed that it should be ready in another 2 years for utilization (Pyzyk, 2020). Hence, in the present state, the use of this technology needs to be done with caution.

(b) Lack of legislation is another area that plagues the optimal use of this technology commercially. As mentioned earlier, regulations and legislation for disruptive technologies such as 5G have always lagged the implementation for various reasons (Agarwala, 2021). However, we firmly believe that, without appropriate legislation, the optimal usage and development of this technology cannot be achieved.

(c) Lack of expertise in handling this technology by countries that procure it may have serious implications on maritime cybersecurity (Wheeler & Simpson, 2019) for these nations.

(d) Greater reliability of wireless communication such as 5G leads to a higher risk of cyberattacks. Such attacks can affect food supply chains; cripple port operations, including entry and leaving harbor, and loading and unloading of cargo; and risk the safety of vessels at sea and in harbor, to name a few. It is, hence, essential that necessary precautions are taken and the hardening of systems is ensured so as to ensure a safer working environment (HelpNetSecurity, 2019). It is essential to mention that cybersecurity gains further significance considering the emergence of autonomous shipping and unmanned vessels (Tam & Jones, 2018). A cyberattack on such vessels can inflict damage on other vessels at sea, result in the loss of life and environment, and could be the new era of 'piracy at sea', causing unprecedented losses to shipping companies and marine ecosystems (Tam & Jones, 2018).

(e) The associated cost of 5G is expected to be high, especially when an overhaul of the existing 4G network infrastructure is required for upgradation (Vallis, 2020). This cost will have to be borne by the shipping industry, a not-so-desirable expenditure in these hard times of low margins of profit (Kawadkar, 2019).

6. The way ahead

From the foregoing discussion, it is clear that advancements in 5G are all set to change the way commercial shipping has been operating to date. This said, it is critical to understand that, if the shipping industry needs to depend on 5G technology, then it needs to look at interoperability to cater for redundancies. This is to ensure that, if one system fails due to technical reasons or physical fault, the safety of the vessels and the cargo is not compromised. This essentially requires that the basic architecture of the equipment being used needs to be based preferably on 'open architecture', rather than the legacy customized and locked system.

It goes without saying that 5G in commercial shipping will become a reality only when the associated technology is considered adequately matured for use. This is keeping in mind the fact that the shipping industry is more of a follower than a leader in the use of technology due to the associated cost of deployment and the need for regulations before the implementation of new technology. With the 'Sulphur Cap 2020' and the need for 'decarbonizing ships by 2030' looming large on the horizon for the industry, expenditure for a transition to 5G is hard to come by, especially in a market that has limited profit margins. However, with the LSPs pushing the use of 5G on containers to monitor them and improve logistic control of these containers, which eventually makes 5G essential onboard ships, it is only a matter of time before 5G, at least in a limited form, will be forced on commercial shipping.

While 5G will make automation a reality, it will make cyberattacks easier if due care is not taken. It is a known fact that the dark world of cyber has always been one step ahead of developers. It is, hence, essential that continuous efforts to harden the system are made to ensure that the possible damage due to cyberattacks is kept to a minimum. An important step towards this is to train adequate human resources to handle these systems and the resulting eventualities to follow.

All this notwithstanding, what is certain is the fact that innovations and experiments for the use of 5G in shipping are here to stay. With 5G already making positive inroads in both ports and shipbuilding, it is only a matter of time before we see the implementation and full utilization of 5G in shipping.

7. Conclusions

In this article, we have seen that 5G is a next generation communication technology that offers a high rate of data transfer, low latency, and simultaneous connection of far more devices than what the earlier generation technologies allowed. Such advantages make 5G a technology with high potential for use in the maritime sector, from which the industry can immensely benefit in a number of areas. The article has primarily focused on the use of 5G in the shipping industry. In doing so, one realizes the possible benefits that can be achieved by using 5G in the improvement of the design of ships and equipment, their safer operations, both at sea and in harbor, easier preventive maintenance, and better logistic management of spares and cargo by the operators, regulators, and the owners.

With the use of 5G in commercial shipping, ships will experience changes in automation, communication, maintenance, operation, navigation, and the human experience at sea. Use of this technology will help achieve the emergence of autonomous or remotely operated vessels which are the future of shipping.

Despite the advantages expected, there are downsides to adopting 5G, as the technology is still in its formative phase. The most obvious of these risks is that of cyberattack that can affect food supply chains; cripple port operations, including entry and leaving harbor, and loading and unloading of cargo; and risk the safety of vessels at sea and in harbor, to name a few, and become the new definition of ‘piracy at sea’, causing financial and human loss. It is, hence, essential that, while we exploit the ‘benefits’ of the new technology, we are also aware of the ‘ills’ of the new technology, in order to be better prepared. Such a preparedness demands proactive policy making and training of human resources to meet the challenges of the future.

Since 5G is still in the development stage, and the commercial shipping industry is known to be ‘reactive’ rather than being ‘proactive’ in terms of technology implementation, the actual use of 5G in the commercial shipping industry in a big way is still a distant dream. However, there is no denying that 5G will have a major role to play in future commercial shipping, both in operations and in the transition of the sector to reduced carbon emissions.

The article is an effort to apprise the reader of the potential that 5G has in commercial shipping. It by no means provides a complete canvas of what 5G can or cannot do, but only acts as a stepping stone for future research for incorporating 5G in commercial shipping. Similarly, it by no means tries to project 5G as a ‘one-stop’ technology that will resolve all the ills being faced by the commercial shipping sector to make it more productive or economical, as there are some known ills, as have been discussed, as well as those that are unknown and waiting in the fold to emerge as the use of 5G increases.

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