PÎRÎ REİS UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEEERING

IMPROVEMENT OF PLANNED MAINTENANCE SYSTEM ON BOARD SHIP

MASTER THESIS

Önder AYDIN (138013006)

Maritime Transportation and Management Engineering

MS Program

2016- 2017 Fall Term

Thesis Supervisors: Assoc. Prof. Dr. Metin ÇELİK, Asst. Prof. Dr. Dinçer BAYER

01-2017

This page is left blank

Önder AYDIN, M.Sc. student of Piri Reis Maritime Transportation and Management Engineering student ID 138013006, successfully defended the thesis entitled "IMPROVEMENT OF PLANNED MAINTENANCE SYSTEM ONBOARD SHIP" which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

APPROVED BY

Assoc. Prof. Dr. Metin ÇELİK (Advisor)……

Asst. Prof. Dr. Dinçer BAYER (Advisor).....

COMMISSION

Prof Dr. Süleyman ÖZKAYNAK :……..…….

Asst. Prof. Dr. Kadir ÇİÇEK :……..…….

Asst. Prof. Dr. Kadri ÖZDEMİR :…….

DATE OF APPROVAL: 19 / 01 / 2017

This page is left blank

To My Daughter "NİSAN"

This page is left blank

ACKNOWLEDGEMENTS

The research presented in this thesis was carried out at the University of Piri Reis during the years 2015-2017. I express my gratitude on my supervisors Assoc. Prof. Dr. Metin ÇELİK and Asst. Prof. Dr. Dinçer BAYER for providing guidance and pushing me forward during my research.

Achieve of this goal I would like to express my grateful thanks as currently office employee to the support and tolerance to Mr. Bülent DANDİN as owner of Statü Chartering and Trading Ltd. Company. In addition, all experiments and experiences during my thesis, I would like to note that the data obtained by our company vessels.

Also, I would like to express my grateful thanks for the great contribution for thesis completion and implementation of created solutions with designed NAVATOM Ship Management Software to Mr. Mehmet ÖNDER, Mr. İsmet ÖZALP, Mr. Özgür AYDINLI as founders of HIVE AS.

This page is left blank

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABS	American Bureau Shipping
AHP	Analytic Hierarchy Process
CBM	Condition Based Maintenance
CEDAC	Cause and Effect Diagram with The Addition of Cards
CM	Condition Monitoring
CMMSs	Computerized Maintenance Management Systems
FAHP	Fuzzy Analytic Hierarchy Process
IACS	International Association of Classification Societies Ltd
ICOR	Input, Control, Output, Resource
ILO	International Labour Convention
ISM	International Safety Management
ISPS	International Ship Port Security
MCDM	Multiple Criteria Decision Making
MLC	Maritime Labour Convention
MOU	Memorandum of Understanding
MTBF	Mean Time between Failures
OEE	Overall Equipment Effectiveness
PCS	Port State Control
PIC	Person in Charge
PIC	Person in Charge
QHSE	Quality, Health, Safety, Environment
RCM	Reliability Centered Maintenance
S/B	Stand By
SMM	Strategic Maintenance Management

SMPM	Ship Maintenance Performance Measurement
SMS	Short Messaging Services
SOLAS	Safety of Life at Sea
SPC	Statistical Process Control
TMSA	Tanker Management and Self-Assessment

ABSTRACT

Planned Maintenance System is the backbone of any shipping organization that aims for higher safety and performance values. The obligatory rules and regulations and insurance pressure also forces their hand on higher standards in proper maintenance onboard vessels. The improvement of such systems requires process analysis methods that are easier to run via software contribution. Furthermore a broken system or failure to abide by a given system could result in incidents that would be reflected in the revenue of the company. As in all other industries, it is of utmost importance that the maintenance costs can be controlled and minimized in the maritime industry. This aim can only be achieved with planned maintenance system which was created modern, sistematic and inovative approaches.

This research aims to define and analyze to the planned maintenance systems and choose optimum decisions for ship maintenance.

Key Words: Onboard Planned Maintenance System, Software Contribution, Process Analysis Methods

ÖZ

Planlı Bakım Sistemi, yüksek emniyet ve performans değerlerini hedefleyen tüm denizcilk şirketlerinin belkemiğini oluşturur. Kurallar, yönetmelikler ve sigorta şirketleri nin baskısı gemilerde uygun, yüksek standatlarda bakım yapılmasını zorunluluk kılmakadır. Bu tür sistemlerin geliştirilmesi, yazılım katkısı ile çalıştırılması daha kolay olan süreç analiz yöntemlerini gerektirir. Ayrıca, hasarlı bir sistem veya kurulmuş bir sistemin gereklerine uyulmaması şirketin kazancına yansayacak kazalara sebeb olacaktır. Tüm endüstrilerde olduğu gibi denizcilik endüstrisinde de bakım masraflarının kontrol altına alınması ve en aza indirgenmesi büyük önem taşımaktadır. Bu amaca ancak modern, sistematik ve yenilikçi yaklaşımlar getiren planlı bakım sistemi ile ulaşılabilir.

Bu araştırma planlı bakım sistemlerini tanımayı, analiz etmeyi ve gemi bakımlarında en uygun kararları almayı amaçlamaktadır.

Anahtar Kelimeler: Gemide Planlı Bakım Sistemi, Yazılım Katkısı, Süreç Analiz Metotları

1. INTRODUCTION

1.1 An Overview

Technical Management and mainly planned maintenance is the single most problematic and major challenge organizations face during their day to day operation. The challenge rises accordingly as the organization strives to increase their service quality. Many companies try to implement preventative maintenance techniques to tackle this issue. The issue is two-fold as companies see planned maintenance and its operation as a costly operation, whereas the outcome of such operation is an increase in the value of the company itself and the increase in the life of its vessels and their equipment's. In modern industrial organizations, maintenance departments play an important role because of their economic balancing effect [1].

The second problem is that the management of the companies do not speak the same language as the staff in the maintenance causing conflict. This is an indication that there is a requirement to build a reliable and detailed yet simplified maintenance system. The said system should include all necessary items as described in their technical manuals and according to rule-makers guidelines and the experience of the company officials and crew members. However, effective planned maintenance is related to performance. It may also be related to the maritime industry's critical nature in terms of safety [2].

The mere adaptation of rules and guidelines and calling it a system is not enough in contemporary marine industry. A system must be applicable with the available resources. The resources themselves should be available for the system to work properly. The crew members and company officials should be trained accordingly. But most importantly the system itself should be analyzed and tweaked to run efficiently to real life scenarios using proven process improvement techniques. Accidents and disruptions in most practical applications at many industries are due to insufficient maintenance planning [3].

The maritime industry faces unique challenges during planned and unplanned maintenance. Supply chain management is crucial for ships that spends significant periods under the sea impact (e.g., labour and availability of resources) [4].

Another problem is safety and the environment where inadequate maintenance is caused by dangerous operations and environmental damage [5].

The factors influencing the performance of the maritime shipping organization along with their related arising issues are to be used to develop a ship maintenance performance framework (SMPM).

1.2 Why We Are Doing Maintenence

The cost of maintenance for many different companies in the industry is quite high. Maritime organizations are one of the industries that have to allocate the most budget for maintenance costs. Approximately 40% of the operating costs of maritime shipping companies consist of maintenance costs [6].

Inadequate planned maintenance can result in serious accidents [3]. Due to the reasons mentioned, it is important to examine the planned maintenance issue and to find factors that affect it, so that maintenance expenditures can be optimized and the occurrence of serious events reduced.

In general, it is intended to emphasize the importance of improving the maintenance performance of maritime companies that affect their profitability. In this research, also, worked on determining the factors that influence the planned maintenance system.

This can be achieved by defining the needs for the assessment of the optimization of maintenance planning for the maritime industry and by evaluating the improvement of maintenance performance.

This study, focuses on defining the main factors affecting maintenance planning aiming to improve the maintenance methodology framework and optimize ship availability.

Based on their professional background, research authors have introduced a wide range of different definitions of the term "maintenance". Some of these definitions are shown below by way of example.

- Maintenance is a qualified work that is repeated regularly so that we can always use machines wherever they are needed [7].
- Maintenance is a process that ensures the continuity of production without interruption [8].
- Maintenance is a business that ensures the continuity of production tools & equipments with optimum costs [9].
- Maintenance is a business that keeps the factory machines and facilities in continuous operation [10].

- Maintenance is an activity that ensures that the machines remain in continuous operation [11].

The maintenance costs in the UK manufacturing industry (as an example) are 12-23% of total operating costs [12]. Dekker (1996) stated that maintenance costs in various refineries accounted for about 30% of total staff costs. In the mining industry, maintenance costs are between 40% and 50% of the total operating cost [13]. Alhouli et al. (2009) reported that maintenance costs were 40% of the running cost of the ship, based on data from a six-year-old bulk cargo ship of 75,000 tons. For these reasons, how to optimize the large maintenance costs are anticipated should be considered considered.

The benefits of an effective maintenance procedure are stated as below;

- The asset remains in operation and the risks of sudden failure are eliminated,
- Ensures that the existing asset is operational in case of instant needed,
- It increases the security level for the safety of machine operators,
- Facility increases reliability by providing less time loss when repaired, less interruption in operations, less variability in output rates and more reliable service,
- Due to the high standards of well-maintained equipment, problems with quality can be avoided.
- Potential operating costs are reduced when maintenance is carried out at regular intervals.
- Longer machine life; Reducing the number of problems that will cause wear or deterioration by regular maintenance during operation will prolong the effective life of the machines.
- Higher sales value; The value of the well-maintained facilities and machinery in the second hand market is higher.

1.3 Aim and Objectives of the Study

The aim of this thesis was to develop a framework to aid decision makers in the maritime shipping industry to optimize maintenance planning for their organizations.

Accordingly, the main objectives of this research project are summarized as follows;

a. To identify the need and importance of maintenance with a specific focus on the maritime industry; and to extract and assess the factors that affects the decision-making process for ship maintenance planning.

b. To evaluate and compare the different maintenance types for indicate best practice planning maintenance per different situations.

c. To investigate the implementation principles of the ship planning maintenance system onboard and support of the software to operationally of planning maintenance system.

d. To identify basic & advanced tools of process analysis and improvement for using of developing maintenance planning system onboard.

e. To develop a more suitable planning maintenance system onboard ship.

1.4 Thesis Organization

The thesis is divided into five chapters, starting with the broad study of the maintenance subject and its importance to maritime industry. The contribution of maintenance software for the maritime shipping industry emphasized. Also, the ship maintenance system and implementations principles are overviewed. After that tried develop ship maintenance software with one of the convenient advanced process maintenance tool. Finally, Conclusions and Recommendations & Considerations for Future Researches are detailed.

In the first part of this thesis was introduced the importance of need for maintenance in the maritime industry. Overviewed the definitions of the maintenance had been emphasized by the different authors.

Then after inside the second part of thesis literature review on ship maintenance has been completed, also maintenance types covering all industry had been reviewed. Maintenance types comparison had been done. Utilization of software for maintenance of maritime industry are investigated. Planning of ship repair and maintenance and sub process are investigated regarding to figure out shortfalls of current implementations of onboard.

For fixing to figure out shortfalls of current implementations of onboard, process improvement tools and techniques has been reviewed at the third part of thesis. Initially basic tools of process improvements are explained. Finally, advanced tools of process improvement techniques have been investigated to find out most convenient process improvement methods for preventing of mentioned shortfalls of current implementations onboard.

Finally modelling of the problem was structured at the fourth part of thesis. Regarding to fixing of problems with process improvement methods as mentioned in part three ICOR had been found most convenient advanced tool.

In the last part of the thesis, results of this study had been reviewed. Also, contribution to knowledge had been identified. Emphasized to recommendations and future research inside of this part.

1.5 Research Question

To keep the ship operating safely and efficiently with the lowest possible operation cost, ship maintenance is a must, due to many factors. Furthermore, the maintenance planning and its costs have great precaution, therefore the factors that affect the PMS for the planned maintenance optimization are vital to ensure that the maritime companies will save a lot of money.

With these considerations, research question of this thesis is defined as to develop a cost effective maintenance framework for ships.

In addition, in this study, weaknesses were determined based on the results of sector analyzes, company experiences, survey results, so that planned maintenance can be carried out most effectively. It was aimed to develop a planned maintenance system by improving these weaknesses. In this context, contribution of software usage had been investigated for planned maintenance system. Process analysis methods and their contribution to the identification and development of the weaknesses of planned maintenance have been examined.

Analyzes of the solutions of the identified weaknesses have been carried out to reveal the results. Planned maintenance system companents developed with software support have been analyzed.

Finally, in order to further improve the planned maintenance system of the current application, it has been determined by investigating what needs to be done in the future.

In the last part, in order to solve real problems that are present in practice; Company organization, crew competence and training, the quality and characteristics of the equipment used on board, initial design stage of the ship, and how the maintenance requirements of ship equipment can affect the planned maintenance system has been analyzed.

This page is left blank

2. LITERATURE REVIEW ON SHIP MAINTENANCE

In the literature, different authors categorized the maintenance into various ways based on the continuity of an ongoing process. Some authors classify maintenance based on different strategies [14], and ohers have categorized the maintenance according to the policy to be realized in different ways [15] and [16].

2.1 Ship Repair and Maintenance

Ship designers and shipowners review their plans for preventive maintenance by agreeing with the class organization that plans for surveys after construction can be considered in accordance with the class requirements [16].

In order to maintain the highest level of availability of the ship, each component of the ship maintenance schedule should be planned separately in the maintenance program. If one of the main components does not work, maintenance will be required. The ship will be considered out of service.

Ship repair and maintenance can be completed in two different ways.

- When ths ship is in dry docking for the control of the underwater areas of the ship with classification surveyor at shipyard.
- Day-to-day maintenance can be performed during normal operations of the ship.

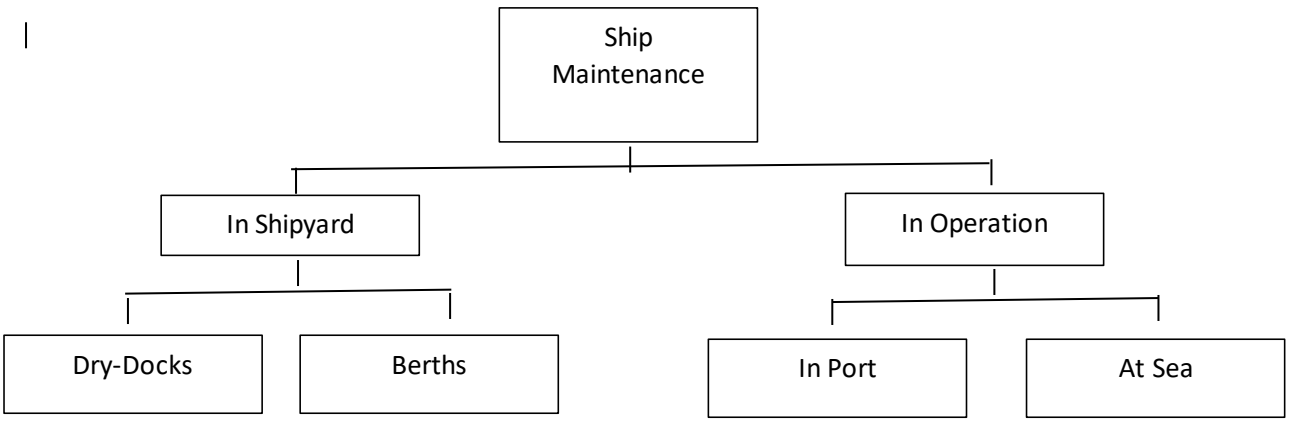

Figure 2-1: Maintenance and Ship Repair

Ship maintenance can be done in different locations. For example, when the ship is in the dry dock for the major overhaul is needed, when the anchor palce at the anchorage at sea, and when the ports require medium-sized maintenance. In addition, vessels of different types and sizes may have to use different shipyards [17].

Ship maintenance policies are typically of two types, such as those in other industries, are breakdown maintenance and preventive maintenance. Breakdown maintenace policies are generally carried out without any preventative maintenance, other than making the necessary lubrication and minor adjustments. Preventive maintenance involves maintenance to reduce the number of failures, which are time-based or condition-based maintenance.

Maintenance work on any machine or equipment in the ship consists of four tasks as shown below:

- Inspection: Visual inspection to determine the condition of the machine or equipment,
- Minor overhaul: Repairing some parts of machinery and equipment,
- Major overhaul: The machines and equipments are dismantled complately and, the necessary parts are renewed and mountback as properly,
- Survey: Inspection and necessary measurements of machinery and equipment usually carried out under the supervision of the classification society in major repair of the vessels.

Ship major maintenance can be carried out in the shipyard dry-dock, which is necessary for the maintenance of the underwater areas of the ship. The vessels usually enter the shipyard once every two and a half years under the intermediate classification survey and once every five years under the special classification survey. During the shipyard maintenances mentioned above, the major refurbishments are usually completed to ensure that the machinery and equipment are brought to their original condition. In the shipyards, typically 75% of the jobs are involves of routine ship maintenance. The remaining 25% of the jobs involves damage repair and ship conversion [18].

Ship repair works can be categorized in an increasing order of scale and cost:

- Voyage repairs (minor and continuous repairs); These are the maintenance that can be done during the navigation of the ship.
- Routine docking (underwater work); These are the specific maintenance which requires the vessel in the shipyard and docking facilities.

- Major repairs (typically steel); This kind of repairs mostly carry out under the shipyard facilities.
- Damage repairs (usually steel); There are various type o f damages onboard of vessel such as engine breakdown, electirical failure, the damages are occurred result of the accidents.
- Refit and conversion; Conversion repairs are made for the purpose of operating the vessel for purposes other than the purpose of the initial construction.

2.2 Maintenance Types

Since the different types of industries have various operational principles and structural characteristics, adopting an appropriate maintenance system requires elaborative systematic approaches. For shipboard systems, the pressures of the operational constraints, safety-related expectations, and environmental concerns in global perspective increase the complexity of the problem. Although studies for planned maintenance system on off-shore and maritime systems are limited in the literature, a wide range of research papers are proposed in different fields such as manufacturing, chemical plants, power plants, nuclear systems, etc. In this context, Wang et al. evaluated different maintenance strategies in power plant systems component by using Fuzzy Analytic Hierarchy Process (FAHP)[1] as Multiple Criteria Decision Making (MCDM) method under fuzzy environments. On the other hand, Bevilacqua and Braglia proposed traditional AHP[2] (Analytic Hierarchy Process) methodology in order to select the best maintenance strategy for an oil refinery processing plant. Another paper was introduced by Mechefske and Wang. In the paper, a fuzzy linguistic approach adopted to achieve the subjective assessments of maintenance strategies and managing practices. Furthermore, Labib developed a different systematic model under fuzzy environment for aiding the computerized maintenance management systems (CMMSs) in execution process. Additionally, Pintelon et al. developed a framework to identify and evaluate the effectiveness of maintenance strategy. Another study was performed by Zeng who performed a sensitive analysis through robotic car assembly lines to introduce optimum maintenance strategy. On the other hand, a detailed

[1] Fuzzy analytic hierarchy process (AHP) proves to be a very useful methodology for multiple criteria decision-making in fuzzy environments, which has found substantial applications in recent years. The vast majority of the applications use a crisp point estimate method such as the extent analysis or the fuzzy preference programming (FPP) based nonlinear method for fuzzy AHP priority derivation [19].

[2] The **analytic hierarchy process** (**AHP**) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then [20].

investigation was conducted by Waeyenbergh and Pintelon. In the research, the authors overview benefits and shortfalls each maintenance strategy [21].

Different maintenance approaches are listed below.

2.2.1 Corrective Maintenance

Traditional maintenance activities are often referred to as repairs in the event of an accident or in the event of an equipment or machine malfunction as an expected event. Corrective maintenance is maintenance to detect, isolate and correct a fault so that the faulty equipment, the machine or the system can be restored to the desired operation [22].

2.2.2 Run to Failure

Run to failure can be used as a maintenance management method, in summary, no repair is performed until an equipment or machine is completely destroyed. Is the main philosophy of the "correct if not a problem" method [22].

A synonymous description is run to break down.

2.2.3 Run to Destruction

Another alternative is the maintenance method that run to destruction. It is necessary to change the machines or equipments when they becomes completely broken down [22].

For example, any of the two methods on board can be applied to the redundent ciculation pump functions e.g. in a fresh water system. In cases where it is often necessary to repair or replace in order to be able to operate it, it is used without notice in place of each other in the case of Run to failure, run to break down, and run to destrution.

2.2.4 Planned/Preventive Maintenance

Planned/preventive maintenance can be defined as systematic inspection, detection, correction and prevention of faults before actual or major failure. Preventive maintenance is based on the calendar times of the objects or on actual working hours. The maintenance intervals are determined based on the calculation of the average failure times between the two maintenance periods (MTBF), [23].

For example, planned preventive maintenance activities on ships are used for propulsion systems and auxiliary machinery.

2.2.5 Condition Based Maintenance (CBM) / Predictive Maintenance

The CBM maintenance method is the maintenance method used to eliminate faults detected by Condition Monitoring (CM). CM is defined as continuous or periodic measurement and interpretation of data to determine the need for maintenance of objects. Monitoring is performed when the object is running, the corresponding data is collected [22]. The object on which the CBM activities are carried out on board, for example, a data taken from a rotating shaft in the turbocharger. According to the vibration check CM shows that a bearing needs to be changed.

2.2.6 Opportunistic Maintenance

Opportunistic maintenance is the kind of maintenance done for other objects in the system when the system does not work, often done with the opportunity, along with the unplanned activity [22]. Opportunistic maintenance can also be achieved in conjunction with planned maintenance of other objects [24].

An example on board is when overhauling a purifier, all wear and tear parts are replaced,

Despite their actual status at the time for the scheduled overhaul of the main parts.

2.2.7 Reliability Centered Maintenance, RCM

RCM (Reliablity Centered Maintenance) is a methodology that is planned with a qualitative risk-based method in order to find the optimum balance between preventive maintenance, periodic maintenance and corrective maintenance.

When evaluating the maintenance strategy of assets that are part of the technical system, these functions and related performance standards are first assessed [25]. Assets are classified in primary and secondary functions and maintenance activities are structured accordingly.

The malfuction are classified into four categories according to their results.

- Consequences of hidden failures
- Consequences of safety and environmental.
- Operational consequences
- Non-operational consequences

Secondary functions and maintenance of objects that do not produce operational consequences are treated with a less stringer maintenance methodology; Some equipment can be classified as run to failure rather than maintenance [25].

2.2.8 Total Productive Maintenance (TPM)

TPM was first developed in Japan in the 1950 by Dr. Deming (Wireman 2004). It is systematic implementation of maintenance with small group activities and by all employees. TPM is a production-oriented approach that requires production and maintenance staff to work together, emphasizing the importance of people.. It is an important part of a general manufacturing philosophy. The benefit of the TPM is the overall equipment efficiency (OEE) improvement calculated by Nakajima [26] as;

OEE = Availability (%) x Performance (%) x Quality (%)

Availability: is the operating time as a percentage of the total available working time. Performance: is the ratio of the actual production to the maximum production.

Quality: is the ratio of good products to the total production.

The aim of the TPM is following;

- Improving equipment effectiveness
- Daily maintenance involving operators
- Improving maintenance efficiency and effectiveness
- Training and educating of the personnel
- Designing and managing equipment for maintenance prevention

2.3 Comparison of Different Maintenance Approaches

Maintenance can be done with different types of strategies. This depends on the most appropriate approach that can be used and on the situation in which the strategy is most appropriate for the process.

Even though the unplanned maintenance method is an expensive maintenance strategy, it may be more appropriate to choose this approach in some cases.

Preventive maintenance can be time based or condition based. The advantages of condition based preventive maintenance over on time-based maintenance is that it avoids unnecessary work based on circumstances. The preventive maintenance approach has the advantage of avoiding costly repairs, system or process errors that lead to costly interruptions.

Reliability and maintenance approaches are designed for specific systems or processes. For example, RCM is usually used for maintenance in the aircraft industry. TPM is designed for maintenance and protection of the production system.

It can be seen from these types of maintenance that in some cases the maintenance can be carried out with more than one approach and more than one approach should be used to achieve the optimum result; This is the case in the maritime shipping industry, Because maintenance must be used in combination with different maintenance approaches to achieve optimal maintenance outcomes.

2.4 Ship Maintenance System

The planned maintenance system ensures that to be sure the vessels and equipment are safe to operate on the basis of the intended use, in accordance with international maritime and environmental protection regulations.

2.4.1 System and Implementation Principles

A maintenance plan is a key component of all vessels. Every ship needs a maintenance plan. If a vessel has a SMC (Safety Management certificate) certificate[3], she has to have a maintenance plan. An officer can use this plan as the starting-point for the development pf maintenance procedure for the vessel. Respectively it can be reviewed as below outlines; [27].

1. What Should Be the Main Objectives of a Maintenance Plan ?
2. How Maintenance Plans Help People to Manage Their Maintenance ?
3. How is The Maintenance Plan Made and Implemented ?
4. The Maintenance Log – Recording Further Actions.
5. Record of Maintenance Plan Amendments.
6. Maintenance Providers and Shore-Side Contractors [27].

The main purpose of any maintenance on the ship maintenance and repair work as soon as possible to make the minimum cost. For this reason, comply with the ship's planned maintenance system to ensure that ship machinery and equipment operate safely on particular standards. The maintenance plan is an integral part of the routine operations of the ship and is an integral part of the maintenance mechanism.

When preparing the maintenance plan for the vessels, the manufacturer's instructions for existing equipment and machinery, especially the International Safety Management Code (ISM)[4], are taken into account.

[3] Safety Management Certificate means a document issued to ship which signifies that the Company and its shipboard management operate in accordance with the approved safety management system [28].
[4] The **International Safety Management (ISM) Code** provides an international standard for the safe management and operation of ships at sea [29].

As mentioned previously, the main objective of the maintenance plan is to ensure that the a maintenance carried out shortest time is at optimum cost with the best efficiency. The various aspects mentioned in the ISM code are considered together with company procedures and manufacturer's instructions. Other aspects include the type of ship, the condition of the ship, and the age of the ship.

The maintenance plan helps by listing all the items that need to be checked at a ship with the inspection periods. The control periods can be each voyage, weekly, monthly, 3-month, 6-month, or yearly.

It also:

- The maintenance plan includes hull, decks, superstructure, machinery, equipment and critical shipboard systems.
- The planned maintenance system includes routine maintenance and the control periods for these maintenance
- The planned maintenance system should include maintenance record, who completed it, what it does during maintenance, and what to do in the future.
- The planned maintenance system should include maintenance requirements for the ship for the next 5 years.
- The planned maintenance system should show the list of preferred maintenance companies and onshore maintenance contractors.

The following steps must be taken into consideration in order to form a strategic approach together with an effective planned maintenance system;

- Determination of the problem
- Establishment of conditions
- Proposal of research solutions
- Evaluation of the solution to the problem
- Implementation of the solution
- Assessing of effectiveness
- Solving

Maritime organizations should consider the following considerations when developing a planned maintenance procedure for a particular ship;

- Maintenance instructions issued by the manufacturers of ship machinery and equipments
- Corrective measures taken with records of faults, defects and damage of ships machinery and equipment
- ISM code requirements
- The age and condition of the ship
- Records of external audit report
- Maintenance intervals of existing equipment at the ship
- Critical equipment and systems on board

A systemic approach will be provided for the creation of the maintenance plan under the light of above. While establishing the ship maintenance procedure, nothing has to be missed.

The following steps should be taken into account when establishing the ship maintenance procedure,;

- Establishment of machine and equipment maintenance intervals
- Inspection method and frequency by the ship's office authorities
- Determination of the characteristics of the inspection of the ship
- Measurement methods and evaluation methods to be used
- Establishing the criteria by determining the level of acceptability
- Appointment of appropriate personnel for ship inspection activities
- Clear definition of ship inspection report requirements and mechanisms

The maintenance interval of ship machinery and equipment constitutes the most important element of the maintenance plan. The maintenance intervals determined in the maintenance plan are prepared taking into account the following factors.

- Manufacturer's reccomendations with specifications of ship machinery and equipment
- Techniques for determining existing predictive maintenance on board
- Practical experience and advice of the engineers and crew who make maintenance of the ship machinery maintenance
- Type and rate of failures obtained from the results of routine inspections
- Periods of use of ship machinery and equipment; Continuous, intermittent, standby, or emergency.

- Practical and operational constraints stemming from ship's conditions
- Internal guidelines set as part of the company's requirements, conventions, administration and classification,
- The need to regularly test the existing standby systems on board.

Finally, the following steps must be taken to establish a planned routine audit procedure;

- Criteria for auditing
- Use of appropriate measuring and testing devices for inspection
- Calibration of measuring and testing equipment,
- The type of inspection and test to be employed – visual, vibration, pressure, temperature, electrical, load, water tightness [27].

The systematic and planned maintenance procedure constitutes an integral part of the planned maintenance system of the ship in the light of the above.

For inspection of vessels, checklists are used for checking, testing and maintenance according to manufacturer's instructions, company recommendations and ISM code. [27].

The maintenance log is where PIC (Person in charge) record any; [27].

- When PIC completes scheduled maintenance and controls, marked with checked mark defined in the scheduled maintenance procedure.
- The extra maintenance and controls that must be performed by PIC are to ensure that the ship is operated safely and that environmental pollution is prevented.

The reference row and column in the maintenance record are used to simplify the follow-up of subsequent processing of the controlled item.

The record of the progress (through to completion), any maintenance log items are kept. PIC initials and the date in the ‘action checked’ are added to the column once PIC have completed an item. If any changes have been made to ship’s maintenance plan are record properly. Maintenance plan should be updated if subject vessel has following conditions;

- If a major repair or modification has been made,
- If the existing "certification scope" of the ship has been changed temporarily or permanently,
- If the ship's carrying capacity is significantly increased [27].

Any changes has been made in to the maintenance plan are signed with related date.; however, these changes are not compulsory to be approved by the surveyor.

Recognized surveyor can advise to ship' representative to plan-scheduling either a monthly or a yearly basis, if any items in the maintenance log need to be added or removed in to the maintenance.

Maintenance Providers and Shore-Side Contractors are a list of contact details for the providers has been used to service the machinery and equipment on the vessel. This lists usually are kept up-to-date and to ensure that to contact ship's providers in advance, so that ship's maintenance gets done on time [27].

2.4.2 Software Support to Maintenance

Future trends in ship management include further consolidations, increased measures for higher competitiveness and investments in innovations that support safe, efficient and reliable operations, including fuel efficiency and compliance with more stringent environmental regulations. Increasing the efficiency of inspections and maintenance efforts is crucial, keeping costs of spare parts and repairs down while complying with all rules and regulations. To keep on top of these challenges, it's important to have the right information available at the right time, keeping track of important processes and also keeping troubleshooting to a minimum [30].

Software support for management of planning maintenance system are as following items;

1. Ship Management Software
2. Ship Management Technical - Simplify and Optimize Technical Fleet Management
3. Ship Management Procurement - Increase Efficiency in Their Purchasing Process
4. Ship Management QHSE - Increase Quality and Safety of Operations
5. Ship management Projects - Project Management System
6. Ship Management Hull - Advanced Hull Integrity Management
7. Ship Management Analyzer - Business Intelligence for Fleet Management

Ship management software provide their needs within technical, operational and compliance aspects, with solutions for technical management, procurement, hull integrity management, dry docking, QHSE, crewing and finance [30].

Ship management technical software is the technical management system for planned and unplanned maintenance, defect reporting and technical asset and data management [30].

A software system that supports purchasing departments and allows them to streamline the complete scope of maritime procurement activities for all spares, services, stores and consumables and other items. Improved information management ensures that crew and office are working with the same information, and always know the status of requisitioned items [30].

Ship management QHSE software helps to reduce the administrative burden of relevant shipping industry regulations, such as ISM/ISPS, SOLAS, TMSA, classification rules, vetting inspections or Port State Control. At the same time, it supports those related regarding compliance with those rules and regulations.

A project management system that supports dry-docking and other technical projects such as retrofitting with planning, tendering and project management. It allows those related to manage a complete dry docking project from work item collection, via quotations management and actual dry dock work. Responsibles can easily re-use groups of work items or templates for types of work and build electronic knowledge library on their dry dock projects [30].

Optimize the ship hull maintenance schemes - not only to save cost in the next drydocking, but also to reduce the probability of structural failures, off hire and risk of pollution. Ship

management software available - for inspection planning and reporting, condition assessment, hull maintenance strategy and documentation [30].

Ship management analyzer extracts fleet data from the other Ship Manager modules for analysis, allowing those related to monitor key performance indicators (KPIs), compare costs and performance of the vessels [30].

3. PROCESS IMPROVEMENT AND ANALYSIS

Process Improvement is the act of making any business process or procedure more effective, efficient, or transparent.

Process improvement helps organizations decrease costs and increase efficiency in the short term. This means that more revenue and growth for companies, as well as increased speed, efficiency and organization. In the long run, process improvement helps create competitive advantage by improving organizational agility.

Process improvement provides benefits to the following issues;

- Increased accountability: One of the primary goals of instituting a process improvement program is to provide greater accountability for departmental functions and ensuring deliverables are met. A company can achieve a system of checks and balances, minimizing the potential for fraud, errors, or loss, and affirming that all employees are aware of their responsibilities.
- Improved reliability: It is critical for executives to receive accurate information when needed in order to make important and time-sensitive busied decisions.
- Simplified regulatory compliance: Process improvement practices help organizations keep track of their obligations, and ensure that they are in compliance with applicable standards and legislation. By following clearly outlined processes and staying up-to-date on changing law, companies can avoid potentially costly repercussions of noncompliance.
- Waste avoidance: Since process improvement involves assigning and tracking resources and performance. There is generally less waste than in companies that do not actively monitor their processes. Organizations that follow best practices will find that they can dramatically reduce waste, enhance efficiency, and ultimately, boost profitability.
- Enhanced safety and security: Organizations can help ensure safety of their employees and protect the company from various other treats, including theft of company assets such as physical resource and confidential information by documenting processes and mandating full compliance with them.

In order to assist professionals in combating the common pitfalls associated with making this leap, we created the process improvement manifesto, a listing of core values.

- Agility: Process improvement values agile and iterative improvement. Because change is inevitable, organizations that wish to continually improve must be able to nimbly adjust to take advantage of emerging opportunities
- Quality: Organizations that understand and focus their attention on all facets of quality, from beginning of transformation initiatives to the end.
- Leadership: Leaders who communicate and inspire a clear and compelling vision for the future have teams that are more engaged and open to improvement opportunities.
- Communication: An organization that recognizes that everyone has a point of view and should have the opportunity to voice opinions, ideas, and experiences is generally more innovative in its improvement designs.
- Respect: Successful organization capitalize on the diverse backgrounds, knowledge, skills, creativity, and motivation of their workforce and partners.
- Discipline: Ensuring a disciplined approach to all process improvement activities help ensure thorough and robust solutions are implemented.
- Enterprise perspective: Ensuring process improvements meet not only the needs of those involved with the activities in question, but also the larger enterprise ensures time and money are not wasted deploying and redeploying solutions.
- Service orientation: Process improvement activities provide a service to companies, departments, sponsors, individuals, the community, the consumer, and the profession.
- Continuous learning: The primary objective of training is to provide all personnel, and suppliers with the skills to effectively perform quality process activities, and to build this concept directly into an organization's operations. This practice enables continuous learning within the organization and promotes improvement and process-oriented thinking.
- Human-centered design: Ensuring processes are user friendly for those are executing their activities helps maintain positive morale.

Depicted above descriptions like as below figure;

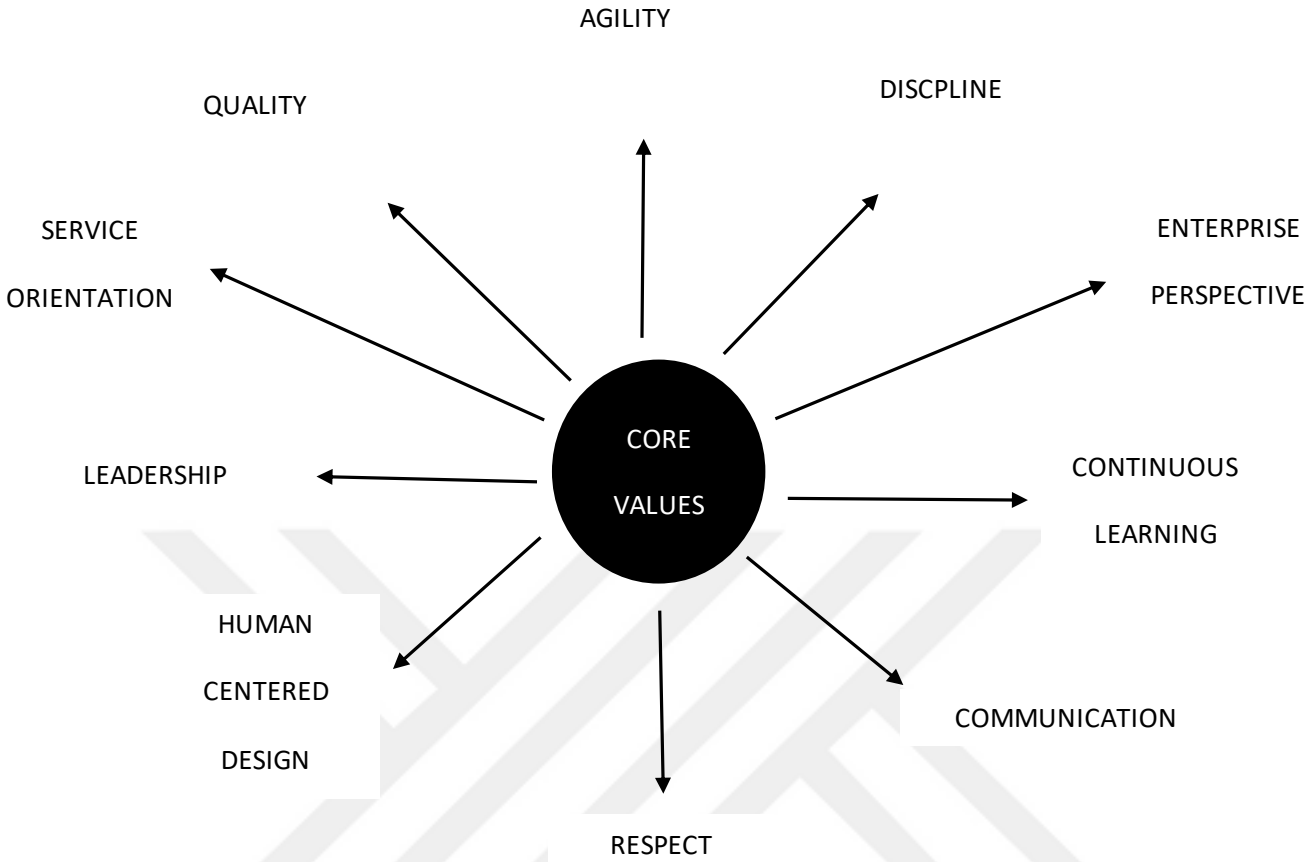

Figure 3.1 Core Values of Process Improvement

Standardization is an important part of process improvement because it maximizes efficiency and minimizes waste. Using standard forms or documents endures that workers always know where to find the information they need do their jobs, without wasting time or energy. Standard tools and equipment provide that workers know how to do their jobs without requiring training as they move between workstation (ships), facilities, or task.

Standardization include that followings;

- Creating an enterprise-wide glossary to reduce interdepartmental communication problems
- Using templates to speed up documentation processes
- Creating templates within a facilities environment so that all parts are the same and easy to convert between parts or size.

Think of a successful organization, regardless of industry. One of the measures of its ultimate success is its agility, whether it manages to stay at least one step ahead of its market or

competitors. Achieving real alignment, where strategy, goals, and process improvement reinforce one another, gives an organization a major advantage because it has a clearer sense of what to do at any given time, and employees are able to constantly move in the right direction. The result is an organization that can focus less on deciding what to do and more on simply doing, improving, and evolving.

As organizations improve and standardize their systems and business processes to maximize productivity, they should also follow a structured approach that will lead to consistent, predictable, and reliable solution design and performance improvement. Deploying a common process improvement framework offers a consistent life cycle to stakeholders as process improvement projects are executed.

Several benefits of developing a process improvement framework include;

- Providing strategic planning and communication
- Providing a common approach to building business cases and proposing improvements
- Focusing attention on the most important improvements and their benefits
- Managing, identifying and mitigating the risks associated with process improvements and the realization of their benefits.
- Increasing productivity through improvement initiatives and quality
- Creating flexibility in solution management
- Improving teamwork
- Ensuring proper accountability is in place for improvements
- Providing a mechanism for independent review or audit

The phases of the process improvement, are as below;

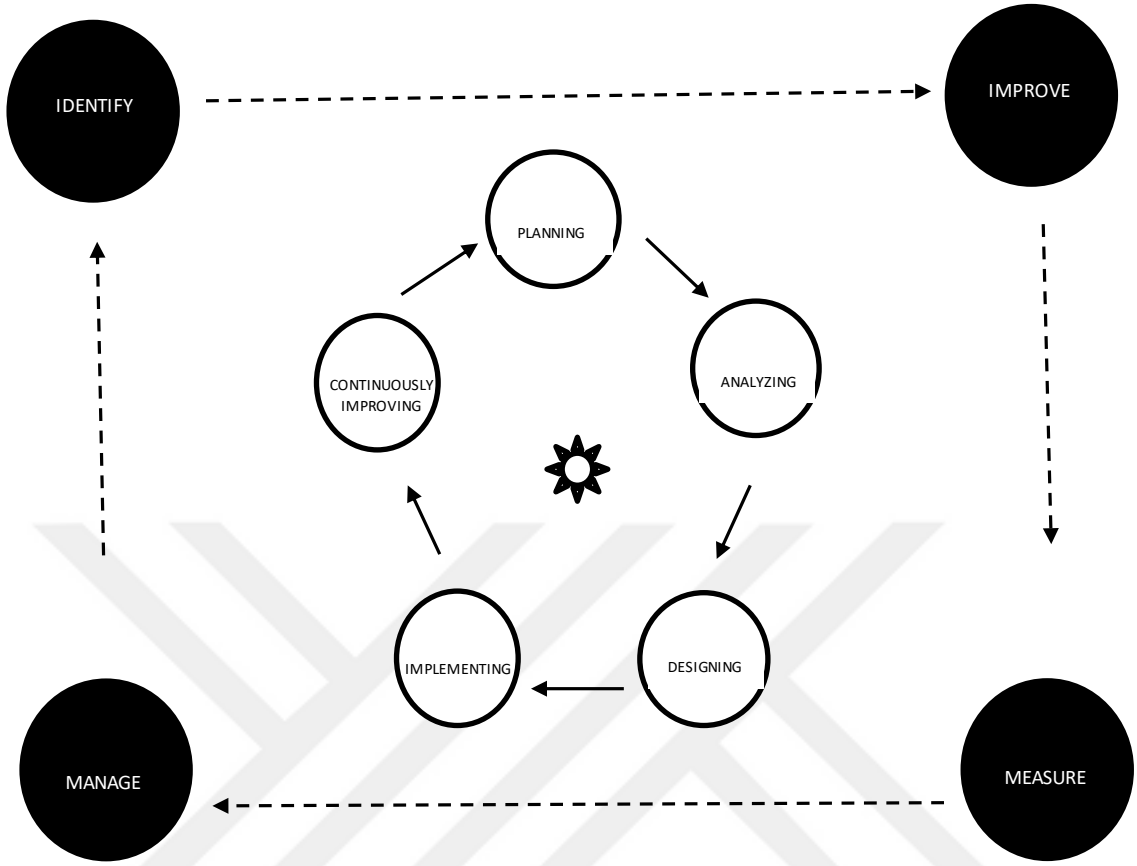

Figure 3.2 Phases of Process Improvement

3.1 Examination of Maintenance Deficiencies

Data of Statü Chartering and Trading Ltd. Company were used in the examination of the maintenance deficiencies of shipping companies. Total 14 pieces general Cargo and Bulk carrier ships has been managed by The Statü company changing by increased tonnage and number of ships from time to time. The company are owner of 11 pieces' ships, and bareboat charterer of the 3 ships which are assigned as under the management company.

Currently The Statü company fleet trading area is generally black sea, Mediterranean, North Europa and rarely trans-oceanic area around South American continent. Although The Company has been working with various classification societies for the fleet ships, all of them are the IACS[5].

Under the light of above subject company fleet ships mostly inspected by the Black Sea Memorandum, Mediterranean Memorandum and Paris Memorandum of understanding

[5] The members of the international association of classification societies.

countries. All memorandum regions use their own database for inspection of the ships with intervals once in every six-month period according to risk assessment calculation considering company performance and ship performance.

Inspection interval could be shorter than schedule according to previous inspection results of ships and company. For example, İf there are outstanding items must be rectifying from previous inspection or serious grounding items which caused detention of ship will negatively effect of ship inspection period. Normally every ship has been passed 2 times inspections within a year at each Memorandum regions. if not have unwanted event, mean that 6 times memorandum inspections have been carried out within a year.

If is taken into account, it could be said that the entire ship fleet of the company had 84 times inspections annualy. Additionally, every ship must carry out annual class verification survey, 2,5 years' interval drydocking intermediate survey, 5 yearly renewal survey. Also, they should carry out once in every 2.5 years intermediate, once in every 5 years' renewal ISM and ISPS surveys. İf unwanted event occur during the inspections, additional inspections of both PSC MoU and class organizations are inevitable.

Management company are inspected regularly interval annual verification, 2,5 yearly intermediate verification, 5 yearly renewal regarding to DOC (Document of compliance)

Under the light of above information following items are defined according to the mentioned company experiences, considering root cause of current deficiencies, rectified deficiencies and all inspection reports.

The below issues are the deficiencies taken from different evaluations;

- Inability to transfer ships structural specifications and chronical problems.
- Control mistakes and problems are solved by the systems inherit ability to inform new crew members of their past, present and future duties.
- Crew members can't correctly analyze equipment malfunctions.
- Difficult situations arise because the vessel can't manually assess which spare parts and stock items they have available, in case of emergency.
- Maintenances and records are not kept simultaneously or realistically by the vessel, and are sent to the company late.
- Recording the planned maintenances is the duty of junior officers and engineers onboard most vessels, resulting in problematic and faulty records.

- There is no real approval system of the planned maintenances, both onboard the vessel and at the company.
- As a pile of records are sent to the company from many vessels monthly, a lot of problems are neglected or missed. Also, most records are archived to be inspected later, and sometimes forgotten.
- Inspectors and officials cannot follow up on maintenances while they're being run.
- Ship equipment, and crew performance cannot be measured.
- Ship stores are hard, even impossible to control.
- Spare parts are used during maintenances, but this is very hard to reflect on the maintenance records, thus where and when spare parts are used is hard to track, resulting in unnecessary purchases.
- Routine measurements are neglected, as the crew members have a lot of them, and no real reminder.
- During audits and inspections, documents requested by the auditors and surveyors can't be found, resulting in unnecessary deficiencies.
- Maintenance systems are usually not prepared per specified vessel, resulting in missing or unnecessary maintenances.
- Loss and misunderstanding of Ship certificates by crew members.
- No real way to check whether the crew members onboard a vessel can travel through the designated voyage.
- Deficiencies, non-conformities, accidents and many other fault reporting systems are mismatched by crew members, resulting in false documentation.
- It is hard to adapt systems to new rules and conventions with a widespread employee base.
- Crew Training and Drills are reported but are not carried out, resulting in high risks in case of emergencies.

Also, addition to above findings, 3rd. parties' inspection results regarding to management of ships and result of management of planning maintenance onboard are seen at the from table 3.1 to table 3.5 below.

3rd. Party inspection results has been examined purpose of pinpoint most popular deficiencies and root cause of it. Above mentioned aim international port state control memorandum

inspection result (Paris Mou, Mediterranean Mou, Black sea Mou), one of the most popular IACS member classification society ABS inspection result is examined.

ABS (American Bureau Shipping) class society made summary report; most popular deficiencies which are obtained ships registered in their classification society is reflected in the table 3.1 and table 3.2.

Fire Safety Measure sit on the first row of the categories due to most popular detainable deficiencies wrote with ratio 21 % as seem below table After that first row of the categories table is secondly comes Safety of Navigation with ratio 15 %, which caused that detention of vessel on PCS inspections third one is the Life Saving Appliances in list of categories table with ratio 13 %. [31]

Table 3.1 Top 10 Major Categories of PSC Detentions (ABS summary report)

Priority number	Categories of Detention Item	Proportion of Detention Item
1	Fire Safety Measure	% 21
2	Safety of Navigation	% 15
3	Lifesaving Appliances	% 13
4	Propulsion & Auxiliary Machinery	% 10
5	Stability, Structure & Related Equipment	% 10
6	Ship's Certificates & Documents	% 7
7	Load Line	% 7
8	MARPOL Annex I	% 6
9	SOLAS Operational Defects	% 6
10	ISM-related Deficiencies	% 5

Other than above ABS report ISM related deficiencies have been categorized at the table 3.2. Deficiencies are categorised according to the ISM code for detention item table, first line will be ISM Code 10 - Maintenance of Ship & Equipment. ISM code 7 - Shipboard Operations has

been on second line, which causes detention of vessel. The third of the categories that make up the vast majority of non-conformities is ISM code 6 – Resource & Personnel.

If an assessment to be made under the light of statistical information, mentioned explanations, and tables; most important deficiencies are becoming from maintenance and repairs of the ISM code. Also, most of the deficiencies are related with lack of planning maintenance and other related jobs.

Table 3.2 PSC ISM Related Deficiencies (ABS summary report)

Priority number	**Categories of Detention Item acc. ISM Code**	**Proportion of Detention Item**
1	ISM Code 10- Maintenance of Ship & Equipment	% 30
2	ISM Code 7 - Shipboard Operations	% 18
3	ISM Code 6 – Resource & Personnel	% 15
4	ISM Code 3 – Company Responsibilities & Authority	% 11
5	ISM Code - Other	% 6
6	ISM Code 11 - Documentation	% 5
7	ISM Code 8 – Emergency Preparedness	% 4
8	ISM Code 3 – Safety & Environmental Protection Policy	% 3
9	ISM Code 9 – Report & Analysis of Nonconformities, Accidents & Hazardous Occurrences	% 3
10	ISM Code 4 – Designated Person(s)	% 2
11	ISM Code 1 – Company Verification, Review & Evaluation	%1
12	ISM Code 5 – Master's Responsibility & Authority	%1

Port State Controls ISM related deficiencies for the Black Sea Region[6] are listed in the Table 3.3. This PSC Annual report covers the period between 1st January and 31st December 2015. During this period the BS MOU member Authorities conducted a total of 4997 initial inspections, representing 1.9 per cent decrease as compared with 5,092 initial inspections in 2014. The regional inspection rate is 69.58% which is 0.2% increase as compared with 2014. A total of 218 detentions were warranted to ships found with serious deficiencies. This represents a detention percentage of 4.36% which is 44.4% increase as compared with 151 detentions in 2014 [32].

During 2015 a total of 18,094 deficiencies were recorded. The average number of deficiencies per inspection was 3.62; resulting in a 0.02 deficiency point increase [32].

Majority of the deficiencies found upon inspection in 2015 were related to safety of navigation (17.5%), lifesaving appliances (14.4%), fire safety measures (10.0%) and living and working conditions-working conditions (8.0%). These four categories make up 49.9% of the total deficiencies found [27]. 2015 Top 5 category of deficiencies presented below.

Table 3.3 Detention Items (Bs MOU, 2015)

Priority number	**Categories of Detention Item acc. Black Sea Mou**	**Proportion of Detention Item**
1	Safety of Navigation	% 17,8
2	Life Saving Appliances	% 14,4
3	Fire Safety	% 10,0
4	Working Conditions	% 8,0
5	Structural Conditions	% 4,5
6	Certificate and Documentation - Documents	% 6,9

[6] Russia, Ukraine, Bulgaria, Romania, Georgia and black sea zone of Turkey are the member of Black Sea Memorandum of Understanding.

Mediterranean Memorandum Annual Report had been analyzed after the Black Sea Memorandum Annual Report. As there are crowded, member of Mediterranean Memorandum of Understanding[7] which also Turkey is the part of this community.

Total 5049 inspection had been carried out by the port authorities of the member states of Med Mou within 2014. The number of detentions increase from 269 to in 2013 to 298 in 2014 [33].

It is understood that in the Mediterranean Region main subjects are remains Safety of Navigation and deficiencies which are arise MLC 2006 convention and certificates, documentation which related basic ISM control & checks according to the table 3.4. [33].

[7] Algeria, Lebanon, Cyprus, Malta, Egypt, Morocco, Turkey, İsrael, Tunisia and Jordan are the member states of supervising under the Med Mou. Except for the port authorities in the Black Sea, the port authorities of Turkey conduct inspections within the scope of the Med MoU.

Table 3.4 Detention Items (Med MOU, 2013)

Priority number	Categories of Detention Item acc. Med Mou	Proportion of Deficiencies Items
1	Safety of Navigation	% 20.9
2	Working and Living Conditions	% 16,53
3	Certificate & Documentation	% 12,56
4	Life Saving Appliances	% 8,43
5	Propulsion and Auxiliary Machinery	% 8,11
6	Fire Safety	% 7,49
7	Pollution Prevention	% 4,38
8	Structural Condition	% 4,15
9	Emergency System	% 3,49
10	Water / Weather Tight Condition	% 3,12
11	Radio Communication	% 2,91
12	ISM	% 1,92
13	ISPS	% 1,92
14	Others	% 4,9

Finally, Paris Memorandum of Understanding Annual Report had been analyzed. Paris Memorandum[8] is the first signed memorandum of understanding before than all others

[8] The organization consists of 27 participating maritime Administrations and covers the waters of the European coastal States and the North Atlantic basin from North America to Europe.

memorandum of understandings in 1982. Latin America MoU(Acuerdo de Viña Del Mar) signed on 1992 after than Paris MoU. Respectively, Asia and Pacific (Tokyo MoU) – 1993/94, The Caribbean (Caribbean MoU) - 1996, Mediterranean (Mediterranean MoU) – 1997, Indian Ocean (Indian Ocean MoU) – 1998/99 West and Central Africa (Abuja MoU) - 1999, Black Sea Region (Black Sea MoU) –2000, Arab States of the Gulf (Riyadh MoU) – 2005 had been signed [34].

In 1978 the 'Hague Memorandum' between several maritime authorities in Western Europe was developed. It dealt mainly with enforcement of shipboard living and working conditions as required by ILO Convention No. 147.

Since that date, the Paris Memorandum has been amended several times to accommodate new safety and marine environment requirements stemming from the International Maritime Organization (IMO) and requirements related to working and living conditions of seafarers.

Annually more than 18.000 inspections take place on board foreign ships in the Paris MoU ports, ensuring that these ships meet international safety, security and environmental standards, and that crew members have adequate living and working conditions [34].

The introduction of the NIR in 2011 has also had an impact on the 2014 figures. After an initial decline, the total number of inspections has increased for the first time. Since 2011 the average detention percentage had slightly increased annually until 2013 (3.61%), after which a significant decrease has been recorded for 2014 (3.32%). Spain, the United Kingdom, Italy, the Netherlands, Germany and France contribute most to the overall inspection efforts in terms of percentage. High Risk Ships have been operating mostly in the southern part of the region, while Low Risk Ships have been calling in the north-western part of the region. With 1,286 inspections and 151 detentions the ships flying a "black listed flag "score a detention rate of 11.74%. For ships flying a "grey listed flag" the detention rate is 6.27% (814 inspections and 51 detentions) and for ships flying a "white listed flag" 2.43% (16,175 inspections and 393

The current member States of the Paris MoU are: Belgium, Bulgaria, Canada, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Norway, Poland, Portugal, Romania, the Russian Federation, Slovenia, Spain, Sweden and the United Kingdom.

detentions). During 2014 the Maritime Labour Convention (MLC) was enforced for the first time during a full calendar year. A new table has been added to this report reflecting the 14 areas of the MLC. The highest areas of non-compliance are "Hours of Work or Rest" (area 6) 21%, "Food and Catering" (area 10) 14%, and "Health and Safety and Accident Prevention" (area 11) 37% [34].

Paris Mou report which are reflected in the table 3.5, top of categories in deficiencies pool is Safety of Navigation with ratio 13,47%. Secondary top of the deficiencies categories is Fire Safety with very close ratio. Third important group of deficiencies is the Life Saving Appliances with ratio 8,73% [34].

Table 3.5 Detention Items (Paris MOU, 2014)

Priority number	Categories of Detention Item acc. Paris Mou	Proportion of Deficiencies Items
1	Safety of Navigation	% 13,47
2	Fire Safety	% 13,43
3	Life Saving Appliances	% 8,73
4	Certification & Documentation - Documents	% 7,59
5	Certification & Documentation – Ship Certificates	% 5,74
6	Propulsion and Auxiliary Machinery	% 4,86
7	Working and Living Conditions – MLC 2006 Title 4	% 4,82
8	Working and Living Conditions (ILO 147) – Working Conditions	% 4,77
9	Emergency System	% 4,55
10	Water / Weathertight condition	% 4,14
11	ISM	% 3,92
12	Certification & Documentation – Crew Certificates	% 3,35
13	Working and Living Conditions – MLC 2006 Title 3	% 2,94
14	Radio Communication	% 2,70

Considering above PSC MoU table, top 5 categories of group of deficiencies are consist of Safety of Navigation, Fire Safety, Life Saving Appliances, Certificate & Documentation and

Ship Certificates. So, its count under 2 main groups, first one is safety matters, second are documentations.

Based on most popular deficiencies table 3.2 according to ISM code identified by the ABS Classification Society, ISM code 10 Maintenance of Ship & Equipment has the biggest portion shown at the first row. Those deficiencies are comply with the identified matters by the Statü Chartering and Trading Ltd. Company experiences, related with weakness and-or shortfall of the planned maintenance system onboard.

Under the light of the above assessment, planning maintenance systems onboard need to be improved to remedy mentioned shortfalls and/or weaknesses of the system.

3.2 Process Improvement Techniques

Improvement of a process ensures the existing problems be solved in advance. Process improvement tecniques have been examined in under the two seperated groups as basic and advanced. The structuring and operation of the ship's planned maintenance includes the maintenance and control of many different equipment. Management company needs to solve many complex complicated problems together and separately, in order to optimize the operation. So, they are uses the process improvement techniques in both groups. However, the ICOR system was used as the main process improvement technique, in order to improve the problems identified by establishing the framework of the PMS system on ships.

The problems people could have face, large or small, simple or complex, easy or difficult. Every employee's job is finding ways to solve those problems is fundamental part.

Using established tools and techniques will help them improve their approach to gathering information and solving the problems that them and their organization face as them execute business process.

Problem solving is the act of defining a problem; determining the cause of the problem, and identifying, prioritizing, selecting alternatives for and implementing a solution [35].

Stages of solving a problem:

1. Evaluating the problem
    - Clarifying the nature of a problem
    - Formulating questions
    - Gathering information systematically
    - Collating and organizing data

- Condensing and summarizing information
- Defining the desired objective

2. Managing the problem
    - Using the information gathered effectively
    - Breaking down a problem into smaller, more manageable parts
    - Using various tools and techniques, such as brainstorming and five whys, to consider options
    - Analyzing these options in greater depth
    - Identifying steps that can be taken to achieve the objective
3. Choosing a solution
    - Deciding between the possible options for what action to take
    - Deciding on further information to gathered before taking action
    - Deciding on resource to be allocated to this problem
4. Resolving the problem
    - Implementing action
    - Providing information to other stakeholders
    - Reviewing progress
5. Examining the results
    - Monitoring the outcome of the action taken
    - Reviewing the problem and problem-solving process to avoid similar situations in the future.

3.2.1 Basic Tools

People can solve the problem when they experience a challenge or have a goal to achieve. They can use the problem-solving stages to look for solutions to concerns connected either their processes or other aspects of work life. They can execute the problem-solving steps by themself, with their colleague, or as a formal process improvement initiatives.

Three major aspects are described below:

1- What is the tool?
2- What are benefits?
3- How is the tool used?

5S Tool; Used onboard of vessel and shipping companies within planned maintenance to keep a better spare part inventory onboard the vessel and reduce tool and spare part usage.

The five S words are sort, straighten (or set in order), shine (or scrub), standardize (or systematize) and sustain. This is a basic methodology for enduring that operations run smoothly without creating or allowing conditions that create waste. 5S is a simple tool for organizing a workplace environment in an efficient, clean, and safe manner to enhance productivity and visual management and endure the introduction of standardized working [35].

By using this tools;

- In-process inventory is reduced.
- Clear methods and standards are established.
- Defects are reduced by mistake proofing.
- Breakdowns and minor stops are eliminated on production lines.
- Changeover time is reduced by streamlining operations.
- Lead time reduced.
- Visible results enhance the generation of more and better ideas.
- The manufacturing floor or office operations become safer.
- The overall workplace becomes cleaner and better organized

Five Why Method; Used onboard of vessel and shipping companies to define the root cause(s) of a problem.

This is a method for finding the root cause of the problem by asking why at least five times. Anyone can delve into a problem deeply enough to understand its root cause, by asking why just five times. Each time they ask why, look for an answer that is grounded in fact and an account of things that have actually happened, not events that might have happened or that are simply individual opinions. Although it's called the five whys, They may occasionally have to ask why more than five times to get to root cause [35].

- The activity generally unearths several other problems that are related to the main problem
- It helps those related get to the center of a problem so that it can be addressed at its root cause.
- There is rarely any need to collect data for using this tool, and it also does not call for statistical analysis of any sort.
- It is easy to use and does not require a great deal of training. Ultimately, it can be used by any person at any level in the organization.

- If problem has more than one root cause, then this tool helps to determine the root cause between them.

8D Problem Solving Method; Used onboard of vessel to solve non-conformities within the system.

Eight disciplines (8Ds) is a problem-solving method developed by the Ford Motor Company and is used to identify, correct, and eliminate recurring problems [30].

- Create a shared understanding about how to systematically solve problems.
- Reduce defects, lead times, and costs through effective problem solving.
- Identify the underlying root causes by applying effective problem-solving tools.
- Strengthen cross-functional teamwork, problem solving, and collaboration capabilities.
- Establish a systematic documentation of the problem-solving process.
- Quickly assist the customer with the problem
- Develop effective process controls to prevent recurrence of known problems.

Activity Network Diagram; Used onboard of veseel and shipping companies to analyze, normalize planned maintenance assignments, work loads and, the approval hierarchy of jobs.

An activity network diagram tool is used extensively in project management and is necessary for the identification of a project's critical path. This is a diagram of project activities that shows the sequential relationships of activities using arrow and nodes. Activity network diagrams can also show which steps can be performed in parallel and which must be performed sequentially. Makes dependencies visible between the project activities [35].

- Enables the calculation of the float(slack) of activity. The float tells people exactly how long an activity can come in late without it impacting the project schedule.
- Organizes large and complex projects, hence allowing a more systematic approach to project planning and scheduling, project execution, and risk management.
- Encourages the project manager to reduces the project duration by optimizing the critical path and using compression techniques as applicable.
- Enables the project manager to optimize efficiency by allocating resources appropriately; consequently, the overall cost can be reduced.
- Increases visibility of impact of schedule revisions, which are usually necessary when major milestones loom large.

- Provides opportunities to respond to the negative risk of going over the schedule by identifying the activities that are most critical.

Affinity Diagram; Used onboard of vessel to categorize and organize planned maintenance data into manageable collections.

This is a method for sorting information, ideas, or items into group with similar characteristics. The method helps to organize large amount of information into manageable chunks and to make connections between seemingly disconnected ideas more apparent. This diagram invented by Kawakita Jiro, so affinity diagrams are also known as K-J charts. Helps organize ideas that at first seem unrelated [35].

- Makes connections or themes more visible
- Provides visual organization cues
- Helps drive group consensus
- Help prioritize actions and ideas from multiple sources

Attribute Control Chart; Used onboard of veseel to help analyze non-conformities and generate new risk definitions and controls.

This type of control chart evaluates the stability of a process by charting the count of occurrences of a given event in successive samples. The varieties of attribute charts include [30];

1. C Chart: Counts the number of defects or nonconformities
2. P Chart: Measures the proportion of defective units
3. U Chart: Measure defects per unit
4. NP Chart: Count the number of defects per sample then the sample size

- Helps to demonstrate the variability of a process and identify special causes
- Measures the effectiveness of process changes on reducing defects

Benchmarking; Used to onboard of vessel and shipping companies in every step of the planned maintenance system development.

Benchmarking can measure products, service or processes against those of organizations known to be leaders in one or more aspects of their operations and provides the necessary insights to help people understand how their organization compares with similar organizations, even if they are in a different business or have a different group of jobs. Clearly identifies specific areas of improvement or opportunity [35].

- Helps gain an independent perspective about how well they perform compared to other companies
- Prioritizes improvement opportunities
- Sets performance expectations
- Helps monitor company performance and manage change
- Helps determine the "gap" between industry leaders and organization

Brainstorming; Used in every step of the planned maintenance system development.

Brainstorming is a method for problem solving by gathering ideas from a group in which the team generates as many ideas for potential solutions as possible in a defined period of time and in an orderly fashion [35].

- Often generates very creative solutions,
- Is conducive to teamwork,
- Develops large numbers of potential solution ideas in a short period of time,
- Eliminates unhealthy group behavior,
- Increases participation by all team members, taking advantage of diverse viewpoints and backgrounds.

Check Sheet; used onboard of vessel and shipping companies structuring of control forms.

Check sheets, or recording table, are matrices designed to assist in the tallying, recording, and analysis of test results or event occurrences. Check sheets may capture quantitative or qualitative data, and typically consist of check marks on a simple tall sheet. They usually include information on the 5Ws (who, what, when, where, and why). Check sheet is used by construct a grid that includes space for recording measurements and the upper and lower limit for a process.

- Quantifies defects by type, cause, or location,
- Keeps track of the steps in a process,
- Visualizes the probability distribution of a process,
- Saves time by showing the frequency distribution as the data are collected.

Fishbone diagram; Used onboard of vessel to found root cause of the problem like mant any other tools.

Ishikawa, fishbone, or cause-and-effect diagrams visually represent the causes of problem-or effect-and help people determine the ultimate source of the problem- the root cause. This tool called a fishbone diagram because of its appearance; Ishikawa was its inventor.

Benefits of the fishbone diagram; Easy to identify process variation causes and helps teams to think about a problem in new ways [35].

Flowchart; Used to onboard of vessel and shipping companies purpose of assignment of hierarchal duties.

Flowcharts visually represent relationships among the activities and tasks that make up a process. They are typically used at the beginning of a process improvement event where people describe process activities, timing, and frequencies. At high levels, flowcharts help them understand process complexity. At lower levels, they can help them analyze and improve the process [35].

- Helps visualize a process
- Identifies decision points
- Provides process documentation

Force Field Analysis; Used onboard of vessel structuring periods of the Planned maintence System.

This is a framework for decisions that identifies forces driving toward an outcome or goal or forces that are blocking or driving away from the outcome [35].

- Identifies factors that may be preventing goal attainment
- Presents alternative paths to the goal by strengthening positive forces or weakening restraining forces
- Helps identify factors that will move away from equilibrium
- Clarifies the alternative approaches

Histogram Chart; Used to onboard of vessel and shipping companies to show analysis report more understandable.

Histograms charts consist of vertical bars, side by side, that depict frequency distributions within tables of numbers and can help people understand data relationships over time (e.g., the familiar bell curve). Histograms are generally used during process improvement analysis. Histograms are best used to show the frequency of values in continuous data [35].

- Easy to read
- Show the shape of the distribution of data

Interrelationship Diagram; Used onboard of vessel to identify root cause of the problems that has been accurance onboard.

An interrelationship diagram (ID) shows how different issues are related to one another. It helps identify which issues are causing problems and which are an outcome of other actions. It also shows the strength of each influence [35].

- Helps identify cause and effect
- Identifies causes with greatest effects
- Shows relationships between issues

Linear Regression; Its mostly used on shipping companies purpose of projection of the futures.

This is a regression analysis technique for modeling scalar relationships between a dependent variable and one or more independent variables. It is used to predict or forecast the probable value of unknown variables or to calculate the strength of the relationship between two variables [35].

- Provides a basis for extrapolation of future data
- Helps predict outcomes. Shows trends

Pareto Chart; Used to onboard of vessel to determine defect's root cause and solutions.

The Pareto chart is named after Vilfredo Pareto, who came up with the Pareto principle (or the 80/20 rule), which says that 20% of the factors account for 80% of potential problems. It is a simple technique for prioritizing problem-solving work so that the first piece of work they do resolves the greatest number of problems. It ranks defects, causes, or data from the most significant to the least significant, in descending order [35].

- Breaks big problems into smaller pieces
- Identifies most significant factors
- Shows where to focus efforts
- Allows better use of limited resources
- Highlights importance of specific variations
- Easy to see the impact of variables
- Simplifies deciding on variations or problems to address to meet a specific outcome

Paynter Chart; Used to onboard of vessel identify maintenance periods of themechanical equipment.

This is a chart that adds subgroupings to a pareto chart to represent the run rate or frequency of specific variables. Invented at the Ford Motor Company, it adds the best qualities of a run chart and a Pareto chart to simplify visualization of data impact. Benefits of the Pareto chart; Provides insight into variation along multiple dimensions [35].

Prioritization Matrix; Used to onboard of vessel for attaing priority of the jobs.

This is a tool to prioritize diverse items into their order of importance by providing a score for each item. It can be especially helpful when there are multiple criteria for importance. Most important benefits are; Clarifies priorities, and builds consensus [35].

Process Mapping; Used to onboard of vessel purpose of identified steps of maintenance.

This is a process for creating a visual representation of a process, including who is responsible for each step and how to measure success. It is a tool for the visualization of processes, including details of each step, responsibility, and any instruction or success metrics [30].

- Helps ensure that process align to organizational objectives
- Identifies non-value-added steps
- Helps ensure effective and efficient processes

Project Selection Checklist; Used to onboard of vessel and shipping companies for prioritize tasks and objectives.

This checklist highlights elements for consideration when selecting and prioritizing projects. It is a method for scoring, ranking, or prioritizing projects to determine which ones to undertake [35].

QMS Review; Used to create onboard of vessel and shipping companies and apply QHSE (Quality Health Safety Environment) systems.

This is a standardized review of the internal quality management system (QMS). International Organization for Standardization (ISO) certification and many industry standards require periodic reviews. The review process and timetable should be documented to ensure consistency [35].

SIPOC; Used to structuring of shipping company purchasing and acquisition processes more effectively.

SIPOC is a high-level process map that examines the details of how an organization satisfies a particular customer requirement or delivers a product or service [30].

- Identifies the actual process and areas of waste
- Helps brainstorm ideas for improvements
- Enhances process effectiveness
- Pinpoints waste
- Sharpens focus on customer needs
- Provides a view of cross-functional activities

Spaghetti Diagram; Used to onboard of ship analyse and realise important and high volume areas of the operation.

A spaghetti diagram is a map of the production process from requirement to delivery. It is a complex map of the actual flow of an entire process, including all employee actions. The diagram gets its name from its frequent resemblance to a plate of spaghetti when it has been completed [35].

Survey; Used to onboard of ship almost every stage of planned maintenance system. Also, its largely used purpose of periodically measure system performance.

A survey is a tool used to gather information through polling or a questionnaire. Surveys may be structured or unstructured, and may include a mix of quantitative and qualitative questions, depending on the audience and the desired result [35].

SWOT Analysis; Used to onboard of ship mostly risk assessment.

A SWOT analysis chart is typically shown with four quadrants, designed for rapid analysis of a market or competitive situation, accounting for the analysis of organizational strengths, weaknesses, opportunities, and threats. Most important benefits are, easy to read and concise, quick to construct, helps in planning to reach objectives [35].

Tollgate Review; Used to maritime industry mostly on construction stages.

This is a checkpoint to verify that all required activities have been completed before moving on to the next phase or project. It is a team review process typically carried out at key points in the project to ensure that activities have been completed as required in the project plan. Tollgate reviews are similar to go/no-go analysis in that they help in the decision to move forward with the next phase of a project or plan [35].

3.2.2 Advanced Tools

Many of the tools defined in the prior section are simple to use and reasonably well known. In fact, some of them are considered essential to quality assurance and process management. However, advanced process improvement requires some additional, more complex tools or concepts. There are also several more advanced tools people can use to understand and improve processes during a process improvement event. Each tool helps them identify sources of variation and aids in the analysis, documentation, and organization of the information, which leads to process improvement and better problem solving [35].

DRIVE is an acronym for an approach to problem solving and process improvement based on five steps. The DRIVE methodology consists of the following steps:

1. Define the scope of the process, deliverables, and success criteria.
2. Review the current process and collect data.
3. Identify improvements and necessary changes.
4. Verify the improvements will meet the defined goals and prioritize changes based on impact.
5. Execute the plan by implementing the changes and measuring results.

Benefits on the DRIVE;

- Provides a framework for process improvement and problem solving
- Builds project and improvement consensus
- Helps identify areas for improvement and ensures that the essential elements of measurement, analysis, and feedback are included in the plan

ICOR stands for inputs, constraints, output, and resources. It is an inter nationally accepted process analysis methodology for process mapping. It allows processes to be broken down into simple, manageable, and more easily understandable units. The maps define the inputs, outputs, controls, and resources for both the high-level process and the sub processes. Benefits of the ICOR are as listed below;

- Helps to train people on new processes
- Can be created quickly
- Highly visual

Using of the ICOR;

- Start with a box representing the overall process.

- List the inputs on the left, with an arrow drawn toward the box.
- List constraints above the box, with an arrow drawn toward the box.
- List resources below the box, with an arrow drawn toward the box.
- List outputs to the right of the box, with an arrow drawn toward the box.
- Order each list from most to least in terms of impact.

Problem Solving Funnel; Used to onboard of vessel identifying root cause of the problems.

This is a method of identifying the root cause of a problem by moving from vague awareness that a problem exists through specific steps that narrow the focus and bring the organization to the root cause and possible solutions. It is a graphic representation of the Toyota problem solving method. Benefits of the problem-solving funnel as listed below;

- Practical and Quick
- Forces focus on specific and detailed problem definition
- Drives to root cause

Using of the Problem-Solving Funnel; Used to onboard of vessel identifying root cause of the problems and planning of solutions.

- Identify the problem and assemble the team.
- Work toward clarification of the real situation or problem.
- Measure the current results.
- Use the five whys or another tool to identify the root cause.
- Brainstorm potential countermeasures and solutions.
- Implement highest-impact countermeasure.
- Measure and evaluate results.
- Standardize the new process if warranted.

Statistical Process Control; Used to onboard of ship purpose of monitoring status during the long and large maintenance process.

Statistical process control (SPC) is a quality control method for monitoring a process to ensure it reaches its full potential for producing conforming products by eliminating or reducing waste, scrap, and rework. Most important benefits of it; Reduces cost by eliminating scrap, rework, and waste, better resource utilization increases throughput, helps improve customer satisfaction from on-time delivery [35].

Using of the statistical process control;

- Establish the process.
- Measure process output.
- Intervene as soon as deviations or trend analysis indicates a problem is developing.
- Resolve the issue.

Statistical Sampling; Used to onboard of ship development of maintenance strategy.

This is the use of a representative subset of a population to make inferences about the entire population. It is a method of quality assurance that requires testing representative samples from a batch or lot to ensure the material meets specifications and is suitable for use. Most important benefits are saves time and resources [35].

Theory of Constraints; Used to onboard of shipping industries at management level.

The theory of constraints (TOC) aims to maximize throughput by managing one or more constraining resources that impose limits on the entire process. The concept was popularized in the book "The Goal" by Eliyahu Goldratt in 1984. The theory is often paraphrased as "a chain is only as strong as its weakest link." [35].

Benefits of the theory of constraints;

- Maximizes total process throughput
- Minimizes inventory investment and costs of process improvements
- Helps prioritize process improvement efforts
- Simplifies planning and scheduling

This page is left blank

4. PROBLEM MODELLING

After investigating the basic and advanced process improvement tools and techniques, ICOR advanced process analysis methodology is decided to be used for process mapping solving problem and analyzing of planned maintenance system onboard ship. It was asssesed that ICOR is most convenient method for analyzing planned maintenance system due to complexity of maintenance system onboard ship.

The ICOR method derives the initials of Input, Control, Output, and Resource words. While process analyzing with this method,, all the sub-processes that constitute the main process and the components in the pool are examined. All subprocesses in the pool are distrubuted seperately to the components of the ICOR system, Input, Control, Output, Resources. By doing so, the development of a planned maintenance system and the resolution of which sub-processes need to be improved in order to solve the problems can be done easily.

The sub-process and the add-ons affecting the planned maintenance system are as follows.

- Equipment conditions
- Running hours
- Spare Parts (Supply Chain)
- Man powers (Number of manning)
- Financial Budget
- Marine Suppliers (Vendor Evaluation)
- Knowkege & qualification (Training of crew member)
- Audits (internal audit, External audit)
- Safety Check List (Deficiencies)
- Performance Checks (Malfunctions)
- Procedure & Regulations (Documentation, Administration requirement)
- Maintenance Schedule (Smart)
- Operation Planning
- Scope of Maintenance

In order to be able to analyze by the ICOR method, it is necessary to determine in which group the above-mentioned sub-processes and annexes belong to the components that previously generated the ICOR method.

After sub-processes and plugins are grouped, the following diagram will be drawn to show the analysis of what the sub-process affects and what other processes are needed to be developed.

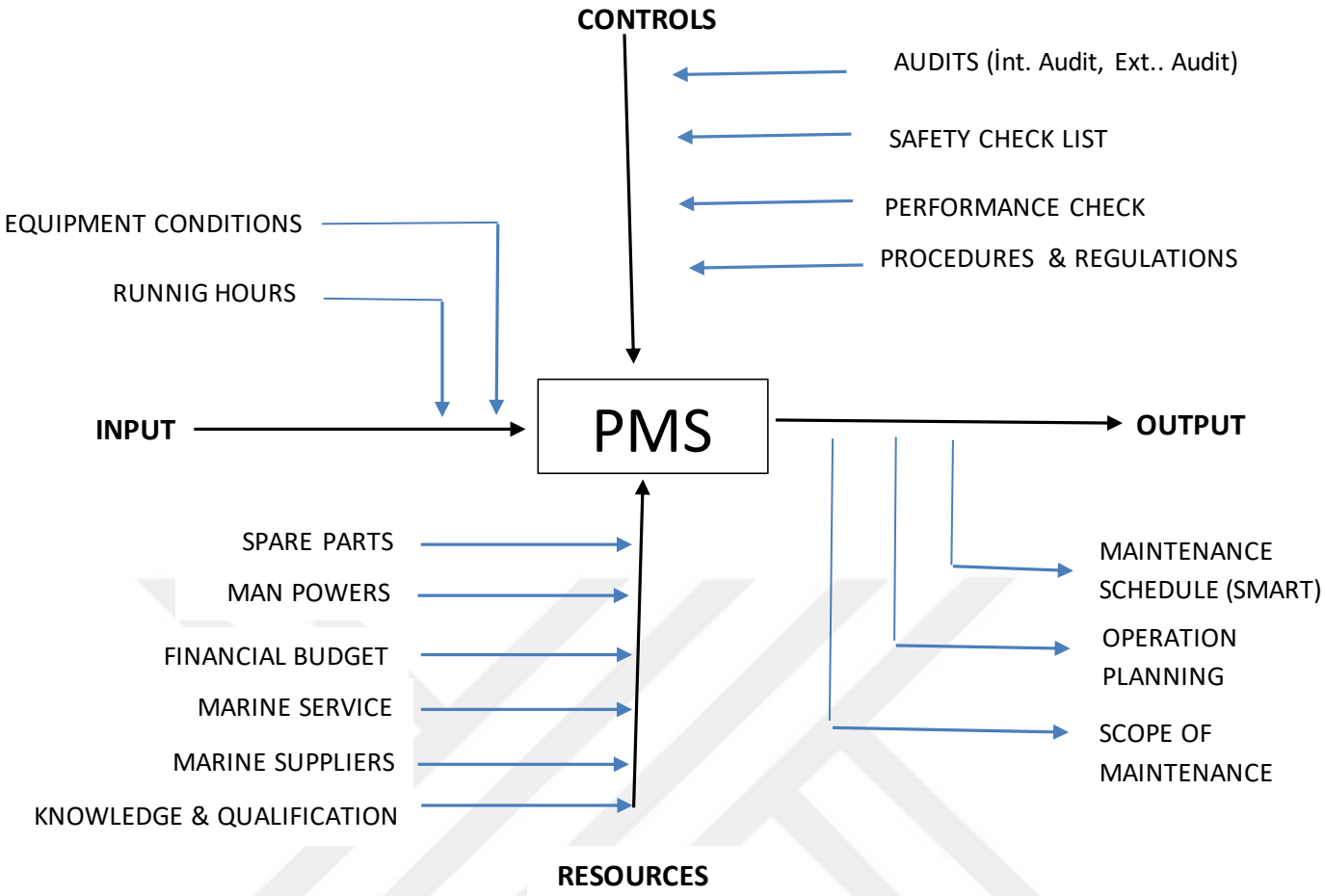

Figure 4-1 Building The ICOR Model

In the execution of the planned maintenance system on board, it has been tried to solve the problems of excessive and unbalanced workload, improper and untimely maintenance planning and safe maintenance operation problems detected by 3rd party inspections and company / sector experience.

Definitions of the Planned Maintenance Process on the ICOR drawings are as follows;

Audits: Means of audits contain internal audit performed by the company superintendent, PCS inspections, Flag state inspection, all other 3rd. Party İnspections, Class surveys etc.

Safety Checklist: Means of that contain all checklist form which were issued with safety management system all phases of jobs and/or events, checking of critical machinery.

Performance Check: Means of that measurement real condition of main and auxiliary equipment of ship.

Documentation: Contains that all correspondence, records & reports including Output result and rules, regulations of company which are prepared based on current IMO convention.

Maintenance Schedule: It means interval periods of ship's equipment maintenance. Maintenance interval indicated considering equipment manufacturers and rules & regulation in force.

Operation Planning: Contains that all operations and activities onboard such as maintenance, maneuvering, loading and unloading, nonroutine special sailing. Prior to planning operation, the vessel's responsible in charge must consider other operations not obstruct each other.

Scope of Maintenance: That shows to us how much we can enhance or restrict the maintenance. Planning of scope of maintenance is important prior to start maintenance considering necessary spares, tools and equipment. Also, must considers other operations onboard.

Spare Parts: Generally used for necessary tools and equipment's for caring out of routine and emergency maintenance operations.

Man Powers: Core elements of the whole ship's operations. It's contains knowledge, manual work force.

Financial Budget: Each ship has financial budget which are calculated beginning of the new calendar year by the company's managers considering their ship conditions, surveys and deficiencies.

Marine Service: All equipment maintenance not performed by the crew members and or company representative. At this point equipment services take this responsibility. Service qualification is important point against to raise any problem on future.

Marine Suppliers: Marine suppliers used for all needed for ship's spares, provisions, paints, chemical, equipment and tools.

Knowledge & Qualification: That is one of the core element of the maintenance. Qualified person has key role for equipment repairs, preventing malfunctions and routine maintenance.

Procedure & Regulations: Most of procedures issued by the management companies considering current regulation in force. Procedures is the ways must be follow by the crew member during the all operations.

In the first column of the table, there is a problem to be improved. The second column contains the corresponding sub-process in the Input group of the ICOR drawing, the third column of the corresponding sub-process in the Control group, the fourth column of the corresponding sub-process in the Output group, and the fifth sub-process of the Resource group. In the final

column, the grouped processes in the table were analyzed to determine the necessary corrections for the targeted improvement.

Table 4-1 ICOR Control Matrix

PMS SUBJECT	INPUT	CONTROL	OUTPUT	RESOURCE	ACTION
Workload Balance	-Equipment Condition -Running hours of Engine	-Safety Checklist	-Scope of Maintenance	-Man Powers	-Safety checks list has prepared considering specify for ship equip. & crew members. (critical & stand by equip.) -Scope of maintenance done by the crew members must indicate considering running hours of engine, equipment conditions. -Sufficient man powers must be provided considering equip. Cond.
Smart Schedule	-Equipment Condition -Running hours of Engine	-Performance Check	-Operation Planning	-Spare Parts -Financial Budget	-Performance check of equip. must be considered. -Operation plan has not conflict work schedule. -Financial budget and spare parts are main object of PMS considering equip. conf. Running hours of enginee
Safe Maintenance Operation	-Equipment Condition	-Safety Checklist -Procedures & Regulations	-Operation Planning	-Man Powers -Marine Services -Knowledge& Qualification	- Safety checklist properly must be done prior to maintenance -Safety procedures must be adopted SMS -Qualified enough man powers must provide. -Marine service evaluation must considered

4.1 ICOR Application to Ship Maintenance Process

After above applications of ICOR method to planned maintenance system its understood that 3 most important problem has been identifed. It has been understood what needs to be improved in order to eliminate the problems and to be able to create an enhanced planned maintenance system.

Workload Balance is the first one of the above-mentioned shortfall. To solve this problem, as shown in table 4.1, the input, control and output in the relevant section have been considered.

Usually ship's management company issues common safety checklist and control forms for their fleet under the management. Unfortunately, sometimes cause that waste of time for responsible persons and maybe insufficient or unnecessary controls of equipment & tools. So, safety checks list must be prepare with consider based on ship equipment & crew members for helps to reduce workload. (critical & stand by equipment)

Scope of maintenance done by the crew members must be identify with considering running hours of engine, equipment conditions. If the matters need to excessive working hours and or contain complex overhaul like as main – auxiliary engine, shore based maintenance must be provided to reduce workload on ship.

Also, another key component of balancing workload onboard is the man powers. Usually, minimum safe manning certificate of ships show us minimum number and rank of crew member of ships for engage international voyage at international waters which issued by the flag state of ship. Mostly, numbers of crewmember that indicate on minimum safe manning certificate is not enough for maintenance and routine operation of vessel and conflict with application of another conventions like as ILO, MLC 2006.The ship's captain and operator must perform crew manning in a manner that does not exceed the maximum number of crewmembers specified in the safety equipment certification, taking into account the condition of the ship, the voyage pattern and the number of equipment on board ship.

As a secondary problem, smart schedule should be considered. To solve this problem, as shown in table 4.1, the input, control and output in the relevant section have been considered.

Regularly performance check or using of condition monitoring system is the main way of structuring maintenance programs of the ship. This ensures maintenance is done by focusing on the equipment that needs to take care of.

Another important part of the smart scheduling maintenance of onboard ship is the operation planning. Often, planned maintenance work is planned without regard to ship operations. This causes the scheduled maintenance to fail carried out in time, to fall in overdue, and to stop the operation of the ship. Good operation planning ensures that successfully maintenance of ship's equipment & tools without suspend operation of vessel.

First of all, before preparing maintenance plan and start maintenance of equipment & tools, necessary spare part must be available onboard. Also, beginning of the fiscal year ship budget must be prepare with consider of ship's equipment conditions and surveys.

Finally, it has been tried to find out to solving of safe maintenance operation which have been identified inside of ICOR control matrix. To solve this problem, as shown in table 4.1, the input, control and output in the relevant section have been considered.

Safe maintenance operations are the most important part of the maintenance of onboard ship. Carefully prepared procedures and before start, during the maintenance, after maintenance control safety check lists are play key role of the safe maintenance operations. Current regulations should be follow-up by the company and declare to the ship's crew information. Implementation of regulations must be applicable and logical otherwise its will not perform onboard ship's operations.

Some of maintenance operations onboard of ship are carried out by the 3rd. Parties, like as marine services. For this situations quality of marine service and approval of specifically manufacturer authorizations are playing key role. Also, company marine service evaluation letters are providing important feedback for future operations. Qualification and knowledge levels of whom carry out maintenance are key point to ensure safe maintenance operation.

4.2 Enhanced Planning Maintenance System Onboard (E-PMS)

Contemporary ship management compared to past experiences has become a medium where considerable amount of detail is managed and completed with many factors. The main goal of any given company to achieve profits with simple methods has become difficult for the shipping industry. Safety, quality, assessment and measurement, followup, procurement, giving swift yet true decisions are only some of the critical business requirements. These goals are slowly but steadily becoming impossible to achieve mainly by human operators, thus a data processing automated systems are becoming a necessity. Multiple ship management companies working in collaboration within this application framework to resolve these critical issues to attain a

perfect standardization would result in optimum solutions. Achieving of above mentioned goals, the company decided to create their own software for business management logic.

After modeling problem focused on the completion of planned maintenance functions. Improvements were determined after the determination of the most critical functions of planned maintenance. Planned maintenance system improvements have been made on this chosen application. The results of the improvements focused on the impact of planned maintenance adaptation.

4.2.1 Introduction of Chosen Planned Maintenance Software

After various research and testing into available systems, it was seen that no feasible software solutions were found offering real time company to ship communication and business implementation. The main problems analysed with current systems and non-system using companies was that company to ship communications were highly delayed. The systems were dependent on data sychronisation at shore, or mailing of the filled paper forms, this resulted in high delays in the company responding to shipboard problems and operations. The software had to implement a real-time solution to manage vessels and respond the problems on time.

4.2.2 Specification and Features of The Software

The system contains various state of the art systems such as, point-in-time recovery system. Module integration allowing data sharing and enhancing capabilities. A detailed logging system that tracks every action within the application. A real-time architecture allowing actual company to ship communication using the application. A cross-platform and no installation architecture that allows anyone with internet connection to immediately start using the application. The application is also frequently updated and has an easy to use and understand user interface and experience.

For every module and feature in this Software, various sources (including Class Surveyors from multiple Classification Societies, Flag State Authorities, and Company Employees) are contacted to acquire the business requirements. These requirements are than compiled into an object, that satisfies all the requirements. After which, simplification is run on all features, to make them as automated and easy to use as possible. Than the alpha version is released to be tested in-company. Later beta version is released for testing within chosen customer base. When module / feature is satisfactory it is released to all customers.

Framework

- Cloud system with automatic horizontal and vertical scaling,
- Point in time data recovery with backups of the whole system every 30 minutes,
- Updates deployed every 6 weeks,
- Load Balancing Systems,
- Client side architecture,
- Real time architecture,
- No Data Synchronization, No Installation, No Delays,
- Very high security protocols, including weekly and monthly security checks, high level.

The Software currently has more than 25 modules, each module is rewritten from scratch for the ship applications for ease of use onboard.

The application contains the following modules:

- Technical Management: Planned Maintenance System, Inventory Management System and Certificates,
- Documentation: Circulars and Manuals
- Safety: Audits, Master's Reviews, Safety Meetings, Drills, Training, Risk Assessments,
- Safety Issues: Deficiencies, Non-Conformities, Incidents, Technical Findings and Defects,
- Human Resources: Crew Management and Watchkeeping,
- Integration: Forms, Enquiries, Analytics.

The software is the first client side web application for the maritime industry. That aims to take advantage of the contemporary communication systems installed onboard vessels. The application is designed to extremely easy to use, so much so that most crew members don't require any training to start using the application.

The aim of The Software is to create an environment for ship management and chartering companies overseeing their every need.

Philosophy of the application is to make everything easier to use, to amass useful data. Which can later be converted into complex yet easy to understand analysis and reports, that will allow managers to fine tune their fleet for more performance with less risks

4.3 An Improvements Implementation Analysis

Previous chapter chosen software has been introduced. There are several important purposes for implementing planned maintenance systems on ships. The planned maintenance systems of the vessels are designed on the basis of the goal and aim of achieving these objectives as much as possible, taking into account the structure of the ship and the company. Although the number of controls and policies varies by company and ship type, the main objectives are common to all maritime industries.

When both the basic process improvement techniques and the advanced process improvement techniques are examined, it is understood that the common objectives are the same as the ISM system, including the planned maintenance system created by the maritime companies and the management of the vessels.

In order to solve the problems in the planned maintenance and management system, the main functions of the system are as follows;

F : Describe function

- F1: Reduce operating cost and increase lead time,
- F2: Reduce defects and downtime,
- F3: Defining root cause of the problem,
- F4: Ensures safe operations of onboard ship.

In order to develop the planned maintenance functions described above, the process improvement tecniques denominated common goals are utilized. When examining both basic improvement techniques and advanced improvement techniques, it was realized that the common goal of many techniques is as follows.

- M1: Strengthen cross-functional teamwork, problem solving, and collaboration capabilities,
- M2: Develop effective process controls to prevent recurrence of known problems,
- M3: Analyze the process for efficiency, effectivity, and waste,
- M4: Enhances process effectiveness,
- M5: Simplifies planning and scheduling,
- M6: Establish standardization.

M : Describe improvement

Under the light of above information, below table has been drawn. Contribution of planned maintenance system will defined which improvement could be apply to functions of the PMS with investigate of below table.

Table 4.2 Improvements Applications Matrix

	Improvements					
Functions	M1	M2	M3	M4	M5	M6
F1	X	X	X	X		X
F2	X	X	X	X	X	
F3	X	X		X		
F4	X	X		X	X	X

As understood from above table defined improvements could apply almost all of the on functions of the planned maintenance system. The implementation of specified improvements was made on the chosen software. The results have been analized. Evaluations has been made according to mentioned improvements analysis result.

When analyzed the selected program design and infrastructure ensures that improvements identified with many features. Solved issues with this software are identified as chapter 4.4.

4.4 Utilization of Analysis in Software Development

Maintenance structure and schedulingThe software makes available to user what in accordance with the ship's planned maintenance can be generated, and the condition of the control period as per manufacturer or equipment has provided the opportunity to be identified as appropriate. The Identified jobs has been assigned to crew member in charge onboard ship within the identified interval. Controls must be made without any missing, ensures aware of the job must be carry out to make prior planning. The software also allows to user, separate into categories specified by operator of planned maintenance works which are the critical items, class items, safety, performance checks, visual checks etc.

Records of maintenance has been done onboard are kept by the assinged person in charge. After that roughly reviews by them superior rank as master, chief engineer and sends to office

approval. Company superintendents should examine the documents, analysis the reports which are submitted at the same time entire fleet and filing it properly. Even the system theoretically can be structures but faces many obstacles on practice. The software ensures that to user instant report system with web client applications, so maintenance can be done by the responsible and approved or disapproved by superior and or master. If the ship's master and superiors have been satisfied to the jobs had been done then makes the job status as company approvalIf one of the approvers at the any of these steps have not been satisfied, so disapproves to the jobs which had been done and return to the assigned person with explanation remark.

All maintenances and sub-maintenances into the planned maintenance system have ability to creates as like tree structures accordance to manufacturer instructions, company's requirements, working hour of equipment and periodically checks. Moreover, the software has assignment feature for on board of all maintenance and sub maintenance, so ensures that not any missing jobs and responsibilities remains at back. The job assignment can be set by the company's authorized persons accordance to the ship's features, number of crew members and any other requirements.

Form structuring and preparing instructions for the maintenance accordance to the specify to the ship are available. When the users have been examined classical planned maintenance systems, will realize that jobs are not separate accordance the ship's type and specification and contains common basic checks without any details and or instructions. This is usually cause that to skip of some maintenance, or are not carried out as it's supposed to be. The software ensures to user make all maintenances and checks without any missing via preparing specific check list and instructions as a guide accordance to ship's inventory. For example, monthly checks of fire extinguishers on board all prepared together with the number, types and location of fire extinguishers, which would be enough to make a detailed list complete control. However, instructions can be added for maintenance work to be done to the ship's machinery and equipment that will be a guide for the ship operators to do their job. That will be prevent to make incorrect and missing operation. Upon maintenance is done, will ensure to be ready for use to prevent loss of time.

Main reasons of the deficiencies related with safety categories are not checks all the safety equipment on board periodically and accordance the instructions what had been mentioned previous chapter. The Software helps to user for solving of this matter.

Objective evidences are available into the software sytem. When has been examined classical planned maintenance applications, that was not sure the reported jobs had been done or not

properly. Thanks to the software makes available to attach various kind of file format while reported jobs as well. (jpeg, pdf, tiff, doc, xls, etc.) Ensures reviewing, verification and archiving of the maintenance jobs had been done with all details of the maintenance jobs and pictures, files of belonging it.

Follow up historical past of the maintenance for each equipments and items is important features of the software. The maintenance performed onboard ship automaticaly keeps into the archive after the final approval of the company. Ensures to monitoring previous maintenance performed with all evidences when the same maintenance had been started. Provides to the users, transfers of the important information about to the maintained equipment to the next employee for gathering big data when necessity to make analysis.

Documentation, certificate and survey follow-up system has vital importance. Usually expire date of certificates and survey windows are followed up manualy on many kind of system on board ship. Sometimes are caused that to expired certificate and overdue of survey window. The Software ensures automatically follow-up once the certificates update into the system. Also, developed e-mail notification system for closing due date survey and expire date of certificates with plugin to the software. First e-mail notifications send to the responsible and continue to sending toward top positions of the company level by level without made any updates. Standardization had been established for documentation and file checks on this software.

Crew management system has many opportunites into the software. Even though several advantages offer to users, it is understood that this part of the program should be develop due to one of the most important sources of planned maintenance on ships, based on the review on crew management system. Employee information's records are kept and could be monitoring by the authorize persons at the same time when it is necessary. The software ensures follow-up to validity date of crew member certificates with available e-mail notifications. First e-mail notifications send to the office crew manager and continue to send toward to top positions of the company level by level without made any updates. Unfortunately, enhanced crew performance measurements facilities are not available in this software. Ship master evaluations, company evaluations, maintained jobs fault rate which had been done under the resposibities and rate-number of deficiencies founded by the other parties inspections result must be gather all of the above informations for achieving this goal. All gathered information's should be integrated each other's to make more analytic evaluations.

Marine services & suppliers evaluation has to be entegrated to the software. All ships must be into the dry dock or shipyard for periodical class maintenance surveys and large scope of maintenance. Also, they are using various and many kind of marine service for their its equipment. They used marine suppliers for spares to necessity for maintenance of equipment. Service evaluation has critically importance for the other parties as shipyards, marine service & suppliers due to encapsulate largest part of the planned maintenance on board ship. Those improvements are vital importance which has been mentioned on chapter 4 identified resources part of the ICOR.

Defect and root causes analysis is most critical issues for the planned maintenance system. Deficiency module has available into the software for defects follow-up and non-conformities follow-up. Classical paper based system was cause the disruption of follow-up and unrectification of defects or non-conformities in time. The Software had been ensured to rectify of defects or non-conformities within proposed time with notification feature. Unfortunately, main root cause of the defects or non-conformities may not identify at this time. For identify of root causes of the defects and non-conformities, it should be categorizing if related with same equipment and same reasons more than once. In the end if defects and non-conformities categorized as described above, it will be ensuring to identify characteristic of non-conformities and defects to accordance of ISM code. Also, written defects and non-conformities in present audit module must be integrated with deficiencies module. Main goal of the plugins is gathering all description about related same defects and same non-conformities, written more than once by the different authorities. İt will help to user identify real main reasons as much as possible.

Inventory management system has vital importance to the purpose of accurate stock management recently. Under the conditions of contemporary on today, it's not easy to said that, classical planned maintenance systems have successful inventory management system on board. The software ensures follow-up the inventories while incoming and consumed stores and spares which has been updated by the crews on board. Also, in this software are able to identify minimum spares of critical equipments with accordance to ship specify as main engine and propulsion system, hatch covers, hydraulic system and etc. This ensures that any time remain out of stock if its keep up to date by the crew members. But for achieving the goal of smart scheduling, inventory managements system must be integrating with planned maintenance and deficiencies module. For example, spares needed for upcoming planned maintenance must ensure enough quantity in stock. Also, always ensures that not falling down below the minimum reserve amount it is. When necessary has ensures to makes store requisition

on planned maintenance window. During the planned maintenance and rectification of deficiencies must be available select used spares and automatically remove from inventory. Auto checks must ensure identified minimum quantity of spares again.

Instant automatically store requisition model should be develop which integrated to the inventory management system with identified minimum quantities of stores, instead of classical monthly periodically store requisition. Spares and store request written in the list could be supply considering to priority, quantity, convenience of supply point at various port of call or on roads or supplying zone (anchorage) with full or part of list. Supply operation for the remaining items could be schedule for the next port call of the ship.

Continues monitoring of running cost & total budget of the ship has vital importance to know instant situations at any desired time. Main goal of the commercial shipping company is the profit. Otherwise, it would be inevitable for the company to go bankrupt. Commercial shipping companies must keep under control of their investments and annual budget sustainably due to mentioned reasons. They should develop necessary mechanism to achieving this goal due to has vital importance. Under the above circumstances main resource of the planned maintenance on board ship is the financial budget. For stabilization of financial budget, maintenance cost must be identifying on beginning of the fiscal year considering ship's condition and upcoming surveys. The Software must ensure that find out current total running cost instantly and identify deviations from scheduled budget. It has vital importance for the resources identified in chapter 4th. with ICOR. These helps to us better decision support and action plan via make analysis at desired moment and evaluation.

Enhanced notification system with voyage module should be develop and should be integrated to the planned maintence system. All commercial vessels send their activity report to the office once a day at every morning at 0800 am or noon with identified forms via mail. These reports concerning the chartering department are also, closely related to planned maintenance on board ship. Because of that ships carries out services maintenance, ship's engine overhaul, supply of spares and store requisitions, repairs of critical equipment and immediate maintenances, audits, survey and inspections at ports or anchorages during the loading & discharging operations. Only some ports and anchorage areas are convenient for above operations. Also, as per the company experiences planned operations can be forget or overdue due to congestion of work if the management company has over 10 vessels sailing within shortage distances. Moreover, as per Statü Chartering and Trading Ltd. company experience if the company has 10 or more ships are working short distance they had delay of planned operations and overdue jobs issues due to

intensity of the works. Chartering department of the companies knows next voyage connections, lay can times, estimated time at harbor for the discharging and loading operations, estimated time of berth to the ports. If above mentioned data insert in to the voyage module will ensures share important information's with ship's management department to find out best solutions for their planned maintenance considering prevention of the commercial lost. Instant updates according to latest situations will ensure to make optimum planning. Collaboration and information exchanges between the departments will become stronger as mentioned above M1 (improvement 1) at this point of view.

Circular, Trainings, Familiarization, integrations should develop into the Software. For the preventing of happen same phenomena with other ships in fleet, the management company shares its experience with all the ships in the fleet. This sharing of information's counts as company's circular. All circulars issues via mail to the fleet ships. Unfortunately, its difficult to verify that readed it by the new employees and aware of it properly. If the crew manager module has features like assign all previously published circulars to related new employees and having of proper notifications mechanism will almost solve mentioned problem. Moreover, crew manager module should integration with trainings and familiarizations. This will ensure automatically reminder and follow-up initial and specific familiarizations of the new crew members. Also, system will check regulatory safety - security drills on board must be carry out with automatically when the %25 of crew member changed at one times.

Chosen planned maintenance system in Chapter 4.2 has been reviewed and improvements has been identified with our subject's methods, identified how to develop the Software accordingly to the identified improvements. It has been realized that entirely infrastructure of planned maintenance system will change and its will become enhanced planned maintenance system when planned improvements have been established. Feasibilities had been completed about integrations and version updates. Some of identified improvement already in force with recently published version and its results observed. Moreover, observed improvement had been done ensure benefits almost %85 of expected.

Plugins and defects have been identified to establish identified improvements on the Software with process improvement techniques & tools and ICOR. The Software infrastructure had been evaluated compatible to apply identified improvements. Some of identified improvements have been applied. Results are as follows to observed experiences with all the fleet ships during the one year period.

The Software has been established for all duties care about their jobs under their responsibilities when they are login the system. The Software had been ensured virtual information about conditions of ship's equipment and maintenance via attached objective evidence during completion & reporting of maintenance.

That ensures to find out for fastest and economical solution with evaluations and contributions of the upper level of the managers related solutions of the deficiencies under favor of reporting on the Software. The Software helps to user identifying and evaluation of the defects and non-conformities with attached pictures during the reporting of its. Moreover, ensures to obtain objective evidence after rectified of it.

The Software ensures to crew members job application on the internet so that gives a chance to check crew's CV before than decide to assignment on board. It prevents chaos and lost times in office. Only to be assigned crew members invite to our office. Even if not the Software does not have crew member's evaluations as mentioned above there are available spaces for the entrance of comments about them. The Software ensures decreasing of workload at office due to STWC certificates validity dates of crew members automatically follow-up.

All the ships in fleet have been adapted using to current version of the inventory management system. The software was used to keep the critical spare part stock list above minimum allowed values.

All the ships in the fleet have used drill and training module with current version without any improvements mentioned above. But the Software gives opportunity to scheduling annual safety – security drill and training plan for each ship in the fleet. So, compulsory drills & trainings had been to notified to the ships on scheduled date and time. Its helps to carry out all drills & trainings without any missing for both sides.

The Software ensured decrease workload due to follow-up due date of surveys & certificates. Moreover, it prevents the disruption and planning can be done in time.

The Software ensures schedule to company audit, internal audit, and ship internal audit for all ships in the fleet for identified time interval. Moreover, its helps to operator dont skip any of items under favor of notifications as adjusted by the company.

This page is left blank

5. CONCLUSION

When the literature has been reviewed, It is understood that the maintenance system is very important in any organization, and that it must be managed in an optimum way. If this approach is used, great savings can be achieved and the risk of failure can be reduced. In addition, optimizing planned maintenance has many benefits., i.e., system availability is increased, the life span of the systems in place increased, the reliability of the system is increased, the safety level for the people involved is increased, and high end-of-life values are maintained for the equipment, machinery, and systems.

It has been realised in chapter 2.2 that many researchers divided maintenance into types or categories, which were based on the system or process operation. Planned maintenance systems are categorized based on the strategies used for maintenance planning. These are 3 types of run to failure, preventive maintenance and predictive maintenance.

Maintenance techniques such as RCM and TPM are available for application of system reliability and maintenance. It is a further category of maintenance classification, indicating the status of the process after maintenance.

The ship maintenance system is one of the most important things to pay attention maintenance in the maritime industry plays a very important role. The optimized, planned maintenance system for the ship maximizes company profitability, crew safety and cargo safety.

Ship maintenance costs may vary depending on many factors that require attention so that an optimum maintenance plan can be established. The mentioned factors can directly or indirectly affect the cost of ship maintenance. In addition, these factors affecting ship maintenance costs can be either controllable up to some degree or uncontrollable. The controllable factors are consisting of, selecting a convenient strategy for maintenance, making the smart maintenance schedule, selecting qualified ship's crew member, selecting convenient shipyard for dry dock of the ship and, desinging the ship with consideration of maintenance planning from the construction stage.

In this study, it is aimed to develop planned maintenance systems used on board ships. For this purpose, process improvement techniques have been examined. Both simple and advanced process improvement methods have been utilized in the creation and development of the planned maintenance structure.

ICOR, one of the more advanced process improvement techniques have been used to investigate the main structure of the planned maintenance system and, also in order to identify the deficiencies that arise during its development. The main and sub items of the planned maintenance system are located on the ICOR system.

When reviewing the sector analysis reports on the safe operation of the vessels, it has been understood that the development of the planned maintenance system is the top priority. In order to determine the problems existing in the operation of the planned maintenance, Statü Gemi Kiralama ve Tic Ltd ships and experience reports and audit reports were used. Identified deficiencies has been explained on chapter 3.1.

As per available data and review with company supervisors, 3 pieces of important problems have been identified as Workload Balance, Smart Schedule, Safe Maintenance Operation which are the important root cause for development of planned maintenance system.

The "Figure 4.1 Building The ICOR model" is used to analyze these mentioned problems. Identified problems have been inserted in to the "Table 4.1 ICOR Control Matrix". In the same table, the INPUT, OUTPUT, RESOURCE and CONTROL sections, where the problems are related, are placed in separate columns and interpreted in the last column.

In order to solve the problems identified efficienctly, the company has made use of the jointly developed software. The software engineers have been made aware of the identified deficiencies related to the development of planned maintenance and have developed solutions together with the company.

The identified shortcomings are largely resolved, but software engineers are still working on the application. The deficiencies that have been solved by the software support and the issues planned for development are discussed in section 4.4.

Planned maintenance on board has been carried out more effectively and increased the conditions of the ship almost 70% observed during this period. Moreover, average ship and crew members, their superior performances have been obtained with observed effectivity of the reported jobs carried out by the duties. Workload balance has been regulated with preventing of authority confusions via assignment officer in charge for the ship's jobs listed in the planned maintenance table. Ship maintenance operation effectively regulated using of Smart Schedule system. Also, observed that whole ship maintenenance operation managed more safely under favor of Safe Maintenance Operation solutions.

It has been understood that the lack of planned maintenance systems used in vessels can be detected using the ICOR process improvement technique and, that the root causes of the factors affecting the deficiencies can be determined, easily resolved by improving the Resource & Control components. Based on this result, it is concluded that other problems existing in the planned maintenance system can be detected and effectively solved by using the ICOR method.

Thanks to the software support, an automation has been created by adaptation of the determined solution methohts. It has been understood that by means of the established auto-control system method, more control with less energy and human resources can be done correctly.

This study is mostly based on experimental and experience results. The aim of the project is to develop E-PMS (Enhanced Planning Maintenance System) by completing the necessary improvements with the full adaptation of the created system and, analyzing the result data of the system which is established as the subject of advanced research.

5.1 Recommendations and Considerations for Future Researches

Regarding the development of the planned maintenance on board the studies done so far have been made mentioned issues of common concern related to improving process ability though studies by the planned maintenance, mainly on ships. Future studies could be perform about company organization in order to improvements planned maintenance system onboard. With regard to management of planned maintenance on board the company organization structure and proper distribution of authorities & responsibilities are vital.

During the identify necessary number of crew member on board the owner must take in account to management of planned maintenance system on board instead of minimum safe manning certificate issued by flag state. MLC-2006 convention, voyage pattern, in accordance with the ship's equipment and specifications to be equipped with enough qualified personnel is vital in the implementation of the planned maintenance system.

Establishing of company organization is other important leg of the planned maintenance system. Following issues must be taken in account to establish proper office organization.

Company organization structure and departments must be sufficient and agreeable with work load. Excessive work load non-related jobs with their own department will cause to move away from main responsibilities and deal with other related management issues. Professional performance of the employee under the responsibilities will be decrease due to aforementioned reasons. For this reason, do their duties by creating various following department and

coordination with the organization and top management will rehabilitate the operation of the planned maintenance system.

1) Crewing Department (if not using crewing agency)
2) Purchasing Department
3) Health, Safety and Quality Dept.
4) Insurance and Claim Department
5) Chattering Dept. (İf not using bareboat or other long term chartering)
6) Accounting Department
7) Agency Department (İf the agency services perform by the company)
8) Ship Management Department (Safety management system duties and technical matters)
9) Ship Operation Department (Operational requirements and supplies)

As exampled above company organization to be identify by the IACS classification society on behalf of flag state organization must be inspect operation of each department on periodical surveys to contribution planned maintenance system.

Created department in the company organization must be proper work load and labor must be distrubuted equally. Especially responsible superintendent of planned maintenance system must be sufficient number and qualification. Qualitative and quantities evaluation must be perform on periodically annual DOC inspection which has to be contains results report and sanctions. For example, an inspector appointed as responsible from the ship in the fleet the problems faced, the evaluation by analyzing the shortcomings and solution methods with duration periods will be the developer of planned maintenance system by the establishment of a system. As above mentioned, all department and responsible must be evaluate by analyzed quantitated and qualitative due to ship's operation and planned maintenance chained together. It’s vital important for obtaining objective evidence.

Most important problem operation of the planned maintenance system is crew member professional competence and ethics. Thought that, secured information exchange database network between maritime companies and administration could be rehabilitate to following situations to contribute planned maintenance system by the sharing of mentioned followed-up evaluations and analytical results.

- Based on the results of the quantitative and qualitative evaluation database system, must do if it's necessary to undergo retraining during the renewal or extension of the document.
- Based on the results of the quantitative and qualitative evaluation database system, must be applicable if it's necessary to downgrade rating during the renewal of the document.
- Based on the mores and discipline of crew member evaluation database system other than professional competence, if it's necessary should be able to do warning, downgrade of rank, cancellation of professional competence to successful operation of the planned maintenance system.

Another important aspect contribution to ship's planned maintenance systems such as fast maintenance and production of long life cycle are ship design, quality of the equipment and features, ship's outfitting technics and materials, fitting materials and quality of workmanship chosen on beginning of the building period. The ship and the shipyard project selection will be create main structural elements related issues is the inclusive nature of the ship.

Equipment qualities and features: Various kind and number of equipment are in use for ship's fitting. These can be combined with the main equipment of the ship or outside. Usually selecting of this equipment is done by the ship owner with the planned budget and decision. Although all equipment in the market has IMO approval there are many type brand features of equipment are in the market produced by the manufacturer. Maintenance periods, time of overhaul and costs of it are variable depending to manufacturer and features of product. Selecting of the equipment should be done with analysis of maintenance and labor costs for short, medium and long term period considering not less than 30 years of ship life cycle. This has a vital important. Also, feasibility study has vital importance to obtain MTBF (mean time between failure) other than the statistical data. Some equipment ensures huge advantage aspect of initial investment and maintenance cost by the simple user friendly structure and multi-functional features. For example, combined equipment maintenance cost is less than the maintenance cost of 2 separated equipment. Also, investigation of manufacturer maintenance instructions for identifying interval of maintenance period ensures identify maintenance work load before selecting of engines and equipment. This ensures to rehabilitate planned maintenance system.

Selecting of navigation equipment for the bridge with compatible same brand manufacturer are ensures advantage of service fee and maintenance time and cost. Moreover, authorized service network and spare part supply should be considered at this point.

Ship design: The stage of determining the cost of maintenance and facilities-related maintenance starts from early of project stage to the cost determination stage. Nowadays, although all commercial ships built under the IMO rules and representative of classification society behalf of the flag state, unfortunately there is a possibility to faced following issue to negative effects on planned maintenance.

- Equipments layout design are not allows to apply planned maintenance due to faulty design.
- Not easily allows to fix deficiencies and makes planned maintenance due to faulty electrical cable fittings foundation design.
- Existence of blind sectors will be obstructing to do necessary planned maintenance.
- Design outfitting project of the ship does not consider planned maintenance some of points.

Ship 'hull technics and materials: The majority of ships are composing of the main shell. For that reason, workmanship of main shell and quality of the materials are the main subjects to identify of maintenance interval. A few negative examples in this regard are as follows.

- Caused weakness such as loss of welding on shell plate and main structure of the ship due to weak welding workmanship. This will cause higher maintenance cost while ship in service and shipyard maintenance period due to welding crack at all time.
- Raw material quality of the ship's shell and main structure elements are indicating exposure time to corrosion and erosion. Especially improperly contains of non-homogeny ingredient of steel plate will undergo structural defect more fastly. Grooving and pitting rise to surface of steel plate. This will cause negative effect to protection of surface and more faster corrosion. Finally, all this causes arise to higher costly maintenance such as shorter maintenance period and completely renewal.
- Ship's hull construct such as block by block and section by section during the building. This sections protect from the outside effects by the coating application. If this coating application done under proper conditions and high quality will ensure protection some enclosed spaces of the ship during whole ship life cycle without major maintenance.

Ship's fitting equipment: Maintenance periods and costs are closely relating with ship's main fittings materials. For example, the followings are of major equipment and system of the ship.

1) Main engine, auxiliary engine

2) Propulsion system and steering system

3) Hatch cover system and type of operation

4) Mooring and anchoring equipment

5) Navigational bridge equipment and system.

Usually, planned maintenance plan identifies by the number and type of the equipment. For example, four stroke engines have shorter maintenance period than the two stroke engines and number of maintenance more than the others. Again, according to our experiences hydraulic folding type hatch covers operation and maintenance less than the pontoon type of hatch covers.

Also, operations and features of equipment are important to indicate maintenance periods and type. For example, if operation of the equipment is difficult will have difficult maintenance other than has easy operations. This will cause maintenance failure due to steal whole maintenance times.

Workmanship quality: All above mentioned subjects commonly are related workmanship quality and the jobs done by the professional. Otherwise root problems of the equipment will remain during whole operational life of the equipment. This root problems will present whole life cycle of the ship and bring maintenance issue at the same time.

Selecting of shipyard has big importance for new building due to it comprise most of the problems as mentioned above. Ship owners still prefers shipyards in Korea and japan, even If the ship building industry developed rapidly in china. Turkish shipyards are also able to build a ship in the shipyard standards mentioned in many aspects.

Planned maintenance system and ISM training curriculum: Nowadays, most important problems of the ship operations of is implementation of the planned maintenance system. Greatest importance, and in front of the biggest obstacles to the operation of the planned maintenance system for the ships it operated economically and safety, the use of electronic planned maintenance system and it is vital to operate. Therefore, it is considered that these matters into the future health of the operation of the ship's officers with new teaching to all aspects of the curriculum in schools as required to be made by the board of officers who will ship exercise duration shorter system successful. IMO and maritime administration must be

studied on this subject as required. Also, necessary certification should be able under STWC convention.

References

[1] Dekker, R. (1996). "Applications of Maintenance Optimization Models: A Review and Analysis." Reliability Engineering & System Safety 51(3): 229-240.

[2] Artana, K. B., D. Priyanta, K. Ishida, Y. D. Kuntjoro and N. H. Education-Indonesia (2005). Development of Simulation and Data Mining Conceptfor Marine Hazard and Risk Management. 7th International Symposium on Marine Engineering. Tokyo, Japan.

[3] Reason, J. T. and A. Hobbs (2003). Managing Maintenance Error: A Practical Guide,Ashgate Publishing.

[4] Rustenburg, W. D., G. J. van Houtum and W. H. M. Zijm (2001). "Spare Parts Management At Complex Technology-Based Organizations: An agenda for Research." International Journal of Production Economics 71(1-3): 177-193.

[5] Rothblum, A. M. (2000). Human Error and Marine Safety, U.S. Coast Guard, Research & Development Center: 13-14.

[6] Alhouli, Y., D. Ling, R. Kirkham and T. Elhag (2009). On the Factors Afflicting Maintenance Planning in Mercantile Industry. COMADOM. San Sebastin Spain.

[7] Lewis, B. and W. Pearson (1960). Management Guide for Preventive Maintenance. New York, John F. Rider, Publisher, Inc.

[8] Moore, F. G. (1969). Manufacturing Management. Illinois, United States of America, R. D. Irwin.

[9] White, E. N. (1973). Maintenance Planning – Control and Documentation. London, Gower Press.

[10] Amrine, H., J. Ritchey and C. Moodie (1987). Manufacturing Organization and Management, Prentice-Hall.

[11] File, W. T. (1991). Cost Effective Maintenance Design, Implementation. London, Butter Worth Heinemann Ltd.

[12] Cross, M. (1988). "Raising the value of maintenance in the corporate environment." Management Research News 11(3): 8-11.

[13] Campbell.J.D (1995) Uptime; Strategies for Excellence inMaintenance Management, Productivity Press Inc.

[14] White, E. N. (1979). Maintenance Planning – Control and Documentation. London, Gower Press.

[15] Mobley, R. K. (2002). An Introduction to Predictive Maintenance USA, Butterworth-Heinemann.

[16] Ben-Daya, M., S. O. Duffuaa and AbdulRaouf (2006). Maintenance, Modeling and Optimization Netherlands, Springer.

[17] Deris, S., S. Omatu, H. Ohta and L. Shaharudin Kutar (1999). "Ship Maintenance Scheduling By Genetic Algorithm and Constraint-Based Reasoning."
European Journal of Operational Research 112(3): 489-502.

[18] Mackenzie, L. (2004). Inaugural Ship Superintendency Forum 2004, Lloyd‘s List Events.

[19] Wang, Y.-M., & Chin, K.-S. (2011). Fuzzy analytic hierarchy process: A logarithmic fuzzy preference programming methodology. International Journal of Approximate Reasoning, 52(4), 541-553.

[20] https://en.wikipedia.org/wiki/Analytic_hierarchy_process (Date of access on 30.11.2016)

[21] Akyüz, çelik 2017 Using of A’WOT to design an enhanced planned maintenance system (e-PMS) on-board ship.)

[22] Stoneham, D. (1998). Maintenance management and technology handbook. Oxford: Elsevier Advanced Technology.

[23] Mobley, K. (1990). An introduction to predictive maintenance. New York: Van Nostrand Knoxville.

[24] Almgren, T., Andréasson, N., Anevski, D., Patriksson, M., Strömberg A-B. & Svensson, J. (2008) Optimization of opportunistic replacement activities: A case study in the aircraft industry. Department of Mathematical Sciences, Chalmers University of Technology and Göteborg University.

[25] Moubray, J. (1997). Reliability-Centered Maintenance. New York, ButterworthHeinemann
and Industrial Press.

[26] Nakajima, S. (1988). Introduction to TPM: Total Productive Maintenance (Preventative Maintenance Series), Productivity Press.

[27] http://www.marineinsight.com/guidelines/how-the-maintenance-plan-of-ship-is-made/ (Date of access on 30.11.2016)

[28] http://www.imo.org/en/OurWork/HumanElement/SafetyManagement/Documents/104(73).pdf (Date of access on 30.11.2016)

[29] https://en.wikipedia.org/wiki/International_Safety_Management_Code (Date of access on 30.11.2016)

[30] ShipManager and Navigator DNV GL - Software

[31] URL: http://ww2.eagle.org/content/dam/eagle/publications/2015/AR2014.pdf 2014 Annual Review - ABS (Date of access on 30.11.2016)

[32] URL: http://www.bsmou.org/category/docs/annual-reports/ Port State Control In The Black Sea Region - Annual report – 2015 (Date of access on 30.11.2016)

[33] URL: http://www.medmou.org/ Med MoU - Annual Report – Year 2013 (Date of access on 30.11.2016)

[34] URL: https://www.parismou.org/publications-category/annual-reports 2014 Annual Report On Port State Control (Date of access on 30.11.2016)

[35] Tristan Boutros and Jennifer Cardella (2016), The Basics of the PROCCESS IMPROVEMENT

List of Publications

John S. Oakland Total Quality Management and Operational Excellence

ABS Guidance for Reducing Port State Detentions

GL The Top Ten PSC Findings

BS MOU Port State Control in The Black Sea Region (Annual Report 2015)

PARIS MOU Port State Control (Annual Report 2014)

MED MOU Mediterranean Memorandum of Understanding on Port State Control (Annual Report 2013)

Maritime New Zealand Developing a Maintenance Plan (maritimenz.govt.nz/moss)