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Predictive Maintenance-as-a-Service (PdMaaS) Using Industrial Internet of Things (IIoT) and machine learning for Mechanical Equipment Used into Indian Ship Building Industry

PNV Srinivasa Rao [1] , PVY Jayasree [2]

[1] Department of EECE, GITAM Institute of Technology, GITAM University, Visakhapatnam, India

[2] Department of EECE, GITAM Institute of Technology, GITAM University, Visakhapatnam, India

Abstract:

Indian shipbuilding has had a maritime heritage from the earliest days of civilization. The coastal regions of India are the primary locations for the country's shipbuilding industry. Shipbuilding activity has shifted because of capacity limitations and reduced shipbuilding costs in developing countries. This has given the Indian shipbuilding sector new chances. The Indian shipbuilding industry's prospects are strengthened by increasing worldwide commerce and high demand for new vessels. A ship's operating profile is incomplete without consideration of maritime maintenance. Reliability and Criticality Based Maintenance (RCBM) is introduced in this paper to examine the use of Predictive Maintenance-as-a-Service using on the Industrial Internet of Things (IIoT-PdMaaS). Improving decision-making analytics, automation, safety, route optimization, and higher efficiency are several notable advantages of artificial intelligence (AI) in the shipping business. Various data sources are fed into advanced analytics software, extracting valuable business insights. Clusters are determined by the concentration of marine industries in a regional community and the presence of a network of businesses and institutions that support the industry's future growth. This research examines the most critical aspects of an organization that could impact the effectiveness of teamwork when at marine. These are the facts: the management of resources, the atmosphere of the organization, and the organization's procedures. The board of directors of a corporation examines the industry's help from the perspective of personnel policy, costs, and the purchase of essential equipment. PdMaaS is an important use of the Internet of Things (IoT) addressed in many industries, particularly manufacturing. PdMaaS uses data, often gathered from sensors, to improve maintenance operations. As a result, this capacity is built primarily for export, focusing on small ships. Offshore supply boats and anchor handling tugs, for example, are being built in India for the oil and gas sector. The resource management and greater availability of skilled workers in India make it an obvious choice for the shipbuilding industry, which is generally labor-intensive.

Keywords: Reliability and Criticality Based Maintenance, Industrial Internet of Things, shipbuilding, Indian, industry, Artificial intelligence , Machine Learning

1. Introduction to Ship Building Industry:

Shipbuilding is one of the world's oldest, most important, open, and highly competitive industries, despite the global economic and political problems [1]. An abundance of coastline, proximity to international shipping routes, and cheap labor costs are only some of the benefits of the Indian shipbuilding industry. India's shipbuilding capacity, on the other hand, has lagged behind the country's economic growth, market demand, and human resource potential [2]. Waterborne transportation accounts for the bulk of global commerce, and shipbuilding is the industry's primary supply source for the worldwide waterborne logistics system. The industry is very competitive and based on new technology [3]. With the advent of self-driving and intelligent ships, the maritime sector is undergoing a digital change. Shipbuilding is one of the four pillars of globalization, and it has a direct influence on global commerce. The rapid adoption of new technology in the shipping sector has sparked a discussion about how digitalization will transform the marine industry and autonomous ships [4]. Because the digitalization of shipping will impact a wide range of stakeholders, from shippers to shipyards to classification societies to freight forwarders, it is critical to map out the path that shipping companies are taking so that all of these parties can come together to accomplish the common goal [5].

Sea transportation is a convenient and efficient means of transportation integrated with other modes and is expected to create an effective. Reliable and dynamic national distribution pattern that connects one region to another, promoting regional economic growth and supporting an already developed economy. Freight and passenger transit are intended to be connected via the national maritime transportation connectivity system [6]. Sustainable and efficient industries can optimize machinery's energy consumption [7]. Industrial cyber-physical systems allow for real-time monitoring, sensing, and actuation of physical equipment for predictive maintenance, departing from the traditional labor-intensive method [8]. Environmental sustainability and operational efficiency are the driving forces in the marine industry [9]. It has recently emerged that shipbuilding industries consider incorporating additive manufacturing (AM) technology into shipbuilding to produce specific replacement components on board [10]. The present state of AM in the marine industry, in terms of its application, design, and supply-chain structure.

The marine industry attempts to use new technology to overcome today's economic crisis to enhance its competitiveness [11]. However, introducing these new technologies will have several interactions and possibly emergent repercussions [12]. International trade in ships and shipbuilding is a significant driver of regional economic growth because it is an export-oriented sector that employs highly skilled workers, relies heavily on cutting-edge technology, and requires substantial capital [12]. Even in the shipbuilding sector, which is renowned for cost overruns and schedule delays, a more comprehensive model for manufacturing supply chains [13] and component installation procedures that include suppliers at the lowest levels can help to encourage investment in appropriate quality [14]. This research examines visions in the cruise shipbuilding industry from the perspective of sustainability improvement, encompassing normative and strategic agendas for desired and feasible [15].

Mechanical systems such as plants, machinery, and equipment are just being changed or upgraded at a predetermined period due to preventative and corrective management in the marine sector. Marine predictive maintenance components might be changed during their planned or periodic service intervals while still operational, resulting in excessive expense. As a result, the predictive maintenance system parts may have reached the end of their service life before the scheduled period. As a result, more traditional methods of maintaining maritime mechanical components are losing their effectiveness in improving their durability, safety, and maintainability. Predictive maintenance could fill up the gaps left by the traditional maintenance method. It is possible to optimize the care of marine mechanical systems using sensor technologies or machine learning approaches in the IIoT platform.

As part of the maritime cluster, ports, ships, logistics service providers, and government regulators will all be located close. To maximize synergy, the collection will take advantage of the proximity and accessibility of these stakeholders. Data from IoT sensors embedded in equipment, manufacturing processes, environmental data, and other sources are all used in AI-based predictive maintenance to decide which parts need to be replaced before they break down.

The shipbuilding industry requires manual work in Predictive Maintenance-as-a-Service using the Industrial Internet of Things (IIoT-PdMaaS). Most goods are carried by sea and inland waterways globally, and this has been universally accepted for a long time now. The preservation of ships' conditions to a dependable operating level is paramount, and ship maintenance is especially required. The results show that the ship's weight has the most significant influence on profit and that active damage to the ship's hull is an essential safety consideration. Increasing port efficiency is the key to decreasing operational delay time. Even more importantly, the study reveals that adjusting input factors can aid in determining how much expenditure is necessary to achieve a certain degree of technology. Ship maintenance expenditures can account for 10-15 % of a shipping company's direct operating costs.

The main contribution of this paper is,

- The IIoT-PdMaaScan helps shipbuilding industries uncover ways to decrease costs by improving maintenance and procedures. It is possible to monitor the ground conditions using the IIoT and wearable technologies to detect potential threats.
- The most recent technological improvements in ship-to-shore maintenance reports need well-trained people and user-friendly software platforms. This is because of the recently deployed online maintenance reports.
- The RCBM framework increases the current marine approach to maintenance, which is currently either too technical or not managed. It is designed in response to the unique demands of the marine market when it comes to solving specific challenges that arise during ship operations.
- As the shipping industry improves its AI capabilities, the possibility of developing new tools that can help humans manage vessels more securely and more effectively grows.
- Clusters are determined by the concentration of marine industries in a regional community and the availability of a support structure for the industry's development.

Accordingly, the rest of the IIoT-PdMaaS approach can be organized. Describe the relevant research in section 2 of this paper. A summary of the planned study is provided in section 3. Section 4 details the simulation results and discussion. Section 5 concludes the report by going into great depth on the observations and developments that have taken place.

2. Related work:

Manufacturing labor-intensive and complicated products could benefit from using newly developed additive manufacturing (AM) processes as part of the industry 4.0 revolution. Using Wire Arc Additive Manufacturing (WAAM), the shipbuilding industry could produce complex double-curved components with more design flexibility and lower costs [16]. Present and prospective WAAM applications in the shipbuilding industry were examined in this article, along with a discussion of the technology's applicability in light of current and potential constraints such as material availability and property requirements, design complexity, and less in the organizational process. The recent expansion of the shipbuilding sector would be an attempt to enhance worldwide competitiveness. Cost accounting as a method of cost information would be tested as the shipbuilding industry develops, necessitating higher product quality. The Activity-Based Costing (ABC) System generates more relevant and systematic indirect costs using activities to identify expenses [17]. A product's cost could be determined using activity-based costing methods, identifying the resources used in each department's operations. Aside from the product costs, activity-based costing could estimate all production-related expenditures accurately and increase the delay time.

In the shipbuilding industry, design flaws could lead to significant cost overruns. Anticipating potential design flaws helps ensure timely delivery and increased efficiency. In addition, conventional associative classification approaches (ACA) did not pay enough attention to the rule consolidation process that allows discriminative association rules to be aggregated [18]. A novel ACA technique proposed in this work incorporates both support and confidence. At the same time, the number of matching characteristics was taken into consideration not only to discover particular rules that capture valuable correlations and to boost prediction performance by efficiently aggregating relevant authorities and less in fuel consumption. A new ship took months to build, which was costly. Thus choosing a shipyard requires the shipowners to be well-versed in the industry [19]. An improved fuzzy AHP (IFAHP)-based game-theoretic model was designed to examine two competing shipyards. Researchers could use this model to compare shipyard hazards and minor resource management. Players and others who benefit from a game could benefit from this research, which provides valuable information about shipbuilding.

This study aimed to identify competent and unqualified shielded metal arc welders (SMAW) in the shipbuilding industry. A low-cost device that could instantly determine a welder's skill level was required to cut inspection costs while ensuring weldment quality and less predictive maintenance [20]. Smart manufacturing in the industry and systems with dewatering pumps utilized for docking and undocking of vessels in shipyards would not be possible without Predictive Maintenance. Machine Learning approaches have emerged as a viable tool in predictive maintenance and dewatering tools in shipyards with smart manufacturing in I4.0. They have raised the interest of writers during the past few years. Research on machine learning techniques like Support Vector Machine (SVM) for predictive maintenance in I4.0 is reviewed here, and the authors categorize the study based on the Machine learning algorithms, machinery, and devices used in data capture and organizing the data in an attempt to illustrate the critical commitments made by the researchers [21].

Yugowati Praharsi et al. (2021) detailed that, unfortunately, there is a lack of supply chain performance research focusing on the shipbuilding sector. An empirical study of the traditional shipbuilding industry, its suppliers, and customers in Indonesia focus on this paper, which provides recommendations for improving the supply chain's performance [22]. This study consists of three sections: the traditional shipbuilding industry, the suppliers, and the individual supplier scores. Supply Chain Operations Reference (SCOR) measures are used to evaluate this study's internal and external performance. It is possible to draw management lessons from examining shipbuilding supply networks to improve the performance of other sectors.

Toh Yen Pang et al. (2021) discussed the digital twin and digital thread technologies in industrial processes are discussed in this study [23]. Transformational technologies such as printing technology and robotics both have the potential to improve current design and production processes. The digital twin is a vital part of Industry 4.0's digitization process; however, the enormous quantity of data created and gathered by a digital twin presents issues in collecting, analyzing, and storing it all. The framework is expected to improve operational efficiency and information traceability in the physical world, particularly in an Industry Shipyard 4.0.

Emil Mathew et al. (2021) prepared in the shipbuilding business that ship recycling operations are commonly considered the most dangerous due to environmental contamination and health dangers to employees [24]. Over the past few decades, strict environmental and labor regulations in affluent countries have pushed recycling businesses to countries in the Global South, where the prices are lower. It's also been suggested that the International Maritime Organization consider setting up a ship recycling industry fund to cover the costs of ship recycling. Access to this fund and effective policy formulations initiated by the consortium of significant ship recycling nations can play an essential role in addressing externalities and making the recycling process environmentally and labor-friendly.

The standard hand actions of welders were observed and recorded using IMU sensors with 9 degrees of freedom (DOF). Artificial intelligence (AI) techniques such as the support vector machine (SVM) method were used to identify and categorize welders based on their hand actions. The IIoT-PdMaaS approach has been suggested to overcome the existing techniques. IIoT-PdMaaS approach has recommended improving fuel consumption, delay time, organizational processes, resource management, and predictive maintenance in shipbuilding.

3. Proposed method: Predictive Maintenance-as-a-Service using the Industrial Internet of Things:

The shipbuilding industry has shifted its supply bases to lower-cost locations. During economic booms, new nations have risen to prominence. Indian shipbuilding can compete with the rest of the world because of its abundance of resources and cheap labor costs. In the public and private sectors, run by the federal and state governments, Shipyards account for most of the Indian shipbuilding. Large volumes of shipbuilding equipment data can now be supplied to shipping companies throughout a route using IoT. Ship operations and maintenance can be more developed and efficient using this data.

Industrial Internet of Things (IIoT) technology is now being used in the maritime industry. IoT technology penetration in the marine sector is still in its early life. Each IoT technology has a wide range of functions and potential applications. Therefore, effective use case scenarios have been developed. IoT decision-making requires a wide range of knowledge because of this wide range of options. In addition, the introduction of IoT could impact a wide range of systems. When it comes to IoT insertion, it's essential to examine all of the ship's complicated systems together. Because it's an intermediary business, it's dependent on the end-user industries that use it. Steel and engineering products manufacture and consumables can benefit from shipbuilding investment. In addition to creating employment and stimulating investment elsewhere, such a large-scale investment has far-reaching effects on other manufacturing industries.

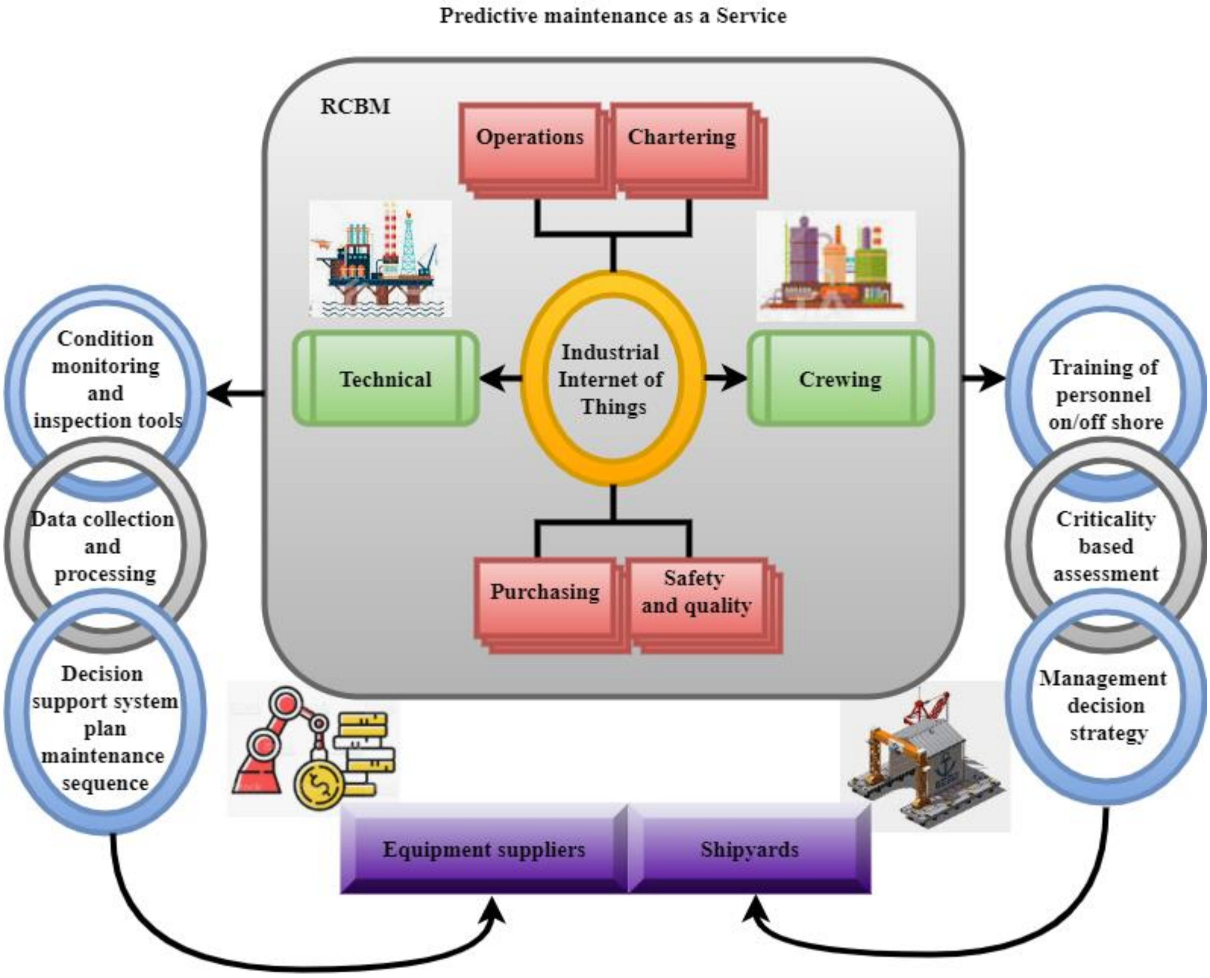

Fig 1: Predictive Maintenance-as-a-Service using the Industrial Internet of Things

Fig 1 shows the predictive maintenance-as-a-service using the Industrial Internet of Things. This paper outlines the steps to develop a ship's PdMaaS using system reliability and criticality analysis. This has been performed as part of the development of the new Reliability and Criticality based Maintenance (RCBM) ship plan. A typical shipping company's present state/structure. The technical, chartering, operations, crewing, safety, quality departments, and buying all exist within this setting. All of the ship's services are provided by these departments, which work together to ensure the ship's functioning. Among these are the responsibilities for technical repair, maintenance, and replacement components and planning and advising on vessel charters that consider the vessel's availability throughout the year.

Consider the vessel's or fleet's operational capacity, as well as the crew that will be employed on board, as well as the training and certificates needed for all different levels of the team, taking into account all relevant Health, Safety, Quality, and Environment (HSQE) issues for the specific vessel or fleet of boats, and then issue the appropriate purchase orders and payments. As part of the proposed framework, there are two more sections: the technical and Predictive Maintenance As a Service. The proposed approach integrates the advantages of the IIoT, such as experts' engagement, extensive system analysis, condition monitoring and gathering of data, execution of maintenance activities, technical assistance in personnel and tools required, and decision support process. The IIoT approach aims to return the system to a functional condition within the operational boundaries of each scenario rather than a perfect active state. Improve the systems' safety and dependability by focusing on their most critical functions. Eliminate or lessen the effects of failures. Avoid or reduce the amount of maintenance that is not strictly necessary to lower maintenance expenditures. For example, supply means moving resources from a provider to a user or consumer. In shipbuilding, equipment supply refers to moving equipment from a supplier to a construction site to make things easier for everyone involved.

$$K_x = \frac{1}{z_m}\max[T_s(z_u) * (e_k - w_h)] * [(D_1 - D_2) * (z_0 + y_s)] \pm [X_1 - X_2] \qquad (1)$$

As shown in equation (1), predictive Maintenance-as-a-Service $K_x$considers the advantages of Total Productive Maintenance (TPM) $z_m$in management and organizational aspects $T_s(z_u)$, including leadership support$e$ d, strategic planningw_h, implementation planningD_1, training and retrainingD_2, and communicating decisions$z_0$to all employees $y_s$involved in-house$[X_1 - X_2]$ (onshore and crew onboard). Building and repairing ships are the primary functions of a shipyard.

These boats can be freight or passenger liners, military craft, yachts, or any other kind of ship. The ship's crew is being trained and retrained to deal with the new technology available. In addition, the marine unit can execute the creation of a proactive team culture toward the repair. This necessitates actions to improve the skills and knowledge of the crew and the ship's crew organization. The company's management must be fully committed and actively involved for any of the plans above to be successful. Finally, this will lead to shipbuilding a PdMaaS decision-support system.

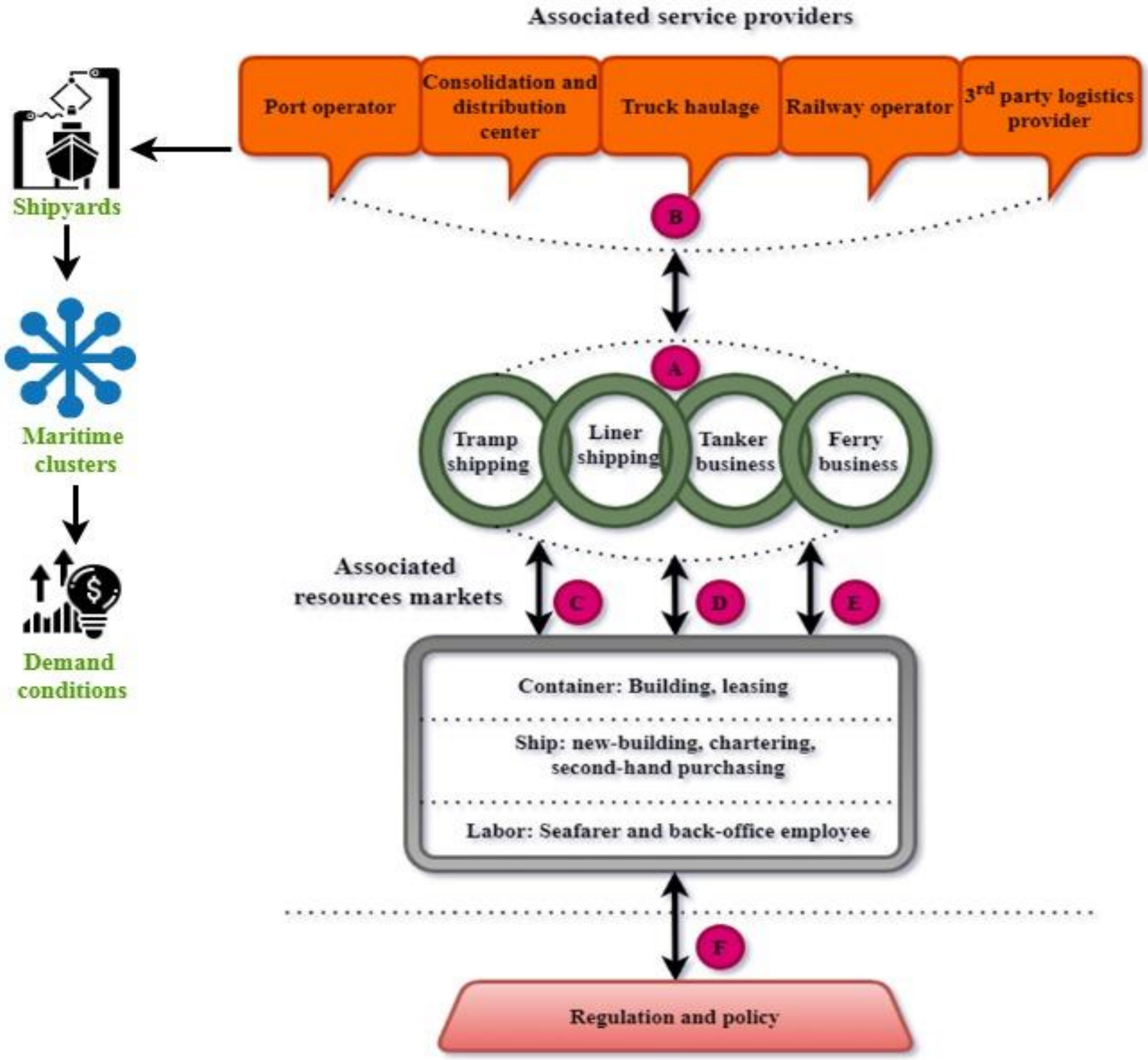

Fig 2: Shipbuilding industry structure and related markets in clustering

Fig 2 shows the shipbuilding industry structure and related markets. A transport network is a geographical system of nodes and linkages through which the movement of freight and people takes place, much as a shipbuilding network. Cargo and passenger movements originate at a node in a transportation network. When two nodes are connected by a physical connection, such as a river, roadway or rail, or air route across some distance, the link is considered a physical link. Nodes and relationships form a graph, which can theoretically describe the structure of a network (edges). In addition, a route is a track that does not include any repeating edges or nodes. Shipping companies can devise service itineraries with many links and call ports. An additional consideration for a link's decision-maker is its impact on other connections. The same holds for node-level decision-makers, a fundamental premise of the IIoT.

Rather than relying just on the routing system, this study uses link activities and node activities in networks to explain the challenges it is trying to solve. This mature and complicated sector is best understood by first outlining the fundamental business problems. The informal business description is then transformed into formal behavioral economics difficulties. Business relationships in the shipping sector take several forms. Liner ships, tramp ships, tankers, and ferries make up the bulk of the maritime industry (Box A). Regardless of whether it's ocean shipping or short sea shipping, liner shipping is a service that follows stated and planned ports of call. There are no set ports of call in tramp shipping; instead, cargoes are picked up and delivered according to demand and either voyage or time charter contracts. However, crude oil products or bulk commodities are transported in tankers instead of containers in tramp shipping. As the last point, the ferry industry offers service to people, which is outside the scope of this study, given that human behavior is more unpredictable than that of freight. Shipyards have a significant impact on the area's economy and national security. The European shipbuilding industry built complex boats, such as cruise ships, ferries, mega-yachts, and dredgers. Marine clusters are described by the spatial concentration of maritime industries in a regional community and the presence of a network of enterprises and institutions that support the growth of the sector. Human resources, physical resources, knowledge resources, capital resources, and infrastructure fall under the umbrella term "factor conditions." Companies can benefit from favorable demand circumstances by innovating more quickly and developing goods that outperform rivals.

$$E(\chi) = \sum_{i=1}^{k} f_i g_i + \frac{1}{K} exp\left[\frac{(y(m)-y_k(m))^2}{2E_n}\right] * \varphi_n(K) \times \alpha_1 \qquad (2)$$

As exposed in equation (2), cargos $E(\chi)$can be substituted for passengersg_i, and the same thinking can be used as explained below. The major shipping businessf_i is characterized by horizontal rivalry K and strategic collaboration $y(m)$ among the same-type carriers. The rivalry and cooperation between pages can be α_1 considered macro-level horizontal linkages$y_k(m)$, given that carriers connect various portsE_n. A link activity $\varphi_n(K)$is thus concerned with developing linkages and the reconstruction of pathways via the consolidation or deconsolidation of the linkage supply to better satisfy demand. Service providers include port operators, consolidation/distribution centers, and hinterland service providers such as truck haulage, railroad operators, and 3rd party logistics providers (link B). An extensive network of service providers would not be complete without ports and consolidation/distribution hubs.

$$AG = E_p - E_q = [Qp(n).G_p] - [K(H_p^2) \times H_e] \qquad (3)$$

As revealed in equation (3), by increasing the node's throughput $AG$and storage capacity $E_p$and its hinterland connections$Qp(n)$, a node aims to attract new linksG_p. This might be done in various ways, such as making accessible infrastructures $K(H_p^2)$ minimize congestion $H_e$in hinterland traffic. Nodes compete with one another to remain a hub if other competing nodes exist within the same trade zone or graphical area. Or, due to their restricted capabilities, the nodes must work along with the current hub. It makes sense to think of ports and consolidation/distribution centers as hubs of horizontal linkages among homogenous actors; however, it is a node activity. Nodes are trying to change the status of their related nodes to make them more desirable for connections, which improves their ability to be found and accessed.

$$H_{ft} = B_{ft}(bw_{ft} + \tau r_{ft}^m) = N_{ft}(E_{ft}) - B_{ft}K_{ft}^m \pm \sqrt{\frac{1-c}{c_r}} \qquad (4)$$

As shown in equation (4), connections $H_{ft}$and nodes cooperate $B_{ft}$to achieve higher performance bw_{ft}as a group than they would individually. The linkages pick efficient nodesτr_{ft}^m to reduce waiting for times $N_{ft}$and the overall journey duration E_{ft}while avoiding possible dangersB_{ft}. Liner carriersK_{ft}^m, for example, have the challenge of $\sqrt{\frac{1-c}{c_r}}$ selecting a port from a list of available options. Occasionally, the linkages will suggest and invest in more nodes if they deem it beneficial. It is important to note that weighted associations are selected by nodes so that the nodes' resources can be effectively used. In this situation, there are vertical relationships between players from different backgrounds.

As part of strategic sub-network integration at the macro level, both links and nodes must be easily accessible and connected to other service providers. The supply of raw materials aids this sector. Containers can be constructed or rented, resulting in bargaining and bidding when hired personnel (links C and E). Consideration of schedule optimization and the network is required if ships are to be deployed (link D). As a final step, rules (Box F) guide and constrain individual operators while considering their ties to others.

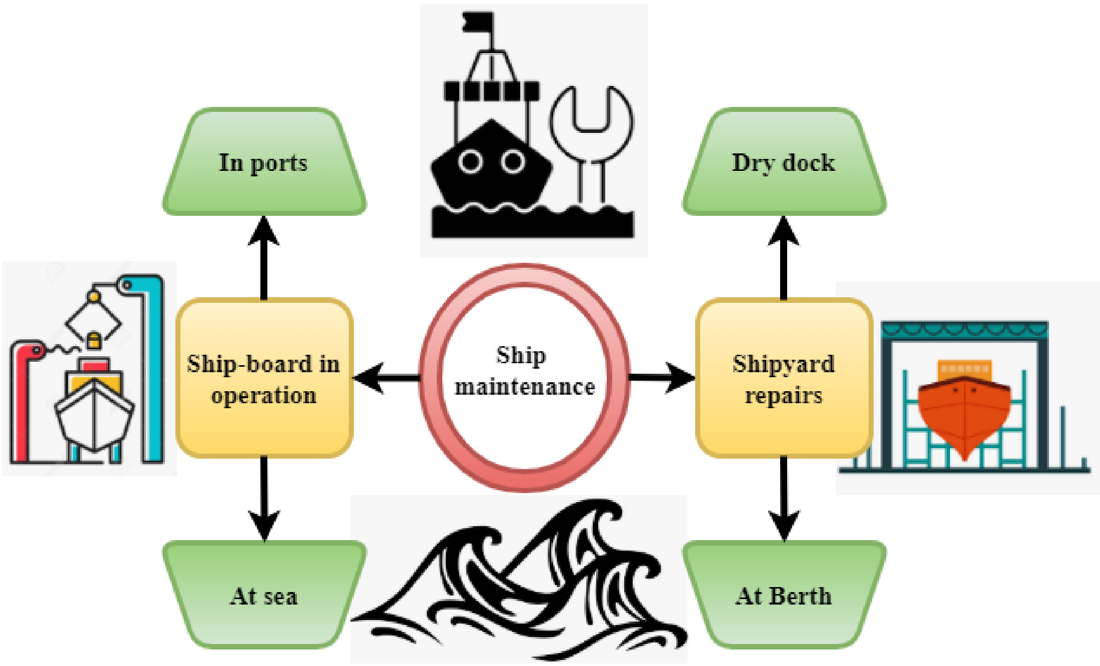

Fig 3: Maintenance strategy for ships

Fig 3 shows the maintenance strategy for ships. Management must be committed to giving the staff and resources needed to carry out other goals on board to carry out any other continuous improvement initiative. There is usually a database that stores the list of all the equipment aboard the ship that has to be maintained. These records have been added to the database to provide a complete history of maintenance actions that have been completed and a list of maintenance needs.

$$D_t(fr) = \frac{1}{ef}\sum_{k=1}^{ef} U_h(B_{fr} + gh_{fr}) + \sum wuw(E_m.dc^1) \quad (5)$$

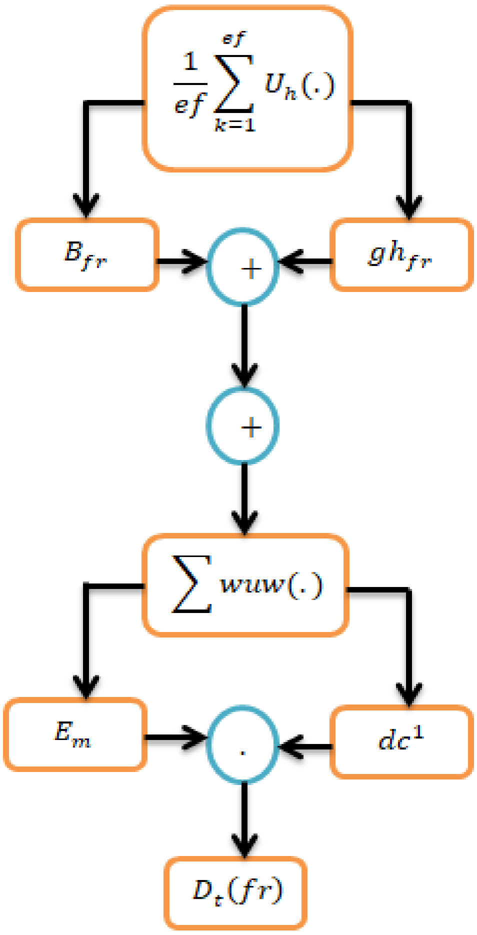

Fig 3(a): Maintenance management

As shown in equation (5) and fig 3(a), maintenance planning $D_t(fr)$ for ships is crucial because of its complexity ef and maritime corporations' U_h need to adhere to specific standards and criteria B_{fr}, such as the International Safety Management Code (ISM) gh_{fr}. Because of the ship's low availability wuw, the company's income E_m can suffer due to ineffective maintenance management practices dc^1. Maintaining a ship's efficiency means paying attention to its fuel use. According to the argument and research results, properly maintained ships are more energy-efficient. Because of this, energy efficiency and routine maintenance are intertwined in every way.

$$S^\sigma(z) = W_z + \beta W_{z-1} + \beta^2 W_{z-2} + \cdots = \sum_{q=0}^{\infty} \beta^q W_{z-q} \quad (6)$$

As shown in equation (6), the maintenance schedule $S^\sigma(z)$ and planning are included in all tasks that require W_z to plan, manage β, and document maintenance operations β^q. The basis for planned maintenance W_{z-q} is a predetermined maintenance schedule for the equipment. The majority of shipping firms use this maintenance program. An examination of the mean time between failures and reliability analysis, for example, can be used to help determine the best time to do preventive maintenance. For this process to be effective, it must be based on a model of the duration between maintenance intervals that considers failure mechanisms. This means that the planned maintenance schedule can not be based on fixed-time programs and less on an analytical approach that considers various elements, such as the equipment's dependability characteristics. Performing Regular Checkups: Planned maintenance has this as one of its subsets. Preventive care is typically based on the manufacturer's recommendations and prior experience scheduling repairs or replacements. Maintenance is carried out regularly by this policy, which is carried out at regular intervals. Preventive care by the number of operating hours or elapsed time makes preventive maintenance time-driven.

The fundamental technique for shipboard maintenance is scheduled preventative maintenance. The intervals are based on the manufacturer's recommendations and previous shipboard or business experience. It is possible to define corrective maintenance as taking place only after a failure has been detected. Corrective maintenance can be separated into immediate corrective maintenance and deferred corrective maintenance. The latter begins as soon as a breakdown occurs (in which work is delayed in conformance to a given set of maintenance rules). Maintenance that is not even scheduled falls under the category of corrective maintenance. Performing ship repairs and maintenance can be accomplished in one of two ways. They can be performed at the ship repair yard when the ship is scheduled for dry docking for regulatory or class surveys. While the boat is docked at the shipyard, several routine maintenance tasks are carried out. When the ship is in port or at sea, maintenance can be done on the ship's daily operations. When it comes to effective equipment and systems, maintenance activities are essential. This happens for various reasons, such as general wear, tear, corrosion, faulty adjustments, or extended durations of operation beyond the original design parameters.

Consequently, downtime, quality issues, energy losses, safety dangers, or environmental pollutants can occur. Maintenance can negatively influence operational costs, profitability, customer happiness, and ecological implications if not executed properly. Maximizing equipment availability and efficiency, controlling the rate of equipment decomposition, and maintaining safe and environmentally-friendly operations are primary challenges of maintenance optimization. The overall cost of operation should be minimized, including energy costs.

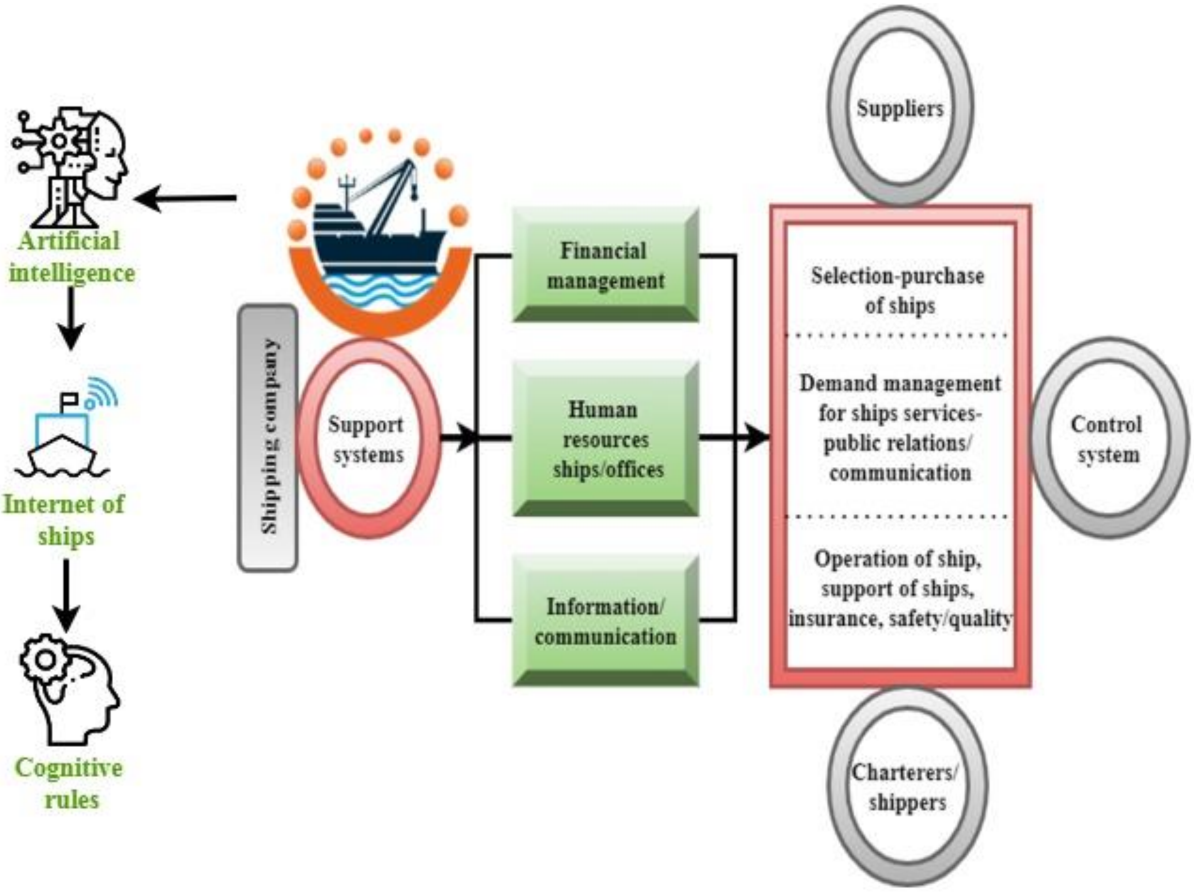

Fig 4: The operations and processes of the shipping industry in AI

Fig 4 shows the operations and processes of the shipping industry. Due to their mobility and distance from their administrative center, the operations of shipping companies are more complicated than they seem to be in their basic form, even if they have many similarities with those of other businesses in terms of their procedures. Depending on the strategy and scope of the firm's activity, a shipping company can naturally have offices in several geographic locations. A shipping company's business area is linked to the fact that elements such as institutional framework, availability of resources, and a variety of variables have a significant impact on the organization and functioning of its infrastructures on land. There are two types of resource systems: those that assist and control. Management of the information and communications and the personnel employed on ships and in the company's offices are all examples of support systems. Each of these will be discussed in more detail later in the article. For a corporation, control systems don't always entail particular procedures. Instead, activities permeate every operation and aim to control how productive resources are distributed and employed. Supplies departments in companies are responsible for ensuring a sufficient supply of consumables and equipment on board the ship to avoid delays and any hazards for both passengers on board and the ship's crew. Artificial intelligence (AI) is a term used to describe the creation of computer programs that replicate human intellect and behavior. In addition, the phrase may be used to describe any machine that demonstrates human-like characteristics, such as the ability to learn and solve problems. Smart interconnected maritime objects, including any physical device or infrastructure associated with a ship, a port, or transportation itself, the Internet of Ships is a novel application domain of IoT that seeks to significantly boost the shipping industry toward improved safety, efficiency, and profitability. Cognitive rules are social constructs that provide information that distills and summarizes society's ideas and experiences.

Shipping company uses SVM for various training and testing data with the suppliers, shippers, and control system. SVM uses limits to produce predictions for particular traits or factors where the classes may be divided and then uses those limits for predictions of various shippers. Data with a relying factor and financial management can be evaluated using an SVM-based machine learning technique. Although the machine learning algorithm calculates the posterior class probability, SVM maximizes the margin among the closest support vectors. SVM can develop a solution that is as fair as feasible for operation and process in the shipping industry. SVM classifies predictive maintenance in dewatering pumps used for the Docking and Undocking of vessels in shipyards, as shown in Fig.5. The shipping companies, financial management, and information collection groups the classes in SVM in the IIoT platform.

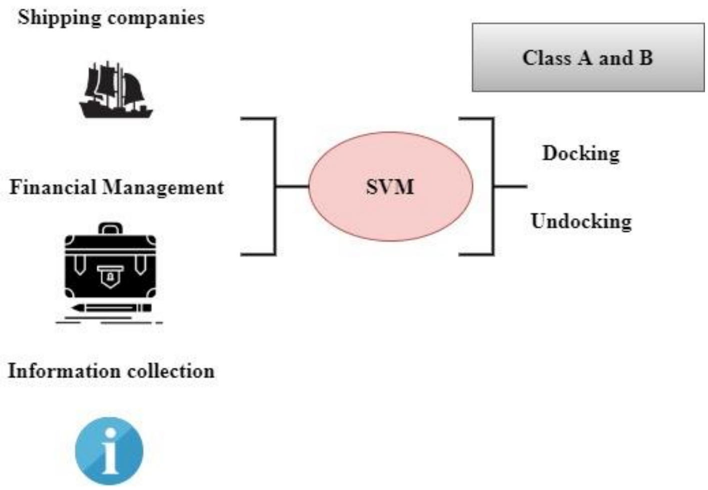

Fig.5. Classification of classes based on SVM

Core processes and systems methods can examine the processes and procedures supporting and controlling a shipping industry. However, each group's operations are distinct since each company's activity generates unique demands stated in the description of each process and the procedures and activities that make up its constituent parts. Consequently, several sets of processes and systems make up a shipping company's operations, including those that deal with the development of the service, demand generation and management, and demand fulfillment. When it comes to the growth of marine transportation, selecting and purchasing a vessel is a crucial step. This is a fundamental strategic choice that has to do with the goals, the strategy for achieving them, the sourcing of the required resources, and the development of the matching competencies. It is a major strategic decision. As part of this decision-making process, a company's fleet composition and new or second-hand ship purchases are considered, along with the implementation timeframe for the choice.

Financing acquisitions of high-value assets is a pressing issue. Bulk transportation businesses penetrate the worldwide market to get the money they require. Consequently, as with every other resource they use, capital is likewise sourced from the global market. How much money is needed often determines the number of institutions that offer it? Fundraising in shipping relies on sophisticated, creative, and complicated financial mechanisms and methods. Equity financing, debt financing, and alternative financing are all types of these products. However, shipping banks remain a vital monetary resource. For the company's marine transportation services, this procedure is all about creating a demand for its boats and ensuring that they have a steady supply of work. In this case, it's the job of the specialist chartering department to handle it. In addition to market intelligence, chartering people often have the specialized skills and expertise needed to negotiate the conditions of the charter party. Their responsibilities are quite similar to those of shipbrokers. An important strategic consideration is an attitude taken by the manufacturing company towards the risk that might be caused by changes in the chartering markets when choosing between trip charter, time charter, or bareboat charter. The survival and growth of an organization are dependent on a creditworthy charterer's accurate market data analysis and selection of the suitable charter type. The proposed method improves fuel consumption, delay time, organizational processes, resource management, and predictive maintenance in shipbuilding.

4. Numerical evaluation of the shipbuilding industry:

Shipbuilding is the process of creating substantial sea vessels, often out of steel, although other materials, such as wood and composites, can be utilized. Shipbuilding is a more complex process than boatbuilding, which uses identical materials. There are three primary markets for ships in this industry: the commercial marine (cargo and passenger transport), offshore energy, and security forces. Products and services used in the building, converting, and maintaining these ships are included. In [21] gaining the support of 100 Indian shipbuilding industry, the data gathering process began. Models for calculating fuel consumption, the number of events during operation, predictive maintenance, resource management, and the delay time are all part of a ship's operating system.

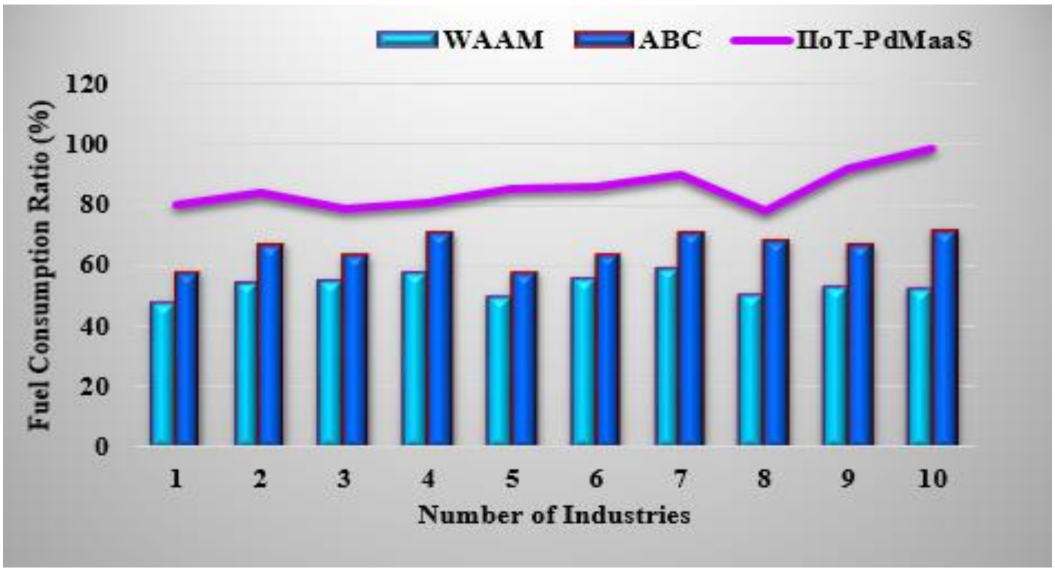

Fig 6: Fuel consumption

The fuel consumption $K_0(p_e)$ is shown in equation (7),

$$K_0(p_e) = S'(r_k) - t_0 + \left(\frac{e'(k_0)}{N'}\right) + \prod_n^m (D_0 - G') * W' \quad (7)$$

Fig 6 shows the fuel consumption. Fundamental ship theories and past research simulate S' ship performance and the impact of degradation $r_k$or contamination. Weather conditions are t_0 taken into account by calculating the fuel consumption increase rate $\frac{e'(k_0)}{N'}$ under constant ship speed circumstances concerning m the ship speed reduction ratio n per Beaufort (BF) scale. Eq. 7 depicts the maneuvering D_0impact by adding fuel consumption fluctuations G' into the predicted fuel consumption. Theoretical fuel usage is based on demand W'due to the weather. The ship's speed is the primary determinant of how much fuel is utilized throughout travel. An engine's fuel consumption can be stated in miles per gallon or liters of fuel per mile. The goal of engine designers is to increase power, reduce fuel consumption, reduce weight, and improve dependability. Compared to the existing method, the proposed method enhances fuel consumption by 98.5%.

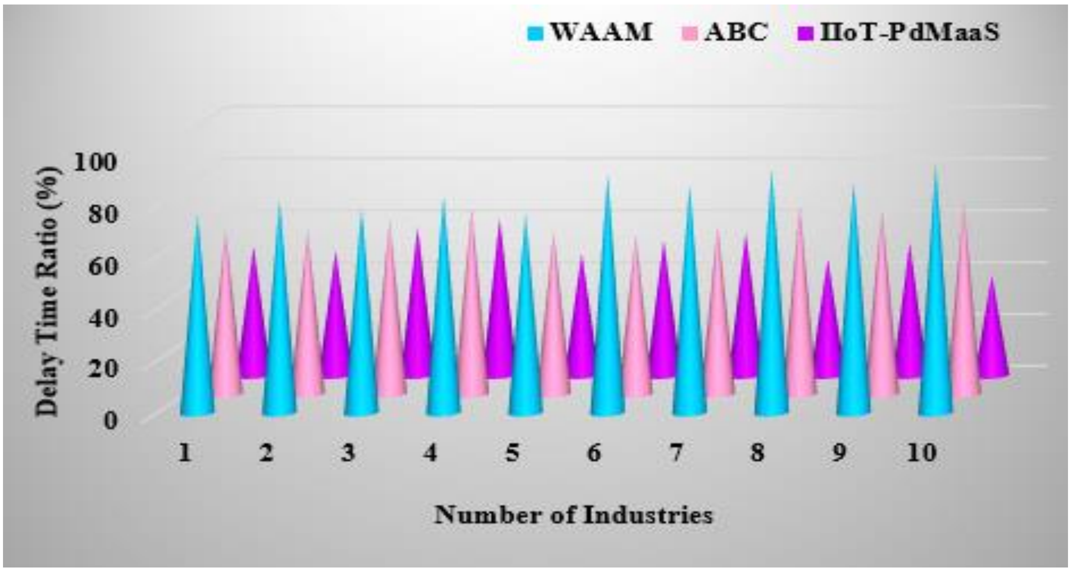

Fig 7: Delay time

The delay time P is exposed in equation (8),

$$P = J'(n) + Y_0 + A'(G_0) * \left(\frac{m'}{\sum_{z'} e' + G_0}\right) - (A + C)$$

Fig 7 shows the delay time. Probability density function $J'(n)$ depending on BF and the effects of driving conditions $Y_0$is used to create damage accumulation value A' in the same manner as the steering damage G_0 affects the parameter. The marine incident rate $\frac{m'}{\sum_{z'} e' + G_0}$ has a predetermined likelihood of occurrence. The average A delay times for incidents and failures establish the delay time associated with incidents C and failures. It is deemed delayed when the shipment does not arrive on time. This might be due to bad weather, overcrowded ports, driver shortages, and other unanticipated events that could delay or postpone the delivery. Compared to the existing method, the proposed method reduces the delay time by 38.5%.

Table 1: Organizational processes

Number of Industries	WAAM	ABC	IIoT-PdMaaS
10	45.5	72	77
20	49	68.2	81
30	55	66	83
40	47	71	90.7
50	53.2	69	98
60	56	74	93.3
70	48	67.7	79
80	52.2	75	85
90	58	73.8	95
100	51	65	98.5

The organizational processesU_n^r is shown in equation (9),

$$U_n^r = \frac{An}{\sum_{m=1}^{n} P_m - T_m} + \frac{G_{rl} + F_r}{Un} . \sqrt{\frac{1}{N} + (W)^2}$$

Table 1 shows the organizational processes. Decisions and regulations set by the company's management Ancontrol the day-to-day operations onboard, which are regulated by the organization's processes. This entails regular operating processes $\sum_{m=1}^{n} P_m$and a review of whether or not the intended tasksT_m has been completed. Working at a fast speed $G_{rl}$and under pressure $F_r$to keep to a sailing schedule are two examples of relevant tasks in this field. Management's impact Uncan compromise sailing safety on the rate of the workforce. Due to supervisory control$\frac{1}{N}$ over increasing work pressure, technical components are overlooked, and the crew becomes exhausted. Because of this, collaboration$(W)^2$ is regarded as the best organizational style of work and activity, allowing the ship's crew to be ready for any situation during navigation or use. Compared to the existing method, the proposed method improves the organizational processes by 98.5%.

Table 2: Resource management

Number of Industries	WAAM	ABC	IIoT-PdMaaS
10	46.3	65.7	79
20	55	71	84
30	47	75	88
40	49.9	62.9	76
50	53	72	78
60	57	78	91
70	45.1	68.2	90.7
80	51	74.1	79.3
90	57	77	82
100	59	75.2	92.1

The resource management K_0 is shown in equation (10),

$$K_0 = \frac{1}{U_n} \mathrm{R}[T_r(G_w) * (O + X)]. (l_i m_0)\, n * [(a_1 + a_2)]$$

Table 2 shows resource management. The shipbuilding industry is concerned with building bigger boats $\frac{1}{U_n}$for the commercial marine, the offshore energy sector R, or the armed forces. Products and services used in shipbuilding, conversion, and maintenance are included. Human resources managementT_r, selection, and training fall under G_w the umbrella of personnel policy. An emphasis is placed on minimizing costs O while ensuring that there is enough money available X to meet the costs of ship maintenance $l_i$and marine education m_0. When it comes to supplying or replacing equipment n, it's vital to examine how efficient the current equipment is and then provide new equipment $a_1 + a_2$that satisfies the intended needs in terms of quality and applicability. The proposed method increases resource management by 92.1% compared to the existing process.

Table 3: Predictive maintenance in shipbuilding

Number of Industries	WAAM	ABC	IIoT-PdMaaS
10	49.7	64	76.5
20	48	63.5	82
30	57	67	78.9
40	60.5	72	84
50	47	63	77
60	52	61.7	92
70	55	65.5	88
80	45	73	94.5
90	51	71	89
100	53	74	96.9

The predictive maintenance $Y_{r_n}(V_n)$ in shipbuilding is shown in equation (11),

$$Y_{r_n}(V_n) = q\left(F_{r_n}^{S_n} \backslash V_n\right) - \sum_{r_{n-1}} Y_{r_{n-1}}((V_{n-1})S(V_{n-1} + V_1^{n-1}))$$

Table 3 shows the predictive maintenance in shipbuilding. Regular maintenance q is preferable to employing faulty equipment $F_{r_n}^{S_n} \backslash V_n$ onboard a ship for marine sector strategy and execution. Sophisticated technology r_{n-1}can monitor and anticipate equipment maintenance $Y_{r_{n-1}}$ to ensure optimal ship performance monitoring (V_{n-1}). A maintenance forecast S is a proactive strategy for coping with unforeseen equipment failures that eventually result in V_1^{n-1} expensive offshore downtime. This technique is more like a prediction than the preventative maintenance procedure that is carefully followed onboard ships. One of the most critical aspects of this service is proactive analysis, used to detect and accurately predict shipboard equipment and machinery failures. This guarantees that the ship's staff knows the equipment's existing and future capabilities. Compared to the existing plan, the proposed method raises predictive maintenance by 96.9%. The IIoT-PdMaaSevaluated fuel consumption, delay time, organizational processes, resource management, and predictive maintenance in shipbuilding.

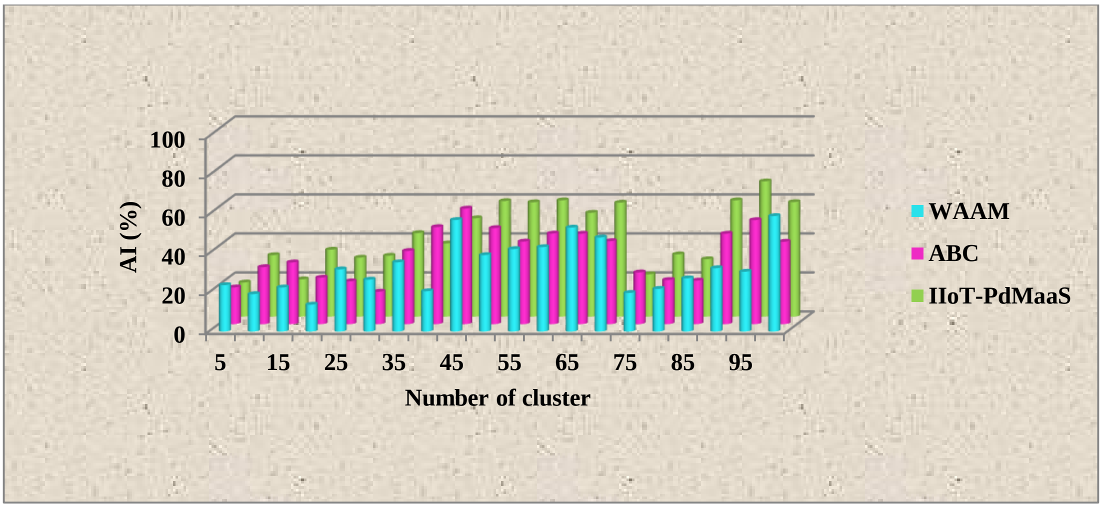

Figure 8 overall percentage of artificial intelligence

Figure 8 shows that the supply chain and shipping operations can significantly benefit from artificial intelligence. Several advantages include decreased costs, less risk, better forecasting, faster delivery through more efficient routes, and more. Designers may expect further changes in the shipping business in the future. Oil tankers, bulk carriers, cargo ships, gas carriers, and product carriers are but a fraction of the many vessels that may be built in the shipbuilding business. Even while global oversupply, recessions, and shifting economic fundamentals played a role in the industry's demise, one policy move stands out. The shipbuilding industry of several countries worldwide has been supported for a long time.

5. Conclusion:

New methods for determining the best maintenance sequence in the maritime industry have been presented in this paper, including the RCBM technique. Analysis of the world and Indian shipbuilding industries suggests that India must focus on several sectors to succeed. With the ability and flexibility of the proposed RCBM technique, it can be used for both the complete system and its subsystems. Aside from saving time and money, proactive and predictive maintenance can increase the overall dependability and availability. PdMaaS included port and consolidation/distribution service providers in our interdependent shipping and port operators network. Organizational and managerial phenomena should be analyzed about this attribute since they interact and characterize these industries. Artificial intelligence is used to solve transportation-related problems. Utilizing shipping AI, they can take a challenge like linking carriers to shippers and apply complicated algorithms using artificial intelligence. Improved efficiency, more business creation, and more incredible Innovation and innovation are the key advantages maritime clusters bring to society. This research focused on the smart factory's service rather than the manufacturing phase for a vessel maintenance depot. There used to be a restriction to using the smart factory idea in production because of the varying nature of repair and maintenance operations. In addition, the RCBM approach can be improved by integrating those above with an IIoT-based application that automatically collects and elaborates data, allowing for real-time decision support activities. The experimental outcome suggested that IIoT-PdMaaS enhances fuel consumption (98.5%), delay time (38.5%), organizational processes (98.5%), resource management (92.1%), and predictive maintenance in shipbuilding (96.9%) overall percentage of AI (98.7%).

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