COMPUTERISED MAINTENANCE MANAGEMENT SYSTEM

INRODUCTION

1. In marine industry, major part of the business model is the profitability, where the role played by the machinery is of great importance. The business model of shipping economics depends on the supply and demand of the global economy. Supply and demand of global economy depends on the fleet productivity ie. the means of delivering of maximum cargo in minimum time depending on the freight rates. Also in addition, the world sea trade is increasing exponentially, as it is the cheapest and the fastest way to transport cargo from one place to other.

2. The world shipping fleet is dominated by bulk carriers, container carrier, tankers, cruise etc. To meet the supply demand requirements, the machinery must perform at their optimum efficiency. Over this period of utilisation, the machinery face downtime due to wear and tear, breakdown, routine maintenance and unforeseen damages/ defects. With these, there comes cost of maintenance, docking, inspection, spares required, manpower and resource management along with detailed planning and execution of the plan, In order to minimise the downtime of the vessel to increase the profitability, optimum and cost-efficient maintenance of the machinery fitted onboard, with best planning and execution of the task is the need for hour. It is pertinent to mention that the maintenance itself takes 10 – 20% of the ship operating costs.

3. With the onset of Industrial revolution 4, integration of machinery with computer-based intelligence is taking up pace. Hence Integrating Machine learning and Artificial intelligence along with data available, we can develop model that can learn the data pattern and predict the trend and train the model. Using this, we can utilise the ship data to make a model that can predict the machinery state and tell the user the most efficient way to carry out the maintenance of equipment, spare planning.

4. **Need for maintenance**. As discussed above, the ships lifespan and business profitability directly depend on the maintenance of the machinery (the longer the ships are operational the more revenue it produces). Regular inspection and maintenance (oil changes, alignment checks, replacement of worn-out equipment's, vibration checks etc) thus avoids unexpected breakdowns, minimising the malfunction chances, increasing vessel reliability, fuel economy and most importantly, lowering the operating costs.

5. **Types of Maintenance**. Maintenance strategies are very important for ensuring the optimum efficiency, reliability and longevity of the machinery across the shipping industry. The main types of maintenance strategies are:

   (a) **Corrective Maintenance**. In this type of maintenance, the maintenance is performed once the defect has occurred or the component is failed, hence it's also known as "Run to failure" maintenance. It's more of a reactive maintenance rather than a proactive approach, which lead to higher cost of maintenance, unplanned downtime, safety risk to name a few.

   (b) **Planned/ Preventive Maintenance**. In this type of maintenance, regular scheduled and planned maintenance is carried out at regular interval/ running hours of the equipment as directed by the OEM/ Supplier. This helps in preventing breakdown, increases the life of

machinery and reduces the downtime. The major drawback of this technique is that it is cost effective, time saving but can lead to over maintenance leading to extra labour and spare consumption/ cost.

(c) **Predictive Maintenance**. This type of maintenance involves analysing and monitoring the equipment performance, parameters and conditions and to predict when & what maintenance is required to be carried out. The goal is to identify potential failures and perform maintenance only when necessary. This technique reduces downtime, minimises maintenance costs but the cost for initial setting up of monitoring and analysing equipment is expensive.

(d) **Condition Monitoring**. It's a preventive/ predictive maintenance technique that monitors the equipment conditions by vibration analysis, lubricating oil analysis, parametric trending etc and determine which maintenance is needed or component it is be replaced.

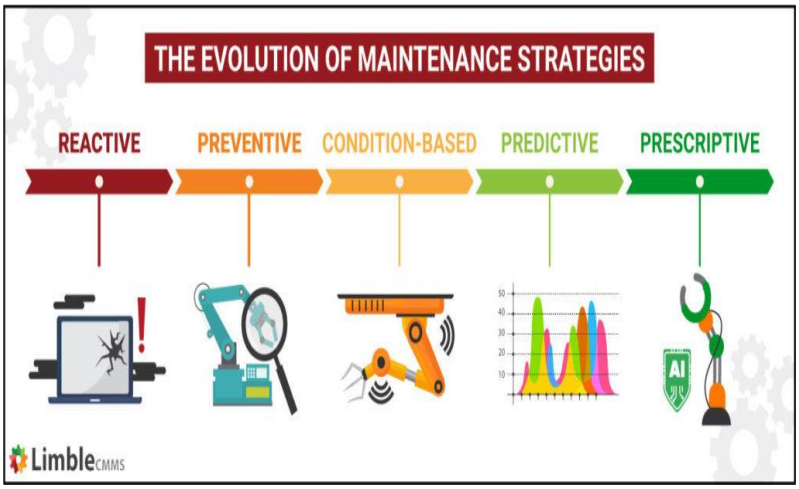


Fig 1. Evolution of Maintenance Technologies

6. **Computerised Maintenance Management System**. A CMMS is a software that centralises the industry maintenance information, facilities and IT services on a single platform/ model/ application that processes the maintenance operation for optimising the maintenance operation, spare availability/ requirement, maintenance planning etc. As discussed above, the maintenance of the equipment is a significant cost in industry, thus reducing these costs requires a shift from traditions methods to a computerised based approach. The main components of the CMMS software are:

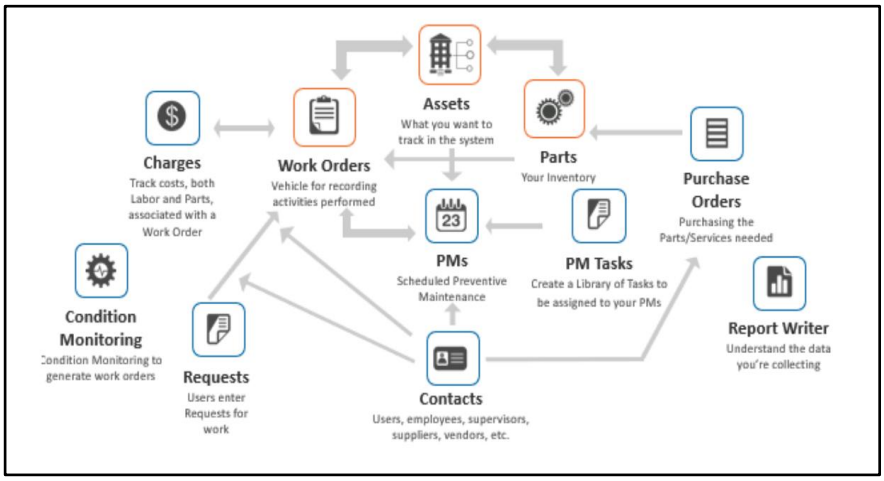


Fig 2. Components of CMMS database.

(a) **Database/Server**. The core of the CMMS is database. This data base is initially fed by the manufacturer based on the available details on equipment and procedures. Upon development, this database is either updated timely or real time data acquisition. This data base is the backbone of a machine learning data model that organises the information about the assets, spare parts and inventory, work orders, Preventive maintenance schedules, Failure codes and maintenance matrixes, Vendor details, defect history of equipment etc.

(b) **Asset Management**. This module in the CMMS tells the details about the assets/equipment fitted onboard a vessel along with all the necessary details wrt to the equipment viz a viz Name, Supplier, Serial Number, Qty fitted, Mfg. Date, Initial cost, Warranty details, location onboard, running hours, Complaints, disposal information etc. These details are initially filled by the software supplier and subsequently updated over the life cycle of the vessel.

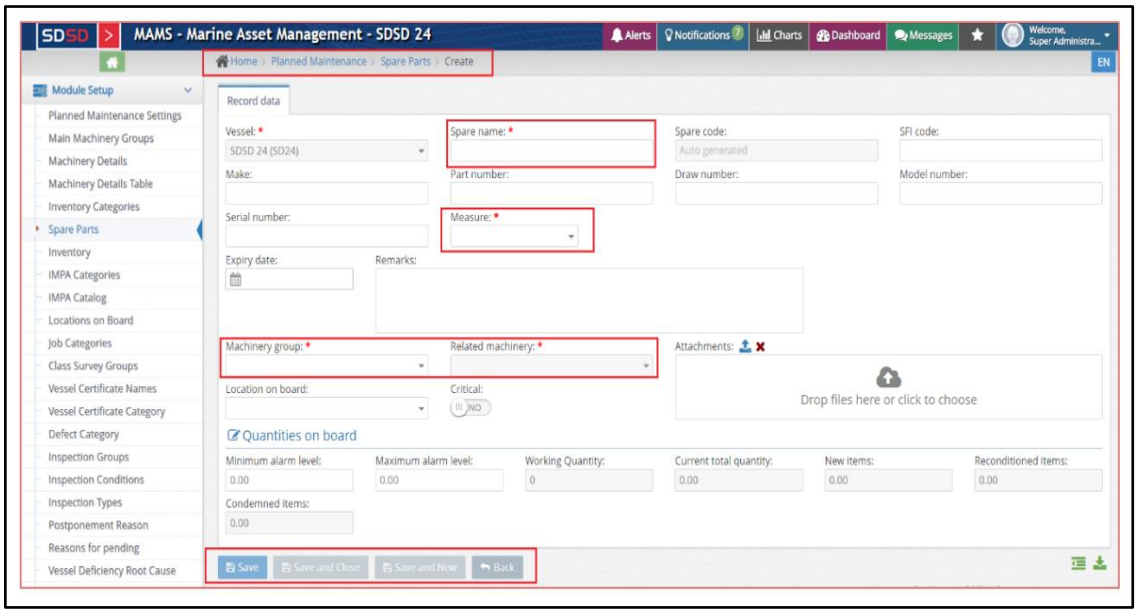


Fig 3. SD CMMS Software with Asset Management feature

(c) **Work orders**. A work order is a record that details a specific maintenance task that need to be carried out on an equipment. It details the description on what to be done, by whom, by when along with details of tools and spares required. This help in efficiently creating tasks, tracking them along with prioritizing and completing them. CMMS generates automatically the work orders pertaining to schedules maintenance tasks. Asset management modules also provide documentation and reporting which helps the model to learn and cost management.

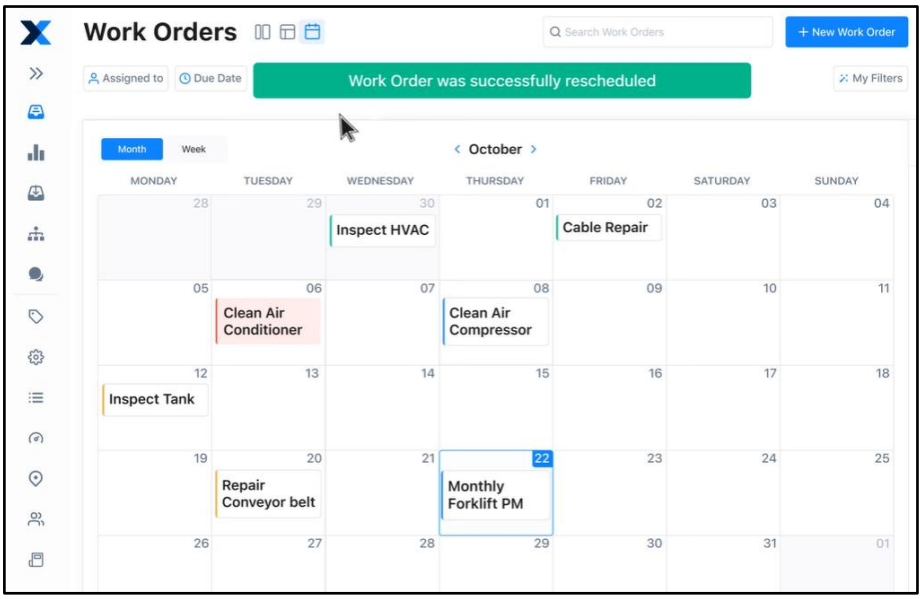


Fig 4. MaintainX CMMS software with work order module

(d) **Preventive Maintenance**. This module focuses on a scheduling regular maintenance task of the assets and equipment to prevent downtime and enhance the operation ability. This module timely notifies the user on the upcoming routines, inspections and surveys as per the schedule fed to the database. The model can also be trained to learn as per the trend and predict any future downtime through machine learning algorithms. The data base can capture real time running hours, defect occurred, and items replaced as part of unpredicted repairs. The keys components of this modules are: -

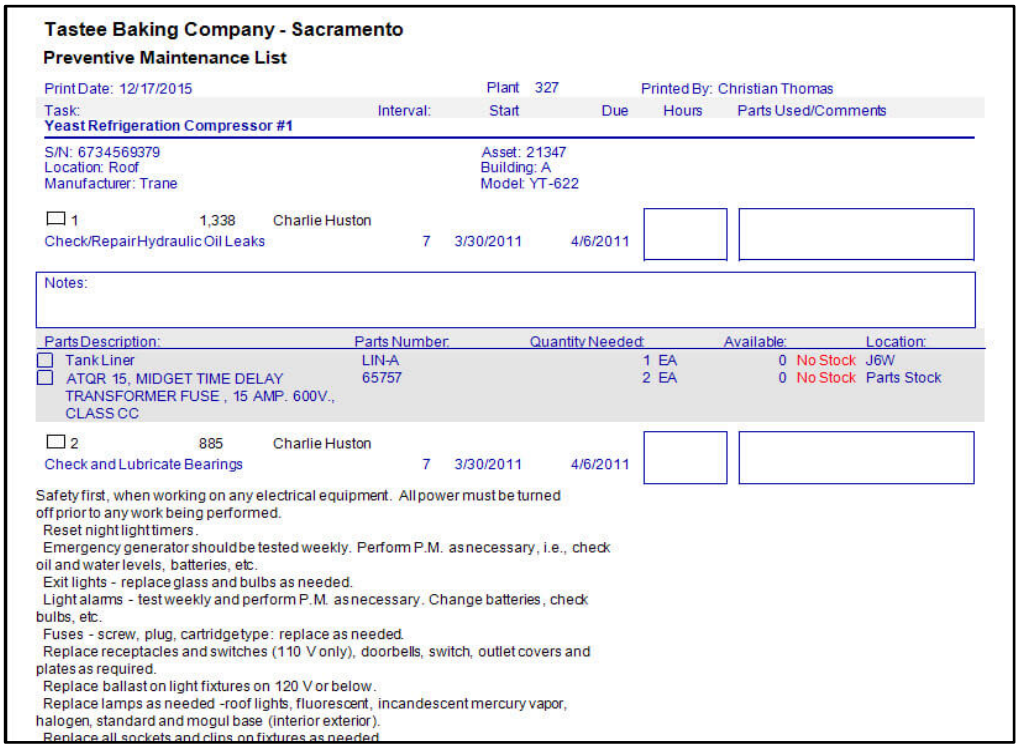
(i) *Callender and Running hour based routine scheduling*. Every equipment is provided by a maintenance schedule which his fed to the module data base for future predictions. E.g. 500Hrs/ 6 Monthly replace engine oil.

(ii) *Task planning and Checklists preparation*. Every routine requires specific pre checks and manhours as listed by the manufacturer. This data is fed to the system module to access and list down the planning/ task to be undertaken while attempting the routine.

(iii) *Automated work order generation & Resource allocation*. Technician, tools, spare parts required are the backbone for undertaking any maintenance task. CMMS modules allow automated responses towards planning these tasks.

(iv) *Tracking and documentation*. Every routine undertaken is tracked about what has been done, time taken, by whom and observation if any. These are documented for future follow -up and one stop references.

(v) *Integration with inventory management*. Integration with inventory management module make it more efficient to track the spare parts and consumables utilised while undertaking the maintenance, qty used and how much qty need to be reordered.



Tastee Baking Company - Sacramento

Preventive Maintenance List

Print Date: 12/17/2015 Plant 327 Printed By: Christian Thomas

Task:	Interval:	Start	Due	Hours	Parts Used/Comments
Yeast Refrigeration Compressor #1					
S/N: 6734569379 Location: Roof Manufacturer: Trane		Asset: 21347 Building: A Model: YT-622			
☐ 1 1,338 Charlie Huston Check/Repair Hydraulic Oil Leaks	7	3/30/2011	4/6/2011		

Notes:

Parts Description:	Parts Number:	Quantity Needed:	Available:	Location:
☐ Tank Liner	LIN-A	1 EA	0 No Stock	J6W
☐ ATQR 15, MIDGET TIME DELAY TRANSFORMER FUSE , 15 AMP. 600V., CLASS CC	65757	2 EA	0 No Stock	Parts Stock

☐ 2 885 Charlie Huston Check and Lubricate Bearings	7	3/30/2011	4/6/2011		

Safety first, when working on any electrical equipment. All power must be turned off prior to any work being performed.
Reset night light timers.
Emergency generator should be tested weekly. Perform P.M. as necessary, i.e., check oil and water levels, batteries, etc.
Exit lights - replace glass and bulbs as needed.
Light alarms - test weekly and perform P.M. as necessary. Change batteries, check bulbs, etc.
Fuses - screw, plug, cartridge type: replace as needed.
Replace receptacles and switches (110 V only), doorbells, switch, outlet covers and plates as required.
Replace ballast on light fixtures on 120 V or below.
Replace lamps as needed -roof lights, fluorescent, incandescent mercury vapor, halogen, standard and mogul base (interior exterior).
Replace all sockets and clips on fixtures as needed.

Fig 5. An overview of Preventive Maintenance module of CMMS software used in Tastee Baking Company

(e) **Inventory Management**. Unlike earlier days where the details of inventory coming in going out was recorded in the company data book by hand, CMMS uses cloud storage and computing to manage the inventory details like Item description, Pattern Number, Qty available, Qty issued, Qty ordered, Price, Location, Manufacturer details etc. This help in managing and tracking stock level that are essential for maintenance activities. Effective inventory management in a CMMS helps maintenance teams ensure they have parts available when needed, minimizing downtime and reducing unnecessary stock costs. The main features of the inventory management are: -

(i) Spare parts and supply tracking. Links spares parts with work orders or any other unforeseen usage and keep a track of the same.

(ii) Stock level management with alert popping when stock reaches critical low level

(iii) Automated purchase order placing: Based on usage pattern and stock level, it places automated purchase orders/ reordering requests, thus ensuring critical parts are always available.

(iv) Supplier and Vendor Management: Store vendor and suppliers information including contact, address, pricing list, delivery times etc.

(v) Inventory cost tracking: Can help in calculating the cost of parts used in maintenance, thus supporting cost control and budget planning.

(vi) Usage tracking and location management: Qty used for maintenance and automatic updating of present stock level. Also tells which part is placed in which warehouse, storeroom and rack, allowing technicians to find it easily.

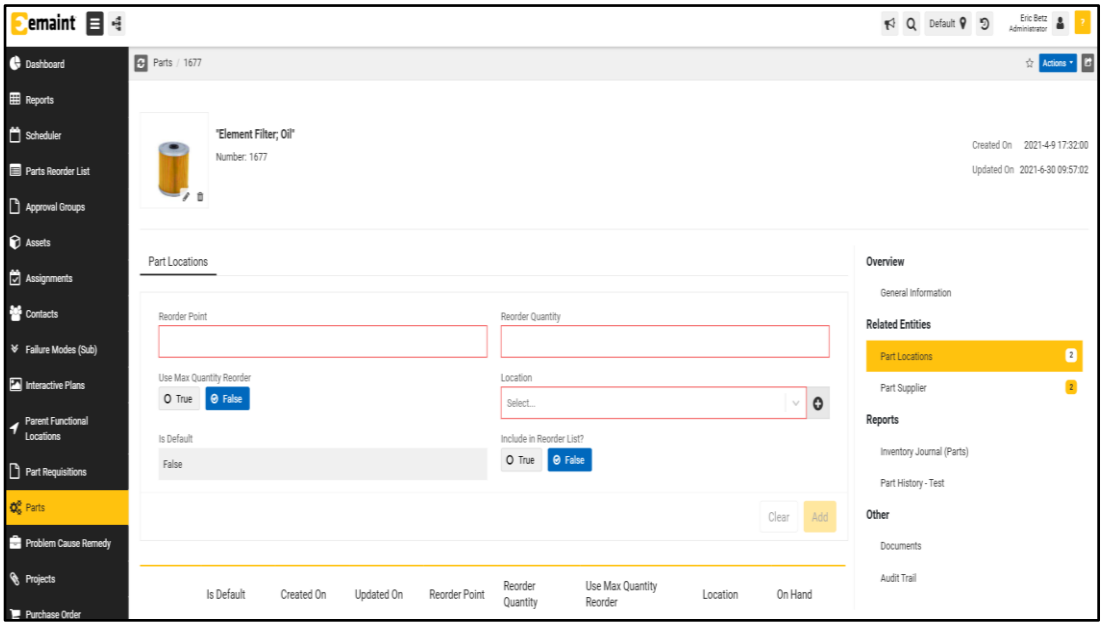


Fig 6. Emaint CMMS software providing Inventory Management

(f) **Condition monitoring (CBPM) in CMMS**. Condition monitoring involves continuously tracking the health of machinery using sensors which measure parameters such as vibration, temperature, pressure, and oil quality. When integrated with a CMMS, this setup enables real-time data collection and comparision with threashold values, facilitating a more proactive approach to maintenance.

(i) Sensor Integration. Sensors can be installed on critical equipment to monitor real-time conditions (work on 4 -20mA loop). The data collected by these sensors is sent to the CMMS, which can trigger alerts or generate work orders when certain thresholds are exceeded. Vibration sensor, Oil water content detector, Ferrous debris monitors, thermal imagine camera, RTD/ Thermocouples etc are few sensor that continiously sesne the parametrs and if a sensor detects unusual parameter in a ship's engine/ equipment, the CMMS can automatically issue a corrective maintenance work order.

(ii) *Automated Work Orders*. Condition monitoring data allows the CMMS to automatically create preventive maintenance work orders without manual input. This ensures potential problems are addressed before they result in equipment breakdowns.

(iii) *Vibration Analysis*. The CMMS platforms leverage predictive analytics to estimate when equipment might fail by analysing vibration data using fast fourier transform. This analysis allows the vibration recording at various point of the machinery in axial/vertical/ horizontal direction and then using the analysis database, conclude the probable cause of high vibration. For instance a 1X peak at any bearing component may attribute to loosness or mis alingment.

Fig 7. Sensor integrated with CMMS Condition Monitoring Module

(g) **Defect Monitoring in CMMS**. Defect monitoring focuses on tracking and analysing equipment failures or defects that occur unpredictably. This process helps in understanding failure patterns and improving future maintenance strategies. In addition, it also help to calculate MTBF and MTTR which constitute a majo part towards quantitative analysis.

(i) *Failure and Detect Codes*. Failure and detect codes are used to categorise and log different types of equipment failures, such as overheating and leakage. When a failure occurs, such as ship's engine overheating, the defect is logged into the CMMS using predefined failure codes. These codes help categorise the type of failure, which aids in diagnosing recurring issues.

(ii) *Data-Driven Maintenance* . By systematically categorizing failures with defect codes, organizations can transition from reactive maintenance to proactive strategies, improving overall equipment reliability. For instance, if multiple instances of overheating

are recorded for the same generator over a short period, the CMMS can flag this as a critical issue that requires immediate attention.

(iii) *Root Cause Analysis*. The system can store detailed information about each defect or failure event, allowing technicians to perform root cause analysis. This helps in identifying underlying issues that may not be immediately apparent from the initial symptoms. For example, if a ship's engine consistently fails due to overheating, RCA might reveal that the root cause is inadequate cooling system performance rather than just high ambient temperatures. This insight allows for more targeted corrective actions that address the core issue rather than merely mitigating its effects.

(h) **Record and Datakeeping**. CMMS allows to store and analyse the data recorded over the period of time. It helps to track the maintenance history, cost analysis, budgeting, asset performance through data analysis and visualisation. It can also help in optimisation of assets, inventory, cost, data by using the right optimisation technique of machine learning. Computatonal techniques can also be utilied towards quantitative assessment of risks and hazards, calcualtion of reliability matrixes like MTBR & MTTR.

7. **Advantages of Computerized Maintenance Management System (CMMS)**. CMMS have several advantages over manual maintenance monitoring systems as enumerated below: -

(a) *Enhanced productivity and Improved Efficiency*. CMMS systems streamline maintenance processes by automating scheduling and asset tracking. This reduces time spent on manual paperwork, minimizes delays, allowing operations to run more efficiently as technicians have quicker and easy access to work orders and documentations.

(b) *Cost savings*. CMMS can reduce maintenance costs by performing maintenance only when needed and helping avoid emergency repairs and unplanned downtime. This also reduces additional cost coming for unplanned spare ordering as it ensures right stock level and avoids overstocking.

(c) *Efficient use of resources*. CMMS optimizes the use and allocation of resources such as manpower, skill availability, task priority, spare parts etc It also ensures that the right resources are available when needed, preventing waste and reducing costs.

(d) *Reduced downtime*. With the integrated PPM and CBPM modules, it's easy to detect any potential defects and timely maintenance reduces unplanned downtime and equipment unavailability. This substantially contributes towards cost optimisation. Also, real time data acquisitions and alert mechanism allows user to address the faulty in advance.

(e) *Improved safety, health & Compliance*. The use of CMMS supports safety by tracking regular inspections, maintenance, Calibration and certification for critical equipment that could lead to accidents. It also ensures all tasks and management are caried out as per standards and regulations laid down.

(f) *Centralised Decision Making*. Ship owners can centralize all maintenance data in one system (cloud storage), making it easier to manage multiple vessels. It also allows to monitor performance across the fleet, track maintenance history, and assess the effectiveness of maintenance practices, leading to better overall fleet performance.

(g) *Reports and Records*. Reports and records generated can be helpful to visualise the data trend, provide insight to key metrics like MTBF, MTTR, asset utilisation, cost appreciation. ROI, ranging and scaling of spare parts etc.

8. **Challenges in CMMS**. Implementing a Computerized Maintenance Management System (CMMS) has several advantages, but there are also several challenges, such as the high cost, lack of crew training, employee and management's resistance to change from old systems to new one, and inadequate IT infrastructure. For the successful implementation of CMMS, it is essential to ensure that

(a) The organization has shifted from a reactive to a proactive maintenance approach, with the necessary policies and procedures in place.

(b) Employees understand that a CMMS is a tool, not a maintenance strategy, and know how to use it to support the organization's maintenance goals.

(c) The IT infrastructure is set up to provide reliable and fast access to the system.

(d) Senior management recognizes the value a CMMS will bring and is committed to supporting the project throughout its implementation.

(e) A well-planned change management process is in place to guide the transition.

(f) There are enough skilled personnel available to lead and manage the project

9. **Conclusion and Recommendations**. The maintenance of machinery on ships is critical to ensuring the operational efficiency, profitability, and efficiency. Several maintenance strategies, such as corrective, preventive, predictive, and condition-based, play essential roles in minimizing downtime and optimizing performance. While manual methods have been used, integrating advanced technologies have the potential for more proactive in maintenance processes, for example Computerized Maintenance Management System (CMMS). The implementation of a CMMS facilitates the centralization and automation of maintenance tasks. This integration can significantly reduce operating costs, improve asset reliability, and enhance overall fleet performance. To enhance operational efficiency and reduce maintenance costs, it is recommended for shipping companies to invest in CMMS. However, successful implementation requires overcoming challenges such as staff training, and resistance to change. Companies should prioritize developing a clear implementation plan, staff training, and ensuring the right IT infrastructure to maximize the benefits of these advanced maintenance.

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