International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 9 Issue 3, May-Jun 2025 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Emerging Technologies in Maritime Industry

Matthew N. O. Sadiku[1], Paul A. Adekunte[2], Janet O. Sadiku[3]

[1]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2]International Institute of Professional Security, Lagos, Nigeria
[3]Juliana King University, Houston, TX, USA

ABSTRACT

Technology is in almost every sphere of human life; it is present also in the maritime industry. Emerging technologies are revolutionizing the maritime industry, focusing on automation, data analytics, and sustainable practices. The rapid growth of emerging technological innovations is shaping the future of the global maritime industry to its next stage of challenges. We are looking at the integration of existing IT assets (such as cloud, mobility, Internet of things, data analytics, and automation) with systems on board vessels and ashore that drive efficiencies, improve operations, and create savings across all organizations and business in the maritime sector. This paper provides insight into potential future developments for several emerging technologies set to revolutionize the maritime industry.

KEYWORDS: *technology, emerging technologies, maritime industry, marine industry*

How to cite this paper: Matthew N. O. Sadiku | Paul A. Adekunte | Janet O. Sadiku "Emerging Technologies in Maritime Industry" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-9 | Issue-3, June 2025, pp.950-959, URL: www.ijtsrd.com/papers/ijtsrd88493.pdf

IJTSRD88493

INTRODUCTION

The maritime industry encompasses all activities related to ships, shipping, and the oceans, including transport, logistics, and related sectors like shipbuilding, fishing, and offshore energy. It plays a crucial role in global trade and transportation, moving a significant portion of international cargo. The terms "marine industry" and "maritime industry" are closely related but have subtle distinctions. Marine industry generally refers to the sector that directly involves the sea and its resources, including fishing, aquaculture, and marine research. Maritime industry, on the other hand, is broader and encompasses all activities related to seafaring, shipping, trade, and the legal framework surrounding these activities. The recent times saw the entrance of some new technologies across the industry and few others are on their way to transform the operations of the maritime sector

The maritime industry stands as a critical artery in the body of global trade, facilitating the movement of goods across continents with efficiency and reliability. It is the backbone of global trade and commerce, carrying over 90% of goods of all types across the world. It has witnessed significant technological innovations, leading to a ripple effect across the entire supply chain. Digital platforms for ship and cargo tracking, as well as the implementation of digital communication and collaboration tools, have become commonplace in the industry. In general, ships are massive, as typically shown in Figure 1 [1], and they follow routes that are pre-set and have been determined based on several input data. Considering the long periods that ships remain at sea, and the possibility that ocean conditions can vary drastically over the matter of a few hours, it is important that real-time data is available for ship operators to use. Faced with mounting compliance challenges and ever stricter rating criteria, vessel owners are challenged to operate more efficiently. However, traditional methods are unlikely to keep pace with the increased regulatory requirements. This has the maritime industry increasingly looking to emerging technology for game-changing ways of optimizing performance for individual vessels and entire fleets. To take a more proactive approach, vessel owners are challenged to

leverage automation and machine learning algorithms to get faster and deeper insights [2].

WHAT ARE EMERGING TECHNOLOGIES?

Technology may be regarded as a collection of systems designed to perform some function. It can help alleviate some of the challenges facing business today. Emerging technology is a term generally used to describe new technology. The term often refers to technologies currently developing or expected to be available within the next five to ten years. Any imminent, but not fully realized, technological innovations will have some impact on the status quo.

Emerging technologies are shaping our societies. They continue to affect the way we live, work, and interact with one another. Emerging technology (ET) lacks a consensus on what classifies them as "emergent." It is a relative term because one may see a technology as emerging and others may not see it the same way. It is a term that is often used to describe a new technology. A technology is still emerging if it is not yet a "must-have" [3]. An emerging technology is the one that holds the promise of creating a new economic engine and is trans-industrial. ET is used in different areas such as media, healthcare, business, science, education, or defense.

The characteristics of emerging technologies include the following [4]:

- *Novelty:* Emerging technologies are typically new or novel, meaning they have yet to be widely adopted or used. They often represent a significant departure from existing technologies or processes.
- *Potential for Disruption:* Emerging technologies have the potential to disrupt existing markets, industries, or ways of doing things. They may also displace existing businesses or industries.
- *Uncertainty:* Because emerging technologies are still in the early stages of development, there is often a high uncertainty surrounding their future potential and impact. It can be challenging to predict how they will evolve.
- *Rapid Change:* Emerging technologies often evolve rapidly, with new developments and innovations emerging frequently. It can make keeping up with the latest trends and advancements challenging.
- *Interdisciplinary*: Emerging technologies often involve multiple disciplines or fields of study, such as computer science, engineering, and biology. They may require collaboration across different fields and industries to develop their potential fully.

Emerging technologies are worth investigating. They are responsible for developing new products or devices. As emerging technologies continue to evolve, engineering is poised for a transformative future. Emerging technologies have driven innovation and progress in today's rapidly evolving digital landscape. The collective impact of emerging technologies such as artificial intelligence, machine learning, big data, and the Internet of things is undeniably transformative. Some emerging technologies are shown in Figure 2 [5].

EMERGING TECHNOLOGIES IN MEDIA & ENTERTAINMENT

The maritime industry is experiencing a significant transformation driven by emerging technologies in ocean freight. These innovations are revolutionizing various aspects of ocean freight operations, enhancing efficiency, safety, and sustainability. The emerging technology trends are depicted in Figure 3 [6]. Common emerging technologies in maritime industry include the following [7-10]:

1. *Artificial Intelligence:* Artificial Intelligence (AI) has the potential to end repetitive tasks and improve the quality of the shipping industry. As the shipping industry is under a big transformation at a global level, artificial intelligence is already making things easier by seamlessly integrating new shipping logistics and communication technology to evolve the business model within the shipping industry. Artificial intelligence helps with route optimization, safety, decision-making and automation. AI also helps distribute goods between hundreds of vessels passing through ports and avoids traffic.

In addition, with the help of new algorithms, the shipping industry can fully rely on AI for mitigating security risks and reduce the cost of operations to a great extent. It is predicted that, by 2040, AI applications will affect almost every aspect of life.

2. *Robotics:* Robots are creating new waves in almost every industry. In this new generation, robots are adding a new magnitude to the modern world with its presence and efficiency while simultaneously cutting cost and mitigating safety concerns. In the coming days, we can expect the use of robots in commercial shipping for two main purposes: for handling assets, and for inspection and maintenance of the environments which are not safe for humans. Along with robots, we may also see the evolution and development of sensors and remote control technologies and their effective implications so as to reduce human interaction. One such robot that has fascinated and attracted everyone's attention is the

Shipboard Autonomous Fire Fighting Robots (SAFFiR) created by the Naval Research Laboratory in collaboration with the Virginia Tech and other US universities. It is shown in Figure 4 [8]. Robotics in the maritime industry is a fast-developing phenomenon, and there is still a long way before these robots replace human counterparts. Industrial robots are already used in the security, maintenance and inspection of vessels. They can do tasks, such as packing, delivering, inspection, and even firefighting. Robots can also help in risky environments where a human's life is in danger by providing autonomous navigation and rotating the ship.

3. *Drones*: Another leading revolution in the marine sphere is drone innovation. Shipping sector is one which can avail the advantages of drones to a great extent. Right from surveillance, photography, mapping, environmental monitoring to establishing wireless internet access and utilization during emergency services, drones have a huge scope for exploration and implementation in the maritime sector. The range of applications for drones in the marine environment have expanded drastically into exploration, environmental monitoring, and intervention which has rapidly increased the value of the industry. Overall, the usage of drones in the maritime industry cuts cost, reduce human risk factor, and saves times beyond question. Drones are now being used extensively for tasks such as delivering goods to vessels, security and surveillance, and remote inspections. Figure 5 shows drones in maritime environment [1].
4. *Big Data Analytics:* Data is the new most important element of the present era. With multiple sources pouring data in abundance, big data analytics will be an essential technology improving the operations of shipping industry by deriving a correlation between the data collected from various sources (for instance oceanographic data, maritime accident data, etc.) and applying relevant and new algorithms automatically on the establishment of any correlation between pieces of information. Figure 6 shows big data in maritime industry [6].
5. *Cloud Computing:* Cloud-based technology is known for providing access to the data easily and therefore will prove to be a ground-breaking technology for the shipping industry. Right from cutting down the cost to preventing any data loss, offering remote access to corporate data to improving the communication channel between the staff at sea and land, cloud-based technology is just another asset for the shipping industry.
6. *Internet of Things:* All the major technologies like cloud-based technology, robots, sensors, and other wireless networks can be utilized to their maximum capacity with IoT. IoT basically involves GPS and cloud-based database. IoT is a relatively new technology that enables users to connect everyday objects to the cloud or the Internet. This allows people to control everyday objects with the touch of a button. The Internet of Things (IoT) enables users to controls everyday objects with the help of their phone or a consolidated control system such as a remote. This means people can turn electrical systems on and off, move doors, and open windows by tapping a button. With IoT, the operations can be carried out rapidly and all the other technologies can be implemented to serve the best of the purposes. Moreover, the latest IoT solutions are providing excellent aid for the maintenance of the ships and will continue to evolve in the coming days. IoT also enables control of some objects even remotely. It works with a GPS and cloud-based database which stores all the data collected by devices on the ship. Lights, fans, doors, and even objects could be closely monitored without even having to step foot in the rooms. Similarly, in the event of an emergency, the master or captain of the vessel would have remote access to the cabins that could prove decisive. Figure 7 shows a typical use of IoT [10].
7. *Blockchain:* Blockchain is one game-changing technology that is said to revolutionize the industry. It is supposed to the next giant step in the aspects of payments by providing a quick, secure, and transparent way of collecting payments from any place in the world.

Decentralization has proved to be a boon and shipping industry is making most out it. By reducing the cost of transactions, blockchain allows the parties involved in the supply chain to save time and money. In addition, the blockchain technology will play a major role in reshaping the industry's future by reducing the paper-work, connecting the parties directly, and carrying out real-time exchanges of documents and transactions.

8. *3D Printing:* 3D printing is another technology that is becoming popular in the transportation industry and enhances shipping as it aids in the timely availability of spare parts onboard ships. This technology allows the creation of physical objects from digital designs. In the maritime industry, this process is being used to fulfill on-

demand orders for spare parts and equipment directly onboard ships. This reduces the need for long-distance transportation of spare parts, accelerates repairs and maintenance, and avoids costly vessel immobilization or operations interruption. 3D printing enables on-demand manufacturing of parts and components, reducing lead times and costs for repairs and maintenance. It can also be used to design and construct new parts.

9. *Immersive Technology*: Though virtual reality is a thing for creative industries, maritime sector is turning this technology into the latest model of training, engineering, and inspection. Certainly, there lies vast scope for the VR technology to change the maritime industry in a number of ways in the coming future. Augmented Reality (AR) is present in lots of industries today. As one of the technological progressions, AR is mainly used by seafarers. AR is presently being used mainly for seafarers training and has been implemented by a couple of maritime training institutes. AR is also being used in the shipbuilding and design process, simulating virtual models which can help resolve several issues at the early stage of designing before implementation. Figure 8 shows a typical use of immersive technology [10].

10. *Autonomous Ships*: Another game-changer for the maritime industry is the use of autonomous ships. Self-driving cars, buses, and trucks will soon be accompanied by fleets of autonomous cargo ships which are known as "ghost ships" that will navigate through the world's ocean using artificial intelligence. The unmanned vehicles cruising through the sea are soon going to be a reality. Automated ships are the next generation vessels with no crew members onboard which will be commanded from a shore operating center. Significant technological progress has already been made, and regulators have to date identified four potential categories of "autonomy." These range from partially automated ships with seafarers onboard, to fully autonomous ships where the vessel makes navigation decisions itself. The major benefit of the sailor-less system will be the reduction in human-errors that would further enhance the safety in the sea. These systems will also extensively change the way through which current cargo ships explore, monitor, and interact. Accidents in the maritime industry are very common; e.g. offshore oil mishaps, tug boat accidents, collisions, grounding, fires, cargo hauling accidents, electrical accidents, assaults caused by stress, drugs, alcohol, slips and falls, man overboard, compressed air accidents and more. Ultimately all these occurrences and accidents boil down to human error.

11. *Green Technology:* Because maritime is a big concern, it is crucial that it moves toward a green approach. As the demand for sustainability in the maritime industry grows, there is an increasing focus on alternative fuels such as liquefied natural gas, biofuels, hydrogen, and ammonia to reduce the sector's reliance on fossil fuels and the carbon footprint of vessels. With the world's major industries dedicating the next decade for the reduction of their environmental footprints, the shipping industry will also have to watch out for the same. Green Technology can help the maritime sector to carry out its operations in a very cost-effective and environment friendly way. A lot of new sea modes of transportation, such as zero-emission ships, are being developed to reduce the carbon footprint of the maritime industry. Many megaships are built from different, more sustainable materials, like fiber-reinforced plastic. Technology trends present in the maritime sector help to reduce greenhouse gas emissions. They also provide alternatives to fossil fuels – fuel cell boats.

12. *Sensor Technology*: Sensor technology is one of the most advanced and well-developed technologies, especially popular in industries connected with transportation. Sensor technology replaces many of the manual tasks, like examining equipment aboard ships. Connecting all machinery to sensors helps marines and ship technicians to manage their equipment more efficiently. It also allows them to detect problems at an early stage and identify their cause. Figure 9 shows examples of using sensors in maritime [9].

These are just a few examples of how the maritime industry is influenced by technology. Other emerging technologies include advanced materials, automation, propulsion systems, and digital twins.

BENEFITS

Improvements in shipbuilding (megaships), advanced materials, smart shipping, propulsion, robotics, big data and sensors are making the work on the earth's waters easier. With the tech progression, the maritime sector can be safer for the environment and still determine the global market's escalation. Other benefits of emerging technologies in maritime industry include the following [11,12]:

- *Automation:* Automation in shipping is helping to deliver products without any interference.

Autonomous systems operate with high efficiency, allowing for detection of materials with advanced heat mapping, eliminating human error possibilities. Container ships are massive and are often manned by a crew of only thirty to forty people, comprising engineers, technicians, and other personnel. Automation would free up personnel for more important tasks.

- *Connectivity:* Today it is more critical than ever before to secure reliable and stable connectivity for maritime operations. Connectivity will boost dynamic routing, considering weather, currents and traffic, and knowing which is the most efficient route. It will power the innovations of the maritime industry now and into the future and help maritime companies stay competitive both on the sea and off it.
- *Transparency:* At the core of blockchain's application in maritime operations is its ability to provide an unalterable ledger of transactions. This feature is invaluable in creating a transparent supply chain where the provenance, journey, and handling of cargo are verifiable by all stakeholders. Such transparency not only builds trust among parties but also significantly reduces the discrepancies and fraud that can plague international shipping.
- *Enhancing Safety:* Human error is a significant factor in maritime incidents. Big data analytics plays a crucial role in enhancing maritime safety and regulatory compliance. Autonomous vessels promise to mitigate risk by relying on precise, consistent, and tireless AI-driven systems for navigation and operational decisions. These systems can continuously monitor for risks, such as collisions or hazardous weather conditions, and take appropriate action more quickly and accurately than a human crew might.
- *Cost Savings*: Autonomous ships offer the potential for significant operational efficiencies and cost savings. By optimizing routes, speed, and fuel consumption based on real-time data and conditions, autonomous vessels can reduce voyage times and energy use.
- *Predictive Analytics:* AI-driven analytics enable predictive route optimization by analyzing vast amounts of data related to weather patterns, traffic conditions, and historical shipping trends. This allows shipping companies to make informed decisions that enhance efficiency and reduce fuel consumption. By analyzing incident reports, navigational data, and crew performance metrics, predictive models can identify potential safety risks and suggest mitigative actions.
- *Maritime Transport:* The maritime industry is the lifeblood of global trade, with ships carrying over 90 percent of all merchandise trade. The smooth functioning of maritime trade and supply chain logistics is integral to economic development and critical to food security and the distribution of essential supplies. Population growth increases the demand for food, energy, and water, which will lead to an increase in the demand for water transport, renewable energy, and water-based food production. Water transport will remain the most economical means of transporting raw materials, finished goods, fuel, food, and water globally. Infrastructure and links with all other modes of transport will grow and adapt in response. Maritime transport, including inland waterways, will also become an integral part of an efficient multimodal long-distance supply chain.

CHALLENGES

Despite the promising advancements in emerging technologies, challenges remain. The integration of these technologies requires significant investment in infrastructure and training for personnel. New ideas and approaches tend to come in waves rather than in a steady stream, inundating stakeholders with new technologies and regulations that often bring more uncertainty than guidance. Emerging technologies today constitute some of the greatest risks and most pressing opportunities that face naval forces. Other challenges of emerging technologies in maritime industry include the following [11,13,14]:

- *Cost:* The initial cost of implementing emerging technologies can be high, with uncertain returns on investment. This financial uncertainty can make it difficult for companies to commit to adopting new technologies, especially in a sector known for its cyclical nature and slim margins.
- *Sustainability:* Corporate sustainability is understood as the integration of economic, environmental, and social considerations into the company's mission. Emerging technologies can be used as a tool to improve their corporate sustainability performance. The scientific and research activity in the area of sustainable shipping has been thriving in the recent years.
- *Ecological Impact:* While the benefits of emerging technologies in ocean freight are substantial, it is essential to consider their ecological impact. The maritime industry faces increasing pressure to reduce its carbon footprint. Innovations like alternative fuels and energy-

efficient designs are being explored to achieve this goal. By leveraging technologies that optimize fuel consumption and minimize emissions, the industry can contribute to more sustainable practices while maintaining profitability. Today, maritime industries are facing complex challenges on the journey to net-zero emissions, both in how to approach decarbonization and in how to apply a new wave of technologies poised to revolutionize marine and offshore sectors alike.

- *Cybersecurity:* As the maritime industry increasingly embraces digital technologies, the need for robust cybersecurity measures has never been more pressing. Cybersecurity risks associated with digitalization must be addressed to protect sensitive information from potential threats. As ships become smarter and more connected, they are increasingly vulnerable to cyberattacks. The International Maritime Organization (IMO) set cybersecurity guidelines in 2017 to protect maritime operations from emerging cyber threats, advocating for a framework that prioritizes prevention, detection, and response.
- *Environmental Insurance:* The development of insurance policies to protect natural assets is a novel concept that could help to protect fragile marine environments. While in its infancy, the idea thus far has seen great success and could be implemented as a conservation measure in the future.
- *Change:* Technologies such as artificial intelligence (AI), the Internet of things (IoT), blockchain, autonomous navigation systems, augmented reality (AR), and big data analytics emerge not just as tools but as harbingers of change. Each technology, with its unique capabilities, offers solutions to longstanding challenges within the industry. From enhancing predictive maintenance to enabling unmanned navigation, these innovations promise to elevate the maritime sector to unprecedented levels of efficiency and safety.
- *Integration:* Many vessels and maritime infrastructure elements are designed to last decades, meaning that they often operate with legacy systems that are not readily compatible with new technologies. Ensuring seamless integration between old and new systems is a considerable challenge. The complexity of integrating IoT technology with existing shipboard systems and ensuring the reliability of sensor data in harsh maritime conditions are significant hurdles. The adoption of blockchain in the maritime industry faces challenges. These include the technological complexity of blockchain, the need for standardization across the industry, and resistance to change from established players.

CONCLUSION

Emerging technologies in maritime industry are reshaping the industry by enhancing transparency, efficiency, sustainability, automation, safety, and overall global competitiveness. Key trends include autonomous ships, AI-powered operations, IoT sensors for real-time monitoring, and the use of blockchain for transparent supply chains. If emerging technologies are implemented properly, the maritime industry will be able to take benefit of advantages such as automation, high data quality, process integrity, configurable smart contracts, lower transaction costs, empowered network, ecosystem simplification, and many more. Several prominent companies and organizations have already joined hands for further research, development, and implementation of the technologies in the industry.

The maritime industry is evolving rapidly, driven by technological innovation, regulatory pressures, and the need for sustainability. Advances in technology are prompting trends that emerge out of necessity to stay relevant. Companies in the maritime industry will have to adapt to these new technologies or be left behind by their competitors. As the maritime sector continues to evolve with these advancements, it stands poised to meet future demands more effectively and sustainably. As the industry looks to the future, the role of emerging technologies will continue to expand. More information about emerging technologies in the maritime industry can be found in the books in [15-17] and this related journal*: Journal on Emerging Technologies.*

REFERENCES

[1] "How technology is changing the maritime industry," October 2020, https://www.martide.com/en/blog/technology-changing-the-maritime-industry

[2] "The top maritime industry tech trends for 2024," March 2024, https://www.kongsbergdigital.com/resources/the-top-maritime-industry-tech-trends-for-2024

[3] M. Halaweh, "Emerging technology: What is it?" *Journal of Technology Management & Innovation*, vol. 8, no. 3, 2013, pp. 108-115.

[4] N. Duggal, "Top 18 new technology trends for 2023," July 2023,

https://www.simplilearn.com/top-technology-trends-and-jobs-article

[5] "How enterprise architects integrate emerging technologies to enhance architecture," https://www.linkedin.com/pulse/how-enterprise-architects-integrate-emerging-technologies-qdgfe/

[6] "Emerging technology trends in the maritime industry," https://orbitshub.com/emerging-technology-trends-in-the-maritime-industry/

[7] "Emerging technology trends in shipping and maritime industry," March 2019, https://seanews.co.uk/shipping-news/emerging-technology-trends-in-shipping-and-maritime-industry/

[8] B. Prapaharan, "New technologies in the maritime industry," April 2025, https://publication.sipmm.edu.sg/new-technologies-maritime-industry/

[9] J. Matuszak, "8 Technology trends transforming the maritime industry," April 2024, https://knowhow.distrelec.com/defence-aerospace-and-marine/8-technology-trends-transforming-the-maritime-industry/

[10] A. Menon, "10 Smart ship technologies for the maritime industry," June 2021, https://www.marineinsight.com/know-more/10-smart-ship-technologies-that-maritime-industry/

[11] M. Sheludko, "Marine technologies and their potential applications in the maritime industry," February 2024, https://lasoft.org/blog/marine-technologies-and-their-potential-applications-in-the-maritime-industry/

[12] "5 Future maritime technologies powered by connectivity," https://www.eutelsat.com/en/blog/5-future-maritime-technologies-powered-by-connectivity.html

[13] "Beyond the horizon: Exploring next-generation technologies in ocean freight," November 2024, https://wefreight.com/emerging-technologies-ocean-freight/

[14] N. Wagner and B. Wisnicki, "The importance of emerging technologies to the increasing of corporate sustainability in shipping companies," *Sustainability*, vol. 14, no. 19, 2022.

[15] D. M. Bielicki (ed.), *Regulating Artificial Intelligence in Industry (Routledge Research in the Law of Emerging Technologies).* Routledge, 2021.

[16] B. Ko and D. Song (eds.), *New Maritime Business: Uncertainty, Sustainability, Technology and Big Data (WMU Studies in Maritime Affairs, 10).* Springer, 2021.

[17] A. S. A. Kader et al. (eds.), *Marine Technology and Sustainable Development: Green Innovations.* IGI Global, 2013.

Figure 1 Ships are massive [1].

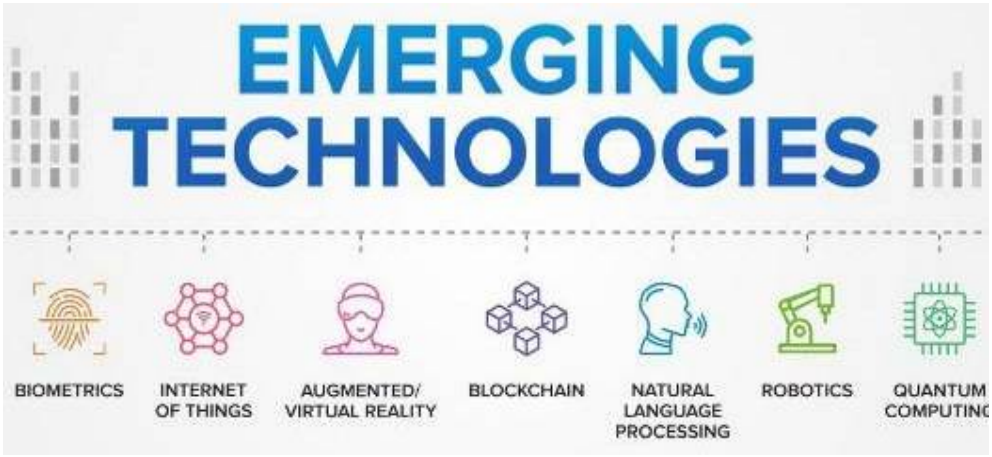

Figure 2 Some emerging technologies [5].

Figure 3 The emerging technology trends [6].

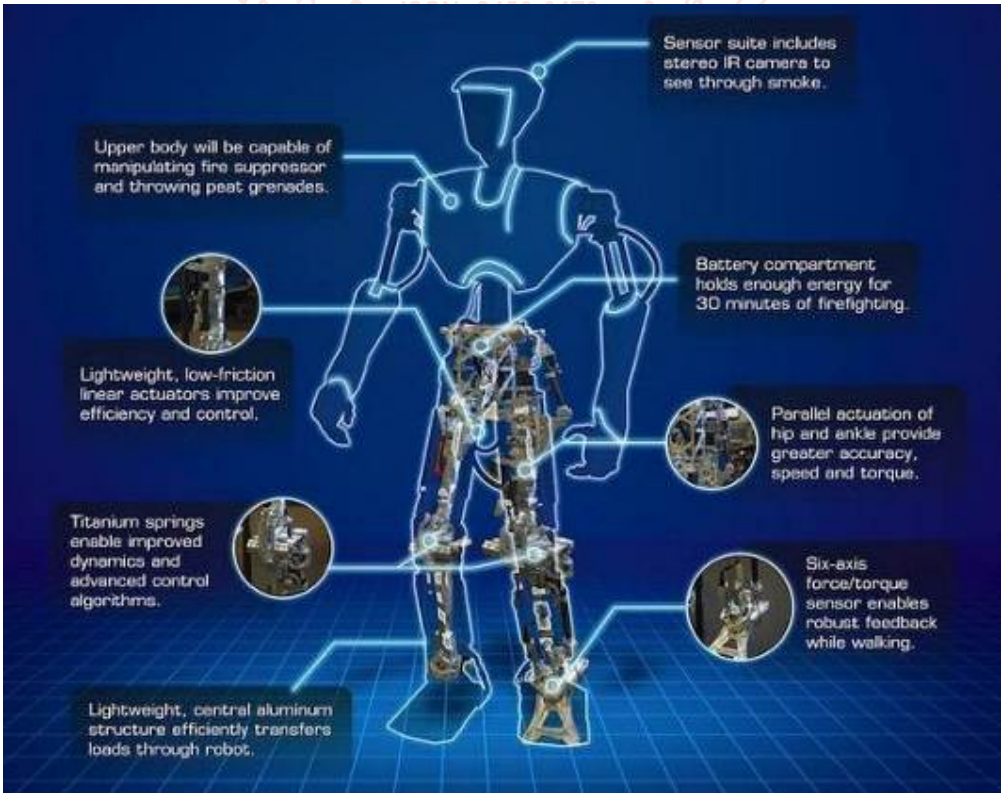

Figure 4 Shipboard Autonomous Fire Fighting Robots (SAFFiR) created by the Naval Research Laboratory [8].

Figure 5 Drones in maritime environment [1].

Figure 6 Big data in maritime industry [6].

Figure 7 A typical use of IoT [10].

Figure 8 A typical use of immersive technology [10].

Figure 9 Using sensors in maritime [9].