ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL

STANDARD SHIPYARD FORMAT FOR REPAIR BUDGET CALCULATIONS OF VESSELS AT DOCK AND RELATIONSHIP BETWEEN THE WORK SCOPE AND THE REPAIR PERIOD

M.Sc. THESIS

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JANUARY 2025

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İSTANBUL TEKNİK ÜNİVERSİTESİ ★ LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ

GEMİLERİN HAVUZDAKİ TAMİR BÜTÇE HESAPLAMALARI İÇİN STANDART TERSANE FORMATI VE İŞ KAPSAMI İLE TAMİR SÜRESİ ARASINDAKİ İLİŞKİ

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To my precious uncle Kamil KARİMOV …

FOREWORD

I would like to thank my esteemed advisor, Assoc. Prof. Dr. Sevil Deniz YAKAN DÜNDAR, who gave me the chance to work together on my thesis and helped me on every step of it patiently.

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January 2025

Rahim KARİMLİ
(Ship Repair Marketing Engineer)

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ABBREVIATIONS

AUO	: Auxiliary Engine Overhauling
AUTO	: Auxiliary Engine TurbochargerOverhauling
BP	: Berth Period
CHW	: Cargo Hold Treatment
CPP	: Controllable Pitch Propeller
CTW	: Cargo Tank Treatment
DN	: Diameter Nominal
DP	: Dock period
DPI	: Dye Penetrant Inspection
DWT	: Deadweight
EMO	: Electrical Motors Overhauling
ETA	: Estimated Time of Arrival
FPP	: Fixed Pitch Propeller
GT	: Gross Tonnage
HT	: Hull Treatment
IGS	: Inert Gas System
IMO	: International Maritime Organization
MEO	: Main Engine Overhauling
METO	: Main Engine Turbocharger Overhauling
NT	: Net Tonnage
PO	: Pump Overhauling
PW	: Pipe Works
RPSW	: Rudder Propeller Shaft Works
SW	: Steel Works
TRP	: Total Repair Period
UTM	: Ultrasonic Thickness Measurement
VO	: Valve Overhauling

SYMBOLS

L_{OA} : Overall length

B_{OA} : Overall breadth

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STANDARD SHIPYARD FORMAT FOR REPAIR BUDGET CALCULATIONS OF VESSELS AT DOCK AND RELATIONSHIP BETWEEN THE WORK SCOPE AND THE REPAIR TIME

SUMMARY

Shipyards are facilities where ships are built, repaired, and maintained. The reasons for repairs can be accidents or obligatory maintenance. Shipowners prefer shipyards that are near to the trading areas in order to avoid transportation costs. However, the selection of a shipyard can also be affected due to the quotes of faraway shipyards. It is well known that realistic repair budgets and repair timelines are considered as key elements in the selection of shipyards, but due to the inconsistencies in the repair reports, different formats, and lack of information, these budgets and timelines usually result in overruns and delays. After all, ship-owners try to maximize profit during a ship's life cycle, but repair processes in shipyards constitute one of the biggest costs and losses.

The repair budgets of ships are prepared based on the developed repair reports by the ship's superintendent. These reports include details about works such as steel renewal, mechanical fixes, and docking activities. They can be used as a gross indication of the total repair cost. The estimates of the budget, however, depend on the repair period, dimensions of the ship, type, and tonnage, in addition to the superintendent report. However, due to the vagueness or incompleteness of the specifications, the precise pricing of repairs is by no means easy for the marketing departments of shipyards. Shipyards usually present their offers in their own formats and comparisons among several bids become difficult for the shipowners. The lack of a specification standard frequently leads to many of errors, ineffective communication, disputes and increased costs for shipowners.

Ship repair periods are one of the most important parameters in a shipyard offer. Repair times vary depending on the work to be done on the ships and the shipyard's busyness. Explaining the relationship between repair work and repair times can help in making predictions about future ship repairs. Providing a correct repair time will not affect negatively the shipyard's future plans, will not increase the cost in the budget and will make the offer more attractive and realistic.

A literature survey of various methods for ship repair budget estimation was carried to identify gaps in current techniques for budget estimation. Common factors for such techniques are that they require consistent information about the ship type, dimensions and type of repairs required. However, not enough research has been carried out in standardizing the specifications and procedures for repair and budgeting. Furthermore, most of the analysed approaches have a bias towards the shipowners or shipyards and thus, a major reason for that universally applicable solutions are difficult to develop. Serious challenges include the non-standard practices and unexpected repair requirements. Lack or inconsistency in the data within the repair reports leads to delay, disputes, and increased costs in the repair process. The inconsistency in bids due to

different interpretations of the repair specification may lead to shipowners choosing inappropriate shipyards. Unexpected repair requirements discovered during the shipyard period result in increased costs and extended timelines of repairs. In addition, a uniform approach to the repair specifications is discussed. These standard specifications would enable shipyards to make precise bids supported by detailed and consistent repair lists, while shipowners could evaluate the bids equitably and effectively. Key components of repair specifications are the details of ships such as length, gross tonnage, thorough descriptions of repairs, time schedules, and accompanying technical drawings. They would allow shipyards to provide a more accurate estimation of the repair costs, and shipowners to evaluate the most adequate shipyard based on more accurate information from the bids, as well as ensuring that the extent of repair works is precisely defined, accurately priced, and consistently considered.

GEMİLERİN HAVUZDAKİ TAMİR BÜTÇE HESAPLAMALARI İÇİN STANDART TERSANE FORMATI VE İŞ KAPSAMI İLE TAMİR SÜRESİ ARASINDAKİ İLİŞKİ

ÖZET

Tersaneler, gemilerin inşa edildiği, tamir ve bakımının yapıldığı tesislerdir. Bir geminin tamir ve bakımı için tersaneye alınmasının geminin daha uzun süre kullanılmasına olanak sağlar. Bununla birlikte tersaneler denizcilik sektöründe var olan uluslararası kuruluşların bazı kurallarının gemilere uygulanması için önemlidir. Bu anlamda tersaneler denizcilik sektörünün en önemli unsurlarından biridir. Tersanelerin bu hizmetleri sağlayabilmesi için çok önemli altyapılara sahip olması gerekir. Tersane iskelesi ve havuzu bu önemli altyapılar arasında yer alır. İskele ve havuz büyüklüğü ise tersanenin hedeflediği müşteri ağına göre, denizcilik sektöründe var olan gemilerin çoğunluğunun boyutlarına göre ve tersanenin bulunduğu bölgede çalışan gemilerin boyutlarına göre belirlenir.

Geminin tamire gitmesinin nedenleri kazalar veya zorunlu bakım periyotları olabilir. Tersanede yapılacak işlerin boyutuna göre maliyetler farklılık gösterebilir. Ayrıca farklı boyutlarda olan gemilerde yapılacak aynı işler de işlerin hacimlerinden dolayı farklı bütçelerle sonuçlanır. Gemilerin tamir giderleri, geminin bulunduğu yerden tamir için gideceği tersaneye ulaşması için harcanan maliyetler ve tamir sonunda ortaya çıkan maliyetler olarak hesaplanır. Geminin bulunduğu yerden daha uzaktaki bir tersaneye ulaşması için harcayacağı maliyetler, geminin seyir alanına yakın bir bölgedeki tersaneye ulaşması için harcayacağı maliyetlerden doğal olarak daha fazla olacaktır. Armatörler ekstra ulaşım maliyetlerinden kaçınmak için gemilerin seyir alanlarına yakın tersaneleri tercih ederler, ancak tersane seçimini geminin seyir alanından uzakta bulunan tersanelerin teklifleri de etkileyebilir. Bu tekliflerin ekonomik olarak daha cazip olması, armatörün geminin bulunduğu yerden daha uzakta yerleşen bir tersaneye tamir için gitmesine karar vermesinde etkili olabilir. Ancak ekonomik teklifler dışında tersanede yapılacak işlerin kalitesi de karar vermede önemlidir. Tersanelerin kaliteleri ile ilgili bilgiler o tersanede daha önce tamir yaptıran denizcilik şirketleri tarafından alınabilir. Bu yüzden tersaneler istek üzerine daha önce tamir yaptıkları gemilerle ilgili referans listelerini yeni müşterileri ile paylaşırlar.

Gerçekçi tamir bütçelerinin ve tamir zaman çizelgelerinin tersane seçiminde önemli unsurlar olarak kabul edildiği bilinmektedir, ancak tamir raporlarındaki tutarsızlıklar, farklı formatlar ve bilgi eksikliği nedeniyle, bu bütçeler ve zaman çizelgeleri genellikle artmalara ve gecikmelere neden olur. Sonuç olarak, armatörler bir geminin yaşam döngüsü boyunca karlarını maksimize etmeye çalışır, ancak tersanelerdeki onarım süreçleri armatörler için en büyük maliyet ve kayıplardan birini oluşturur. Gerçekçi bir tamir bütçesinin bulunduğu bir teklif, enspektör tarafından hazırlanan tamir raporundaki bütün işlerle ilgili fiyatları içerir. Bu fiyatların tamir yapılacak işlerle ilgili final fiyatların olması ve gemi tersanede bulunduğunda bu işlerle ilgili ek ücretlerin ortaya çıkmaması önemlidir.

Gemilerin onarım bütçeleri, gemi enspektörü tarafından geliştirilen tamir raporları esas alınarak hazırlanır. Tamir raporlarının hazırlanmasında enspektöre gemi çalışanları da yardımcı olurlar. Uzun bir süre gemide bulunan ve farklı görevlerden sorumlu olan gemi çalışanları, geminin yapısı, makine sistemleri, güvenlik ekipmanları ve diğer bütün konularla ilgili enspektöre bilgi verirler. Bu raporlarda sac değişimi, mekanik tamirler ve havuz faaliyetleri gibi çalışmalara ilişkin detaylara yer verilir. Bunlar toplam tamir maliyetinin brüt bir göstergesi olarak kullanılabilir. Ancak bütçe tahminleri, enspektör raporunun yanı sıra tamir süresine, geminin boyutlarına, tipine ve tonajına da bağlıdır. Ancak raporlardaki işlerin belirsizliği veya eksikliği nedeniyle tersanelerin pazarlama departmanları için onarımların tam fiyatlandırılması hiç de kolay olmuyor. Tersaneler genellikle tekliflerini kendi formatlarında sunmakta ve bu da armatörler açısından birden fazla teklif arasında karşılaştırma yapmayı zorlaştırmaktadır. Bir standard raporun olmaması, gemi sahipleri için birçok hataya, verimsiz iletişime, anlaşmazlıklara ve artan maliyetlere yol açmaktadır. Aynı zamanda tersaneler bu standart dışı formatlara göre yeni teklifler hazırlarken çok fazla zaman harcıyorlar. Bu tersanelerin pazarlama departmanlarında çalışan kişilerin verimlerinin düşmesine ve tekliflerin geç teslim edilmesine neden olur.

Gemi tamir süreleri bir tersane teklifindeki en önemli parametrelerden biridir. Tamir süreleri gemilerdeki yapılacak işlere ve tersane yoğunluğuna göre farklılık göstermektedir. Aynı zamanda tamir süresini tamirde yapılacak işler için temin edilecek malzemelerin tersaneye ulaştırılma süresi de etklileyebilir. Tersane özel cihaz veya sistemler dışında bir çok malzemeyi kendisi temin eder ve gemi yanaşmadan önce tersanede hazır bulundurur. Ancak bazı özel cihaz veya sistemler denizcilik şirketi tarafından getirildiği için, burada oluşacak gecikmeler toplam tamir süresini de etkiler. Tamir işleri ile tamir süresi arasındaki ilişkilerin açıklanması gelecekteki gemilerin tamirleri ile ilgili tahmin yapmada yardımcı olabilir. Doğru bir tamir süresinin verilmesi tersanenin gelecek planlarını negatif etkilemeyecek, bütçedeki maliyeti artırmayacak ve teklifin daha çekici ve real olmasını sağlayacaktır. Bu tezde açıklanan tamir süresi ve tamir içeriği arasındaki ilişki gerçek gemilerden alındığı için, farklı boyutlar ve tamir içeriğine sahip gemilerin gerçekçi tamir süreleriyle ilgili bilgi sahibi olmaya yardımcı oluyor.

Gemi onarım bütçesi tahmini için kullanılan çeşitli yöntemlerin literatür taraması yapılarak, mevcut bütçe tahmini tekniklerindeki boşluklar tespit edilmiştir. Bu tür tekniklerin ortak noktaları, gemi tipi, boyutları ve gereken onarım türü hakkında tutarlı bilgi gerektirmesidir. Ancak tamir ve bütçe hesaplamaları için raporların ve prosedürlerin standartlaştırılması konusunda yeterli araştırma yapılmamıştır. Ayrıca, incelenen yaklaşımların büyük çoğunluğunun ya gemi sahiplerine ya da tersanelere tek yönlü çalışmaya sahip olması, evrensel olarak uygulanabilir çözümler geliştirmenin zor olmasının başlıca nedenlerinden biridir. Tamir raporlarında yer alan verilerin eksikliği veya tutarsızlığı, tamir sürecinde gecikmelere, anlaşmazlıklara ve maliyetlerin artmasına neden olmaktadır. Tamir raporunun farklı yorumlanması nedeniyle oluşan teklif tutarsızlıkları, gemi sahiplerinin uygun olmayan tersaneleri seçmelerine yol açabilmektedir. Tersane döneminde ortaya çıkan beklenmedik tamir ihtiyaçları, maliyetlerin artmasına ve tamir sürelerinin uzamasına neden olmaktadır. Ayrıca burada tamir raporlarına yönelik tek tip bir yaklaşım tartışılmaktadır. Bu standart raporlar, tersanelerin ayrıntılı ve tutarlı tamir listeleriyle desteklenen kesin teklifler vermesini, gemi sahiplerinin ise teklifleri doğru ve etkili bir şekilde değerlendirmesini sağlayacaktır. Tamir raporlarının temel bileşenleri, gemilerin uzunluğu, tonajı, tamir işlerinin ayrıntılı açıklamaları, tamir periyodu ve bunlara ilave olarak tamir edilecek bölgelere ilişkin teknik çizimler gibi detaylarıdır. Bütün bunlar tersanelerin tamir maliyetlerini daha doğru tahmin etmelerine, gemi sahiplerinin ise tekliflerden gelen daha doğru bilgilerle en uygun tersaneyi değerlendirmelerine olanak sağlanacak, ayrıca tamir çalışmalarının kapsamının kesin olarak tanımlanması, doğru fiyatlandırılması ve bunların tutarlı bir şekilde dikkate alınması sağlanacaktır.

1. INTRODUCTION

Shipyards, one of the most important touchstones of the maritime industry, are places where ships are repaired and maintained, new ships are constructed and different installations are built on existing ones [1]. One of the main goals of every shipowner is to make huge profits of the ships they own, from the day they are first used until they are sent for scrap. In order to achieve the intended profits during this period, many ship-related expenses are made carefully and in advance by the shipping company.

After the construction of ships, the biggest expenses of shipping companies are spent on the repair of existing ships, and since the ships stop working during these periods and remain in the shipyard for a certain period of time, shipping companies cannot make a profit from these ships. The main reasons for ships to go to the shipyard may be the occurrence of a sudden accident, the arrival of a mandatory maintenance period, the need to change the ship's class and structural or system changes to be made to the ship depending on the shipowner's request [2]. In all cases, shipping companies want to be familiar with the general prices of the shipyard when selecting a shipyard. After the offer is confirmed, a repair contract is signed between the shipyard and the shipping company. The offer is prepared by the shipyard's marketing department estimators or marketing engineers. Here, the repair specifications sent by the vessel’s superintendent to the shipyard are taken as basis when quoting the works. Repair specifications are prepared by the employees, who work on the vessel, such as captain, chief engineer and the shipping company's superintendent [3]. For shipowners, the total repair period and budget are one of the most important priorities in in decision making. Shipowners prefer that the selected shipyard area for repairs is close to one of the vessel trading areas, so that they do not meet large costs for the vessel to sail to a different and more distant area. Regardless of this, an economical offer may cause the shipping company to choose a shipyard located further away from the area where the ship trades [4].

1.1 Research Objectives

The marketing departments of the shipyards provide detailed information to the shipping company about the budget and repair period with the offers they prepare. Repair specifications prepared by the superintendents of shipping companies include the definition of the works planned to be done on the ship under certain headings, all the details necessary to give a price for these works and the repair start date planned by the shipping company [5]. Repair specifications are prepared in different formats in shipping companies. Shipyards have their own formats where they give price offers for the works included in the repair specifications and shipyards define the works as they plan to do them in this format and add the availability date according to the shipyard's workload or the date requested by the shipping company. At the same time, the contract that the shipyard wants to make with the shipping company is included at the end of the offer. Nevertheless, repair details can be comprehensible for certain yards however not for remainings. It is important to quote all the works in the repair specifications, as well as to quote each work correctly, but sometimes quoting some of the works in the repair specifications can be difficult for the shipyard's marketing employees and they may not want to take the risk. Yet, in some other shipyards, marketing employees proceed according to their own experience and similar ships and works they have previously prepared offers for. The fact that the formats and contents of the offers of the shipyards located in a region are different from each other negatively affects the shipping companies' selection of a suitable shipyard for repairs. Failure to select the right shipyard causes many things, especially the repair budget and duration, to be higher and longer than planned. The fact that the works included in the repair reports are not clear, incomplete, the amount of the works to be done is not specified, isometric drawings and necessary documents are not provided in works such as pipe and steel renewal are among the factors that prevent the preparation of a good offer. Such factors cause different shipyards to perceive the works differently and consequently to price them differently. However, having a standard format that includes all the works for both repair reports and shipyard offers makes the decision of shipping companies much easier and also helps shipyards to prepare offers in a shorter time. The lack of sufficient and different resources and the few publications on repair estimated budget calculations have prevented the preparation of a standard offer and repair format. In this thesis, such a format was created with the help of existing studies and the requirements for its development are explained.

1.2 Scope and Significance of the Study

The reasons for a vessel to arrive at a shipyard can vary from minor repairs to major structural changes. The budget that will emerge as a result of the repair can range from hundreds of thousands of dollars to millions of dollars. The fact that the vessel has high expenses without making any profit during this period reveals the importance of this period. Before coming to the shipyard, shipowners want to receive estimated repair budget offers from shipyards and classify their repair budgets according to payment terms during this period. The detailed and standard format allows all works to be listed in the format in a sequential manner and the units of quantities for works to be the same. These works include all possible works in the dock and on the pier. If no new work arises while the vessel is in the shipyard, all work can be given in a standard format in advance. This helps ensure that all expenses will be the same as the previously calculated budget.

In this thesis, studies that can help ship repair budget estimates are mentioned and the thesis shows what the ship repair specifications contain and the information that should be together with the repair specifications in order to estimate the ship repair budgets. The fact that there are not enough clear studies directly related to these calculations in the literature makes this thesis important. The thesis aims to provide a format that is clear, uniform and suitable for future development, which can be used by both shipping companies and shipyards.

1.3 Structure of the Thesis

This thesis consists of five main sections and in each sections, specific aspects, problems and solutions of the study are shown. In the first section, the study is introduced, the problems related to the subject are listed and the importance of the study is emphasized. The second section evaluates the literature studies related to this study. It shows the differences and gaps in these studies. Existing methods related to ship repair budget estimates are discussed. In the third section, the approaches to the literature review are mentioned, the criteria required for the study and the analysis of different methods in the literature are shown. The fourth section covers the results, discussions and recommendations and explains the importance and necessity of a standard document for the accurate budget estimate calculations and the relationship between the work scopes and the repair periods. The thesis ends with the fifth section which includes, a summary of the main and important results, required further study and final explanations.

2. LITERATURE REVIEW

Choosing a shipyard is a difficult process for a shipowner. The location, reputation and references of the shipyard are the initial evaluations made by the shipowner or superintendents when choosing a shipyard. The reason why the shipyard location is one of the important considerations is that there would be extra expenses if the territory of the vessel trading before repairment is far from the territory of the repairment. While evaluating the shipyard reputation, the shipyard's success in its own region and globally, accidents that occurred in that shipyard and their results, information about the shipyard owners, the shipyard's development process and investments are taken into account. The references of the shipyard are an important document evaluated by the shipowner, containing information about which companies and what size vessels have come to that shipyard before and what kind of important work has been done. Information about the shipyard location can be easily accessed on the internet and from the shipyard's website. Some information about the shipyard's reputation can also be accessed on the internet or requested by the shipyard along with shipyard references. After this process, the superintendent sends the repair specifications of the vessel to be repaired to the shipyard and requests offer. The shipyard then prices these works in a certain amount or all of them, depending on the details provided by the superintendent, and sends the offer. The offer here includes the dates on which the shipyard will accept the vessel to the berth and dock, the price offer for the specified works and the contract. For all shipowners, the most important consideration here is the price offer of the shipyard. Because if the prices are very profitable, the shipowners can send the vessel to a shipyard further away from the trading area, and if there are not very negative issues, shipowners can ignore shipyard’s general reputation and references and accept contract differences. Therefore, it is very important that ship repair reports are prepared in detail and that these repair reports are priced appropriately by the shipyard.

2.1 Overview of Budget Estimation Methods in Ship Repairs

There are very few publications and researches in the literature about ship repair budget calculations and bid formats, but although there are few studies on general shipyard evaluations and selections, these studies can assist in ship repair budget calculations in dock.

Don Butler [6] gave detailed information about works done during the repair of a ship. In this publication he gives the details of the works to be done in the repair of a ship and explains the necessary things for pricing these works. This book is of great importance in order to have sufficient information about the works to be done during the repair of a ship and to understand the pricing policies of the shipyards. The author's long years of work in the maritime field also provides great benefits to those working in the technical departments of shipping companies. In the book, man-hour labor is shown so that the price calculations can be used in the future. Therefore, this study helps to make future calculations of the shipyard whose prices change. In the selection of the shipyard, which is a long process, one of the most important factors is a competitive offer without deficiencies and incorrect calculations. What is shown in this study helps to prepare such an offer. However, Mourtzis [3] has made a comprehensive research on these processes as well as all the others and showed in detail all the processes mandatory for a successful shipyard to be preferred by shipping companies. In addition to his own work, he also supplies information on existing software programs and their shortcomings created fo the usage of shipyards. Once again, Chryssolouris et al. [7] have stated in their study the features that a shipyard must have in order to have a successful tender process in a planned manner. In his study, Celik et al. [8] provides a systematic evaluation model for ship owners about the problems that may happen in their shipyard selection process. In their studies, shipyard prices, territorial price changes, ship docking plans, agreement terms and other important parameters are taken into account in the selection. The fact that the rapidly developing Turkish shipyards are taken as a case, especially for repair evaluation, adds a unique value to the study. It is known that shipping companies meticulously consider all their costs and give the greatest importance to the budgets spent for ship repairs. The real values obtained from ships in the studies make the study more important and accurate. Kavussanos et al. [9] used data on 112 ships obtained from shipowners in their studies. Although this study provides important information for the shipowners rather than the shipyards, it explains the relationship between ship repair budgets and the age, size and usage of the ship. At the same time, since there will be difficulties in selling ships to other shipowners after a certain period due to the age of the ship, it explains why shipowners try to have lower budgets during the mandatory repair periods of the ships after a certain period. In addition, since it is an empirical study, it also sheds light on the studies conducted today and to be conducted in the future regarding ship repair fees. Some shipyards only carry out new construction activities, while others only carry out repair activities. We can also come across shipyards where repair, new construction and conversion activities are carried out at the same time. Senturk [2] explains the factors that may cause shipyards to switch between these activities in his study. In this study, the general structure of shipyards is examined and the types of barriers that may exist in these transitions are stated. At the same time, important issues regarding the ship repair market are mentioned. In their study, Lirn and Thanopoulou [10] discuss the criteria put forward by brokers in two different countries for shipyard selection. In their study, they reveal a critical piece of information that global container carriers should be the focus for gaining insight into shipyard marketing. Although it is related to the new construction area, Kafalı and Ozkok [11] explained the criteria that shipowners consider when choosing a shipyard and the importance of each criterion. The aim of this study is to explain to shipyards how shipowners evaluate shipyard selection and thus how they can strengthen their weak points and gain more approval from shipowners. Lu et al. [4] analyze the shipyard selections made by shipowners with the criteria of shipyards' offer conditions, repair costs, technical performances and offered repair time. This study mentions the attractive price policies and production areas of Chinese shipyards, whose demand has increased in recent years. References are very important for shipowners in choosing the right shipyard. These references include information about different ships that have been repaired at the shipyard. However, unfortunately, it is very difficult to obtain complete information about repairs made on previous ships. Arif et al. [12] in their study mention the design of a website based on comments from shipowners of previously repaired ships. Ship repair budget calculations are prepared based on the repair specifications prepared by the ship's superintendent. Any incorrect or missing information in these specifications prevents a detailed and accurate repair budget calculation. Manea et al. [5] mention the importance and content of these repair specifications in their studies. One of the most important factors affecting ship repair budget calculations is the repair period. When preparing the offer, the repair period required to carry out the work is also specified. This repair period also affects the offer budget. People working in the shipyard's marketing department must calculate this period very carefully. Dev et al. [13] has provided information about many repair works and the calculation of repair periods related to these works in their book.

2.2 Importance of Accurate Budget Estimation

A correct repair offer prepared by the marketing department of the shipyard helps the shipping company to have accurate economic information about the ship they will repair and to make the right shipyard selection. A proper repair quote includes all pricing related to the work in the repair report and any increases that may affect the price due to the materials to be used in the repair or the location where the work will be done. In order to prepare a correct shipyard repair offer, all the work for which a price is requested must be in the repair specification together with its details. For example, if a pipe is to be replaced, the material and the location where the pipe will be replaced must be specified in addition to the length and diameter information of the pipe. The marketing departments are responsible for finding new customers in the shipyard and preparing offers regarding the repair requests of these customers. After the ships arrive at the shipyard, if there are additional works that are not included in the repair specifications, these works are quoted by the planning department. When the repair is completed, the shipping companies compare the budget in the first offer sent with the budget of the ship at the end of the repair, together with the quality. If there is satisfaction in both senses, the shipping company can also make a fleet agreement with the shipyard. This agreement means that the other ships of the shipping company will come to the same shipyard and will have the same high expectations at the end of the repair.

2.3 Classification of Budget Estimation Method

Periodic Maintenance costs in average corresponds to 14% of the total operation cost of a ship [14]. It covers the cost of standard maintenance of the ship running components, general repairs not covered in the standard maintenance and possible spare parts required by any of the sub systems. Periodic maintenance is necessary to obtain insurance and to pass inspections and therefore is important to consider its impact on the regular operation. Over the usage of the ship periodic maintenance corresponds to a 4% of the total cost of the ship. Therefore, a correct approach to the maintenance budget estimation is necessary for the profitability of shipping.

Budget estimation methods are decision making tools that estimate the cost of a due repair works based on assumptions such as the dimensions and age of the ship, the period since the last repair, the operating conditions and regulatory compliances with rules from classification societies. Some semi-empirical models are accessible in the literature. Kavusanos et al. [9] for example considers the ship repair and maintenance as an iterative optimisation problem to provide an econometric model for ships. It considers that variables such as the type of ship, ship construction, flag state, age of the ship, classification category and location and yard of the maintenance work, have an influence on the cost of future maintenances. The study uses all the information to provide a log-linear model that estimates the total costs. A more holistic approach to ship maintenance budget estimation consists on evaluating each required work on a case by case basis. Dev et al. [13] identify typical repairs in ships and identify the following key factors to estimate the total labour costs of each repair: age, deadweight (DWT), vessel type, hull status and structural status. They provide with a set of simple regression equations to estimate the total hours required for the total repair of a ship. With the labour hours directly translating into work-hours required in a shipyard, hence can be used as an estimation of the maintenance costs. Note that the quantity and the quality of the services provided by each maintenance yard is not considered in the previous step. Considering that each shipyard offers different repair works with different quality it is also important to include the correct shipyard estimation in the maintenance budgeting. Lu et al. [4] provide with a fuzzy logic classifier to choose the most adequate yard for a given periodic maintenance work. It considers the cost of the repairs, payment conditions, repair quality and distance from the current position of the ship. Similarly, Kafali and Ozkok [11] also provide a fuzzy technique to select the most adequate shipyard for a new vessel construction, although this approach is not contradictory of Lu et al. [4]. These fuzzy models provide with a complex estimation of the repair cost that may not be suitable for actual budgeting. Up until now, studies on both repair and new construction budget estimates have been presented unilaterally for the use of either shipping companies or shipyards. General practice shows that both shipping companies and shipyards use their own formats rather than these systems. It would be beneficial to standardize these separate formats used by both parties in the industry and to make them a single format where both shipping companies can enter the details of their repair reports and shipyards can specify their prices.

2.4 Common Issues Faced by Shipyards

Every shipyard aims to get large revenues through the repair, conversion and new construction services they provide to shipping companies. The most active among these is the repair services. Carrying out repairs and maintenance of many different types of work within a predetermined period of time makes the repair department the most active department in the shipyard. To be a preferred repair yard, shipyards aim to provide quality service to their customers during the offer approval period, while the ship is in the shipyard, and for a certain period of time after the ship leaves the shipyard. Here, the offer approval process covers the period from the initial contact with the customer until the shipyard offer is approved. During this period, marketing department employees aim to successfully market the shipyard to their new customer and make a competitive offer. Problems that may arise here include difficulty in finding a new customer and preparing a competitive offer. Shipyards can find information about new customers and their ships on various websites and from the connections of their previous customers. Preparing a competitive offer is related to being close to the pricing policies of other shipyards in the region where the shipyard is located. It is difficult for a shipyard to be successful with prices that are much higher than the prices of other shipyards in the same region. During the period,when the ship is in the shipyard, the ship is dealt with the shipyard's planning and production departments. During this period, failure to deliver the work done within the previously notified time and in high quality leads to problems. When the vessel is in the shipyard, the marketing department employees are still concerned with customer satisfaction and shares the problems with the shipyard management and appropriate departments. A shipyard that aims to be successful will still be in contact with the ship after she leaves the shipyard and will be responsible for the work they have done for the period specified in the contract. This period is known as the warranty period for the work done.During these warranty periods, superintendent contact the shipyard if a problem occurs in the repair areas or equipments they repaired at the shipyard and the shipyard either sends a team to the ship or, based on the degree of the problem, the ship come back to the shipyard again.

3. RESEARCH METHODOLOGY

Shipyards need shipowners to fill their slots and generate good turnover, and shipowners need shipyards to repair their ships in a short time, with high quality and within economical budgets. The shipowners' search for suitable shipyards is done by superintendents who carry out the technical responsibilities of their ships, and the shipyards' search for customers for repairs is done by their marketing departments. Sometimes superintendents contact shipyards in the appropriate region directly or through brokers. But usually, shipyard marketing departments find suitable ships for their shipyards directly or through brokers. If a shipyard is not urgently needed for the ship due to an unexpected accident, this process can take a long time. It can be difficult for shipyards to get approval, especially from big shipping companies. Such companies want to continue to go to shipyards they have been before because they know the operations there very well. Much of the information necessary to understand this process between superintendents and shipyard repair departments has been stated by Mourtzis [3].

A ship consists very complex and detailed machinery and systems, as it operates for a long time and carries the desired cargos without damage and at a certain speed. Due to its structure, there are many systems and areas on the ship where malfunctions or breakdowns may occur. Ships must go through a detailed repair process to perform general inspections or repair of faulty or damaged areas and systems. The lists and details of the areas and equipment to be inspected and repaired are determined by the ship's chief engineer, captain, boatswain, etc. If this information is entered in a standard form with details and sent to the shipyard, then the shipyard can clearly state its prices. Much of the information needed to prepare a single standard format that can be used by both shipping companies and shipyards has been provided by Butler [6] and Dev et al. [13].

3.1 Relevant Variables for Budget Estimation

Ships are obliged to repair areas and equipment with problems during mandatory repair processes and to perform general inspections. Shipyard repair offers include the shipyard's price lists for the works specified in the ship's repair specification, repair period and contract. The works in the ship's repair specification are specified in different sections. These are generally stated as general services, dry docking and wharfage fees, works to be done in the dock, mechanical works, steel works, pipe works and other works. The main reasons for dividing the work into sections are to ensure that the repair specifications and offers are regular and to obtain general price information about the works in similar categories. Sometimes the shipowner may postpone the repair works to the next shipyard period because the repair budget is higher than expected. Therefore, during a mandatory repair process, for example, dock works can be done, small outfitting works or mechanical works can be kept for the next period.

A shipyard's repair offer for a ship may differ depending on some parameters of the ship. The main differences here are due to the type and size of the ship. Many systems on the ship are the same in different types of ships. However, the ship has systems that can vary depending on the type, such as hatch covers due to being a bulk carrier or Inert Gas System (IGS) due to being a tanker. Differences depending on the type of ship do not affect the price policy of the shipyard. The shipyard also includes prices in its offers for specific works depending on the type of ship, if requested. The price change depending on the weight and length of the ship is mostly seen in the docking and wharfage rent of the shipyard. Some shipyards charge daily wharfage rent for the ongoing repair works of the ships at the pier. Some shipyards do not charge this due to their marketing policies. In the dock, which is one of the biggest investments of the shipyard, the ship weight parameter is used for both docking and the machinery work to be done at the dock. These are the two basic parameters used, but apart from these, specific parameters used for each area or system of the ship are used as a basis for the prices that shipyards give for repairs.

3.2 Analysis of Work Scope and Repair Time

Some of the works included in the ship repair specifications have a great impact on the total repair time. It is possible to understand which of these works will affect the repair time and to what extent with the following analyses.

3.2.1 Correlation analysis

The correlation analysis method quantifies linear relationships between pairs of variables X_1 and X_2 from the measurement data. The expression for the correlation coefficient is given by in Equation 3.1 [15].

$$r = \frac{\sum(X_{1i} - \overline{X_1})(X_{2i} - \overline{X_2})}{\sqrt{\sum(X_{1i} - \overline{X_1})^2 \sum(X_{2i} - \overline{X_2})^2}} \tag{3.1}$$

Here the numerator represents the degree to which the variables jointly deviate from their respective means, while the denominator normalises the correlation between -1 and +1. A high positive r indicates linear relationship, while a high negative r suggests an inverse linear relationship. Smaller values of r imply that the data pairs are independent. This is solved using the library pandas.

3.2.2 Regression analysis

The regression analysis method which,models the relationship between a dependent variable and one or more independent variables using the general linear regression equation is given by in Equation 3.2 [16].

$$Y = \beta_0 + \beta_1 X_1 + \varepsilon \tag{3.2}$$

Here, Y is the dependent variable, X_1 is the independent variable, and ε is the error term. The parameters β_0 (intercept) and β_1 (slope) are estimated using the ordinary least squares (OLS) method, which minimises the sum of the squared residuals is given by in Equation 3.3.

$$\min \sum_{i=1}^{n} \left(Y_i - (\beta_0 + \beta_1 X_{1i})\right)^2 \tag{3.3}$$

This model assumes a linear relationship between the variables and is used to capture the trend I the data. It is implemented through the library linregress. For completeness, the goodness of the regression analysis is measured through the coefficient of determination (R^2), defined in Equation 3.4.

$$R^2 = 1 - \frac{\sum(Y_i - \widehat{Y_i})^2}{\sum(Y_i - \bar{Y})^2} \tag{3.4}$$

Where $\widehat{Y_i}$ is the prediction of Y using OLS.

3.3 Standard Budget Estimation

Shipyards price the repair specifications prepared by the superintendents according to their own pricing policies. These repair specifications and offers are usually prepared in Microsoft Excel format. The reason for using this format is to ensure that the offers are visually understandable. A standard shipyard repair offer includes unit and total price offers for the works included in the repair list, the date the ship will be accepted at the shipyard and the contract.

4. RESULTS AND DISCUSSIONS

4.1 Key Specifications for Accurate Budget Estimation

Shipping companies send many documents to the shipyard regarding the ship, but certain documents are needed for pricing the repair works. In order to have all the information about the ship, the main particulars of the ship must be stated. For a complete and definite price offer, all the details of the works to be repaired must be specified. These details can be supported with pictures and technical drawings depending on the works. The ship's Estimated Time of Arrival (ETA) information must also be stated in the repair list, because shipyards avoid preparing offers for a very long period due to possible price changes in the local market. If the quantities of the work to be done are not specified, the shipyard may send a bid for unit price or may not make an offer at all because they will not have any information about the budget. Again, if there is no information about the budget, the discount amount given by the shipyard may be low.

4.1.1 Critical parameters required by shipyards

The ship's overall length, overall breadth, depth, Deadweight (DWT), Gross Tonnage (GT) and Net Tonnage (NT) information is found in a file called Ship Particulars. This file is usually sent with the repair report or the information in the file is sent within the repair report. Information such as the overall length (L_{OA}), overall breadth (B_{OA}) and NT of the ship must be known in advance, not only for budget estimation, but also to determine whether the ship is suitable for the shipyard's dock. The shipyard uses the ship's length overall (L_{OA}), to determine the wharfage rental price. After the ship's work in the dock is completed, shipyard continues to do other works at the wharfage. Some shipyards do not apply the wharfage rental price.

Generally, shipyards use GT in dock pricing. Dock pricing here is the pricing for docking and undocking operation and the pricing of the period ship stays in the dock. Docking and undocking is considered as an operation, and a price is written according to each dock operation. Some shipyards charge one operation price for docking and undocking, while others charge two. The period ship stays in the dock is priced daily. The reason why GT is used instead of DWT in these pricings is that in some ship types, such as passenger ships or vehicle carrier ships, the DWT value is smaller than the GT value. Shipyards do not use the same price for all ships in jobs such as docking, instead a certain GT range is made and a price is determined according to each range. As the GT value increases, the prices also increase. GT also provides information about the ship size in pricing, for example, larger GT value ships have more blasting and painting costs.

The repair period is usually stated by the superintendent in the repair report. Superintendents calculate this period based on their own experience and so that the ship can go for new loads again as soon as possible. In some cases, this period is not realistic. However, shipyards specify the total repair period in their offers according to the work volume they quote. Shipyards have a certain capacity for both the dock and the wharfage, and in this sense, the shipyard also aims to complete the repair as soon as possible and to accommodate new ships for repair.

Shipyards usually give prices for steel renewal and pipe works together with the material. But in general, the supplies for the works are provided by the shipowner. The shipyard always wants the supplies to be provided on time. If they are not delivered on time, for example, paints for hull painting, the dock period will be extended.

Especially the dock period is very important for the shipyard. The shipyard plans to complete the dock works on time and accommodate the ships waiting or likely to arrive in the new periods. In this sense, the shipyard wants the ETA (Estimated Time of Arrival) of the ship to be realized. If everything goes well by both the shipyard and the shipping company and the weather does not prevent the docking, there will be no delay.

4.1.2 Impact of missing or incomplete data

The accuracy of a ship repair budget estimation heavily relies on the information provided by the ship superintendent. As a result of missing or incorrect information, mistakes will therefore affect the total budget. Some shipyards can correct mistakes and deficiencies themselves, while others can prefer on-site pricing. These errors or missing information in the worklist can result in the shipowner choosing the wrong shipyard. However, since the parties are in contact, the shipyard side can ask the superintendent about the parts they see as faulty and they can give a price accordingly. The missing parts are mostly seen in the amount of works, also in the maker and model information of the systems. If the units used by the shipyard for pricing and the units used by the superintendent for the works are different, this can also make it difficult to for the shipyard to give an accurate cost estimation as it may have to spend additional time verifying the data. This can delay the repair process and lead to disagreements between both parties. In addition, missing information in the repair list are translated into delays in the repair work, for example, if a component is not specified in the list, it might prevenet the shipyard from sourcing its replacement ahead of time and can incurr in additional costs due to its urgent procurement. Futhermore, incomplete specifications increase the risk of underestimating the scope of the repair work and may also incur in additional cost to be handled by the shipowner. From the shipping company side, incomplete specfications can influence the selection of the shipyard itself. When the shipping company evaluates multiple shipyard bids for the repair works, these bids may contain inconsistent pricings due to the shipyard's interpretation of the repair specification. In consequence the shipowner may select the wrong shipyard for the work or experience higher repairment cost due to all the aforementioned causes.

4.2 Framework for Repair Specification Submission

The International Maritime Organization (IMO) is an organization affiliated with the United Nations that ensures the safety of international maritime trade and takes measures to prevent pollution caused by ships [17]. Classification societies are organizations that apply certain standards to ships regarding ship safety and quality [18]. Classification societies ensure that IMO rules are technically complied with on ships. Shipyard repair periods are important to eliminate problems that occur in the ship's systems and structure during its service life. Depending on the ship's mandatory repair period and the status of the work done in the shipyard, repairs are made either only in the dock, only at the pier, or both at the dock and the pier. Repairs and general inspections made here are made upon the requirements of the classification society, flag administration and other institutions [19]. During mandatory or accidental repair processes, while the ship is being repaired in the shipyard or at the end of the repair, the classification societies representatives are also on board and examine the work done. The repair report prepared by the ship's superintendents also includes information about the problematic parts and systems on the ship, as well as the parts and systems that do not comply with the rules of the classification societies to which the ship is affiliated. In this sense, books containing the rules of the classification societies also provide information about many works in the repair report.

Standard ship repair specifications include all details, quantities and units of these jobs along with the repair start and end date. Some may also include the ship owner's side contract or be sent separately. Some shipping companies may also agree to work with shipyards' contracts. These repair specifications, prepared by the superintendents of the shipping companies, are divided into sections. These sections are classified according to the volume of the repair work and budgets of each. [5].

In addition to the works that ships will do in the shipyard, the shipyard charges the ship with many items under the name of general services while the ship is approaching the shipyard, while it is in the shipyard and while it is leaving from there.

After the ships approach the shipyard area, depending on the situation of the shipyard, they are either taken to the shipyard immediately or they wait at anchor in that area for a certain period of time and then berth with the help of the shipyard, the ship's agent and the pilotage of the area. Generally, shipyards want the ship to dock or berth with the assistance of agency to which the ship is affiliated and local pilotage teams. Because these organizations have sufficient infrastructure and they work with professional people in this field. A ship leaving the dock with the help of a tugboat after repair works is shown in Figure 4.1. Each shipyard has a dock master and a dock team, and these people, in addition to their other responsibilities, pay attention to the tying and control of the ropes to be given from the ship to the appropriate areas in the shipyard while the ship is berthing and leaving.

Before the ship arrives at the shipyard, the tanks, lines, containers or any closed areas inside the ship are tested to make sure they are gas-free and a certificate for this is issued. These tests are given by an authorized chemist. Thus, the ship comes to the shipyard gas-free. But, the shipyard also first performs its own gas-free tests to make sure that all compartments of the ship are gas-free. At the same time, during the repair process, gas-free tests are carried out in any closed area on the ship before the hot process, and the suitability for starting work is determined.

Figure 4.1 : A ship is undocking with a help of tugboat from a floating dock, after maintenances [20].

While some shipyards only provide repair services to ships at the pier, some shipyards provide both pier and dock services to ships [21] . Shipyard piers must be suitable for accepting ships in terms of length and depth. Shipyards want to complete the repairs of the ships they accept both at the pier and in the dock as quickly as possible. The piers of the shipyard affect the shipyard economy in this sense, because the work of existing ships is completed and the acceptance of new ships is planned. In this sense, piers are seen as a general service as well. Figure 4.2 shows the appearance of the shipyards in the Tuzla region of Turkey. As can be understood from the image, the piers are important facilities that provide information about the efficiency and capacity of the shipyards.

Figure 4.2 : Tuzla Shipyards [22].

Apart from gas-free, authorized security personnel are always on board the ship to protect security and prevent certain accidents such as fire. These persons are responsible for every event that will occur on the ship from the moment the ship first arrives until the ship leaves and they give the necessary permissions for the work to be done. In addition to these persons, if it is considered that there are many ships in the shipyard and hot works will be carried out in various places on these ships, a fire line is also connected to the ship against possible accidents.

Considering that the ship is no longer working when it is in the shipyard and is connected to the outside by the shipyard, it needs cooling water supply to cool the circuits on the ship, air supply to ensure working and living in closed areas or desired compartments, ballast water supply to catch the stability, shore electricity, telephone and internet supply for general systems and needs. Also since the shipyards are located in special areas and that ships are under repair for long periods of time, shipyards can also supply drinking water to ships for the crew and other needs. All these are included in the repair specifications as a general service.

It is not easy to access some parts of the ship due to its structure and the need for detailed repairs. In terms of both height and danger, appropriate platforms are needed to access different parts of the ship and to do work. These can be scaffoldings or cherry pickers depending on where the work will be done. Figure 4.3 shows the scaffolding installed around rudder and propeller of a vessel to carry out necessary inspections and repairs. At the same time, a reliable shipyard crane with a platform can also undertake this task. Shipyard cranes and their dimensions also provide information about the capacity of the shipyards.

Figure 4.3 : Scaffoldings around rudder and propeller of the vessel [23].

Shipyards plan to do repair work on large-volume ships in a shorter time by building cranes of different types and with large lifting capacities. Figure 4.4 shows the gantry crane from a shipyard, which can serve the vessels at afloat conditions. Since scaffoldings and cranes will be used to assist in different tasks during the repair, they are also included in the general service section.

Figure 4.4 : Gantry crane at a shipyard [24].

It is known that different types of wastes are generated due to the usage of machines, systems and crew life on ships. Here, the wastewater created by the crew is called sewage [25] . Water that does not flow through a drain hole and, on the contrary, collects in the bilge of the ship is called bilge water [26] . Considering environmental pollution and international rules, ships must discharge in special areas to get rid of these wastes. Shipyards also allow the discharge of these wastes due to their infrastructure and because they cut off the ship's connection to the sea. At the same time, since the daily life of the crew continues on the ship, the shipyards place a container in the appropriate part of the ship for the daily garbage generated and ensure that this garbage is emptied on a daily basis. Therefore, information about the types and amounts of these wastes is given in the general services section and is included in the specifications.

When ships are at the pier or in the dock, shipyards provide a secure gangway for shipyard workers and ship crew to get on and off the ship .In this way, they provide the connection between the ship and the shipyard.

Docking works generally involve structures and systems located in the underwater part of the ship. Docking of ships in shipyards is considered a job in itself. The operating costs of these docks, which shipyards purchase or build themselves with large investments, are high. Therefore, both the docking and undocking process of these docks and the period the ship stays in the dock are considered as a job. This is also written as an additional item in the repair specifications and the dock time requested by the ship side is specified. Shipyards themselves also offer a standard time for dock operations and works.

One of the most important tasks of docking a ship is cleaning the ship's hull. Since ships stay in the water for a long time and depending on the areas they work in, on their hulls fouling starts. In order to extend the work-life of the ships and reduce the resistance in the areas that come into contact with water, they need to be cleaned periodically and new paints should be applied. In the shipyard, these tasks are done by washing, blasting and painting [27] . These are controlled by the shipyard workers, the ship's responsible superintendent, the paint superintendent and the class society representative to which the ship is affiliated. In order to remove the dirts formed in the ship hull, shipyards apply sandblasting or waterblasting to the ship hull in the dock. The choice of sand blasting or waterblasting here depends on the environmental rules in the area where the shipyard is located and the ship side’s request. It is important to prepare the hull surface for painting by washing after blasting. Depending on the blasting rate to be applied, touch-up or full paint can be applied to the hull. Figure 4.5 shows the surface areas of a ship. The surfaces of the ship that are under water are exposed to more dirt. This means that the blasting rate in the above water parts may be less depending on the surface condition [6].

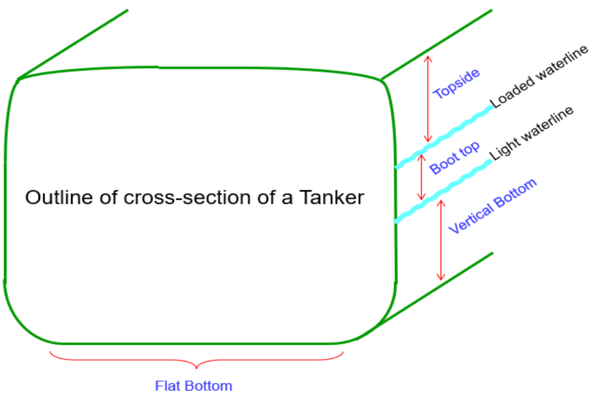

Figure 4.5 : Shipside and Bottom [28].

The propeller, rudder and shaft system, which provide the ship the ability to move and maneuver with the power it receives from the main engine, are also subject to maintenance works while the ship is in dock. If there is no major malfunction in these systems, general inspection and cleaning work is usually done. The rudder is considered as a ship hull and the cleaning operations in the hull are carried out on the rudder surface as well. However, this situation is different for the propeller. While the operations on the propeller blades are carried out separately, it is also important to protect these systems while cleaning the hull. In addition, it may be requested that these systems be taken from the ship and repair work and renewal operations be carried out in the shipyard workshops on the systems and the parts there. The main difference is that the Fixed Pitch Propeller (FPP) blades have a fixed, unchangeable angle, while the Controllable Pitch Propeller (CPP) allows the blade angle to be adjusted during operation for better efficiency and maneuverability.

Compared to the Fixed Pitch Propeller (FPP), the Controllable Pitch Propeller (CPP) has higher efficiency and maneuverability because it allows the blade angles to be adjusted during operation. The pricing policies of the shipyards may be different for these two types of propellers. While a total price can be given for Fixed Pitch Propeller (FPP) when the propeller is removed from the ship, a price can be given per blade for Controllable Pitch Propeller (CPP). At the same time, in order to maintain propeller efficiency, it is important to clean the dirtiness settled on the surfaces of the propeller blades by polishing. In order to detect if the surface of the propeller blades has breaking or not Dye Penetrant Inspection (DPI) is also done during the docking works [6]. Figure 4.6 shows the condition of a ship's hull and propeller after cleaning works.

Figure 4.6 : Vessel after treatment of hull and polishing of the propeller [29].

Rudder systems that are used to steer a ship are subjected to cleaning operations during docking also. At the same time, rudder can be removed from the ship for inspection during docking. Shafts are used to transmit the power produced by the ship's main engine to the propeller to move the ship. During repairs, it may be requested to take general measurements on the shafts and, depending on the shaft condition, it may also be requested to withdraw from the ship. To carry out these works, it is necessary to remove the rope guard that acts as a protection barrier. The opening of bottom plugs, which act as a stopper on ships, aims to dispose of water waste collected at the bottom of the ship while the ship is in dock. At the same time, vacuum tests are also performed to ensure that there is no leakage. Depending on their conditions, old bottom plugs can be replaced with new ones. General cleaning and maintenance work of the sea chests, which are located in the underwater part of the ship and receive the sea water required for cooling the systems on the ship through strainers, is carried out while the ship is in dry dock. When the ship is in dock, the cleaning, measurement and painting of anchor chains and chain lockers are also required. Repair works related to cathodic systems that exist to protect the ship hull from corrosion is done while the ship is in dock. Here, system control work and replacement of anodes are done. As in many circuits of ships, there are many different sizes and types of overboard valves in the underwater parts as well. After the ship is out of contact with the water in the dock, the aim is to perform general maintenance of these valves and replace the necessary ones. Thrusters, which are located at the bow or stern of ships and increase the ship's maneuverability, are located in the underwater section. In these thrusters, which also have gratings, the removal of gratings, cleaning the inside of the thruster tunnel, and polishing the blades of the propellers in the thrusters are among the targeted tasks while the ship is in the dry dock. Thickness measurements are made both in the underwater and other parts of the ship. Ultrasonic Thickness Measurement (UTM) is performed especially in the underwater parts of the ship while it is in dock, to obtain information about the structure of the ship, and renewal can be made in these structures according to the test results [6].

4.3 Challenges in the Current Practices

The fact that shipping companies prepare repair details in their own format and shipyards prepare their offers in their own format negatively affects both the duration and the accuracy of the offer. A shipping company that is urgently looking for a shipyard after a ship accident can quickly add the details of the repairs to a standard format and receive rapid offers from shipyards in the same way. In addition, since the standard format is clearer and more understandable, evaluations between different shipyards can be made better and faster. There are other unavoidable issues other than the format difference. While the ship is in operation, the condition of the areas to be repaired may not be clear until the ship goes to the shipyard. Especially the condition of the structures and systems in the underwater parts cannot be fully understood until the ship goes to the shipyard. At the same time, the amounts in the areas to be repaired may be higher than expected.

4.4 Recommendations

4.4.1 Proposed standard specifications for budget estimations

In this section, the works described in section 4.2.1 are shown in the form of a sample repair specification.

Table 4.1 : Maneuvering services.

No:	Work Scope Description	Unit	Quantity
A.1	Maneuvering Services		
A.1.1	Docking and undocking of the vessel	each	2
A.1.2	Berthing and unberthing of the vessel	each	2

Table 4.1 shows the shipyard's operation works for docking and undocking of ship together with berthing and unberthing of ship. Here, many shipyards only provide shore riggers and mooring boat assistance and request that the ship's local pilotage and agency for operations. Here, each operation is priced individually by the shipyard.

Table 4.2 : Berth period.

No:	Work Scope Description	Unit	Quantity
A.2	Berth Rental		
A.2.1	Berth period	day	X

Table 4.2 shows the shipyard's berth rental for the period the ship will be at the berth. Here, if the shipyard wants to charge the ship while the work is ongoing at the berth, they offer a daily price.

Table 4.3 : Gas-free inspection.

No:	Work Scope Description	Unit	Quantity
A.3	Gas-free Inspection		
A.3.1	Initial gas-free inspection	total	1
A.3.2	Daily gas-free inspection	day	X

Table 4.3 shows the work of the shipyard regarding gas-free inspection. Here, the first gas-free inspection is carried out as soon as the ship arrives and a total price is given. After the ship's arrival, gas-free inspection is carried out on a daily basis in the areas where hot works or specific works will be done and prices are charged daily.

Table 4.4 : Fire precautions.

No:	Work Scope Description	Unit	Quantity
A.4	Fire Precautions		
A.4.1	Fire line connection-disconnection	each	2
A.4.2	Fire line water supply	day	X
A.4.3	Fire watchman	shift	X
A.4.4	Placement of fire extinguishers	each	X
A.4.5	Security watchman	shift	X

Table 4.4 shows the work to be done to take fire precautions in a shipyard. Here, the connection of the shipyard fire line to the ship and the disconnection from the ship when it leaves the shipyard are calculated separately, the supply of water to the fire line is calculated daily, the presence of the fire watchman on the ship is calculated as a shift, and the supply of additional fire extinguishers to the ship is calculated in units. Here, 1 shift includes 8 hours, and number of fire watchmen is assigned according to the size of the ship in each shipyard. If requested by the ship, shipyards can also assign a security watchman to the ship for additional security measures and the price calculations here are calculated as shifts, like the fire watchman.

Table 4.5 : Cooling water.

No:	Work Scope Description	Unit	Quantity
A.5	Cooling Water		
A.5.1	Cooling line connection-disconnection	each	2
A.5.2	Cooling line water supply	day	X

Table 4.5 shows the work of providing cooling water to the ship. Since cooling water is provided regularly while the ship is in the shipyard, it is priced on a daily basis.

Table 4.6 : Air supply.

No:	Work Scope Description	Unit	Quantity
A.6	Air Supply		
A.6.1	Air line connection-disconnection	each	2
A.6.2	Air supply	day	X

Table 4.6 shows the work of providing air to the ship. As with cooling water, air is also supplied regularly while the ship is in the shipyard, so it is priced on a daily basis.

Table 4.7 : Ballast water.

No:	Work Scope Description	Unit	Quantity
A.7	Ballast Water		
A.7.1	Ballast water line connection-disconnection	each	2
A.7.2	Ballast water supply	tons	X

Table 4.7 shows the supply of ballast water to the ship. Ballast water is taken or given in specific cases such doking and berthing, or if there is work in the ballast tanks. Therefore, it is calculated in tons.

Table 4.8 : Shore electricity.

No:	Work Scope Description	Unit	Quantity
A.8	Shore Electricity		
A.8.1	Electricity line connection-disconnection	each	2
A.8.2	Electricity supply	kW	X

Table 4.8 shows the establishment of a shore connection and the supply of electricity to the ship. Electricity price calculations are made in kW.

Table 4.9 : Fresh water.

No:	Work Scope Description	Unit	Quantity
A.9	Fresh Water		
A.9.1	Fresh water line connection-disconnection	each	2
A.9.2	Fresh water supply	tons	X

Table 4.9 shows the work of providing fresh water to the ship. This is a service provided to the ship in times of need. Therefore, the price is calculated per ton.

Table 4.10 : Scaffolding.

No:	Work Scope Description	Unit	Quantity
A.10	Scaffolding		
A.10.1	Scaffolding in an open area	m³	X
A.10.2	Scaffolding in a closed area	m³	X

Table 4.10 shows the work involved in scaffoldings installed on ships. The installation of scaffoldings in open or closed areas affects the costs of some shipyards. In this sense, most shipyards apply separate pricing policies according to open or closed areas. Since scaffoldings create a volume, price calculations are made in m^3.

Table 4.11 : Waste disposals.

No:	Work Scope Description	Unit	Quantity
A.11	Waste Disposal		
A.11.1	Disposal of bilge wate	m³	X
A.11.2	Disposal of mud	m³	X
A.11.3	Disposal of sewage	m³	X
A.11.4	Garbage disposal	day	X

Table 4.11 shows the work involved in different types of wastes taken from the ship. There is a separate pricing policy for each waste generated on the ship and their disposals are priced per m^3. During the repair period, a container of a certain volume is placed in a suitable area on the ship for the disposal of garbage by the crews on the ship and emptied daily. The pricing of this garbage is priced per day.

Table 4.12 : Gangway.

No:	Work Scope Description	Unit	Quantity
A.12	Gangway		
A.12.1	Installation of gangway	day	X

Table 4.12 shows the work involved in connecting the gangway to the ship. There are gangways at different heights in shipyards. When the ship docks, these gangways are connected to the ship and pricing is done daily.

Table 4.13 : Docking.

No:	Work Scope Description	Unit	Quantity
B.1	Docking		
B.1.1	Docking and undocking operation	each	2
B.1.2	Docking period	days	X

Table 4.13 shows the dock operation of the shipyard and the work related to the duration of the ship's stay in the dock. Here, each operation is priced individually, and the dock fee is charged daily for the duration of the ship's stay in the dock.

Table 4.14 : Hull washing, blasting and painting.

No:	Work Scope Description	Unit	Quantity
B.2	Hull Washing, Blasting and Painting		
B.2.1	High Pressure Washing	m^2	X
B.2.2	Low Pressure Washing	m^2	X
B.2.3	SA-2 Grit Blasting	m^2	X
B.2.4	SA-1 Grit Blasting	m^2	X
B.2.5	Grit Sweeping	m^2	X
B.2.6	Touch-up Painting	m^2	X
B.2.7	Full Coat Painting	m^2	X
B.2.8	Boot Top Line	m	X
B.2.9	Painting of vessel's name and other markings on the hull	total	1

Table 4.14 shows the works related to washing, blasting and painting the hull surface of the ship, drawing of the boot top line and painting the ship's name and other markings on the hull. Since we are talking about works on a surface area here, works related to washing, blasting and painting are priced per m^2. Since the Boot Top Line is drawn around the ship, there is a length involved. A total price can be given for the vessel’s names and markings on the ship.

Table 4.15 : Propeller, rudder, shaft works.

No:	Work Scope Description	Unit	Quantity
B.3	Propeller, Rudder, Shaft Works		
B.3.1	Dismounting and mounting of Fixed Pitch Propeller (FPP)	each	X
B.3.2	Dismounting and mounting of Controllable Pitch Propeller (CPP)	per blade	X
B.3.3	Propeller polishing	per blade	X
B.3.4	Dye Penetrant Inspection (DPI) of the propeller	each	X
B.3.5	Dismounting and mounting of rudder	each	X
B.3.6	Dismounting and mounting of rope guard	each	X
B.3.7	Withdraw of shaft	mm	X
B.3.8	Taking measurements on shaft	each	X

Table 4.15 shows the work related to the propeller, rudder and shaft. Here it should be noted that in shaft withdrawal, pricing is done according to the shaft outside diameter in mm.

Table 4.16 : Bottom plugs.

No:	Work Scope Description	Unit	Quantity
B.4	Bottom Plugs		
B.4.1	Dismounting and mounting of bottom plugs	each	X
B.4.2	Vacuum tests of bottom plugs	each	X
B.4.3	Security cementing of bottom plugs	each	X
B.4.4	Renewal of bottom plugs	each	X

Table 4.16 shows the works related to bottom plugs. There are a certain number of bottom plugs on the ship, and the work related to these can be priced individually.

Table 4.17 : Sea chest.

No:	Work Scope Description	Unit	Quantity
B.5	Sea Chest		
B.5.1	Dismounting of gratings of sea chest, cleaning and painting and mounting back	each	X

Table 4.17 shows the work associated with sea chests. Here each sea chest is priced separately.

Table 4.18 : Anchor chain and chain locker works.

No:	Work Scope Description	Unit	Quantity
B.6	Anchor Chain and Chain Locker Works		
B.6.1	Ranging of anchors and chains for inspection, cleaning and painting	each	X
B.6.2	Chain Locker washing, blasting and painting	each	X

Table 4.18 shows the work associated with anchor chain and chain locker. Here each of them is priced separately.

Table 4.19 : Anodes.

No:	Work Scope Description	Unit	Quantity
B.7	Anodes		
B.7.1	Renewal of old anodes in open areas	each	X
B.7.2	Renewal of old anodes in closed areas	each	X

Table 4.19 shows the works related to anodes renewal. The pricing policy of the shipyards may vary depending on the location of the anodes. Each anode replacement is priced individually.

Table 4.20 : Overboard valves.

No:	Work Scope Description	Unit	Quantity
B.8	Overboard valves		
B.8.1	Removal and cleaning of valves	mm	X
B.8.2	Renewal of valves	mm	X

Table 4.20 shows the works related to overboard valves. Depending on the condition of the valve, a change may be requested. Valves can be priced according to Diameter Nominal (DN) of each. Some shipyards may also have different pricing policies depending on the valve type.

Table 4.21 : Bow thruster.

No:	Work Scope Description	Unit	Quantity
B.9	Bow Thruster		
B.9.1	Dismounting of gratings of bow thruster, cleaning and painting inside and mounting back	each	X
B.9.2	Polishing of bow thruster propeller blades	each blade	X

Table 4.21 shows the work related to the bow thruster. Here, each bow thruster tunnel cleaning is priced individually. For bow thruster polishing, prices can be given per blade or in total.

Table 4.22 : Ultrasonic thickness measurement.

No:	Work Scope Description	Unit	Quantity
B.10	Ultrasonic Thickness Measurement		
B.10.1	Ultrasonic Thickness Measurement	per point	X

Table 4.22 gives information about the Ultrasonic thickness measurement on the ship. Pricing is given per point.

4.4.2 Essential data points for shipyards

Superintendents send a file containing information about the ship's features along with the repair specification for the price request to the shipyard or add this information to the repair report. This information must include the ship's IMO number, the ship's length, width, Deadweight, Gross tonnage and year of construction. In addition to this information, the ship's side must specify the periods in which it wants to come to the shipyard for repairs. After the shipyard knows these features of the ship, it decides whether it wants to work with that ship or not. At the same time, it is checked whether these features of the ship are suitable for the shipyard infrastructure. All the works included in the repair specification must be written in detail and clearly. The types and features of the materials to be used must also be specified. In addition to these works, sending pictures and technical drawings from the ship allows for a more accurate pricing of the works. In return, the shipyard also states the payment terms it wants when sending the offer. If the ship does not accept these conditions, the shipyard may not want to work with the ship.

4.4.3 Recommendations for the industry collaboration between shipyards and shipping companies

For a shipping company to establish long-term cooperation with a shipyard in the region where its ships operate, would be in the interest of both parties. Because both the shipyard will have a certain budget view in advance regarding the upcoming ships, and the shipping company will be inclined to the pricing policies of the shipyard it has been working with for a long time. In order to establish such a relationship, shipyards and shipping companies need to be open to each other in terms of communication. Rapid transfer of information, quick resolution of problems, and both parties being able to master each other's work can create such a process. Usually, the pricing policies of shipyards in the same region can be similar. If there are very similar repair offers in the same region, references will be important in choosing a shipyard. A list of previous ships that have repaired at the shipyard can be obtained both from the shipyard and from various sources. Big shipping companies can repair its ships in the same region at different shipyards, which has good references and compare the repair results in terms of time, quality and final repair budget. Then, they can make a long-term fleet agreement with the most suitable shipyard.

4.5 Relationship Between the Work Scope and the Repair Period

Ship repair specifications include details about the repair work to be done on the ship while it is at the wharfage, in addition to the dock works [5]. After the price is given for all these works, it is very important to calculate the repair time correctly. Because the repair time will affect the budget, the shipyard's plan for other upcoming ships, and the shipping company's plans for the ship to be repaired [6]. Table 4.23 and Table 4.24 contain information on repair work performed on ships of different sizes, ages and types.

Table 4.23 : Repair periods for different type of vessels [30].

Vessel	Type	L [m]	B [m]	DWT [tons]	Age	BP [days]	DP [days]	TRP [days]
A	Bulk Carrier	180	30	35783	10	8	7	15
B	Bulk Carrier	200	32,3	60388	6	3	7	10
C	Tanker	130	21	13078	15	21	7	28
D	Container Ship	143	22,6	12268	10	7	10	17
E	Bulk Carrier	229	32,3	80545	13	12	7	19
F	Tanker	183	32,3	50000	15	13	7	20
G	Bulk Carrier	229	32,3	82052	5	8	7	15
H	Tanker	170	25,4	25997	15	15	7	22
I	Tanker	176	29,9	30720	15	18	7	25
J	General Cargo	139	22	14695	10	7	7	14

Table 4.23 shows the berth period (BP), dock period (DP) and total repair period (TRP) given for 10 ships of different length (L), breadth (B), deadweight (DWT) and age. Different types, sizes and works were taken into account in the selection of ships.

Table 4.24 : Repair scopes for different type of vessels [30].

Vessel	Type	HT[m²]	SW[tons]	PW[m]	CHW/CTW	MEO	AEO	METO	AETO	VO[mm]	RPSW	EMO[pcs]	PO[pcs]
A	Bulk Carrier	8950	20	50	Yes	Yes	No	Yes	No	13000	Standard	15	No
B	Bulk Carrier	12800	10	76	No	No	No	Yes	Yes	5500	Standard	8	No
C	Tanker	5600	55	900	No	No	No	No	No	2500	Standard	5	7
D	Container Ship	5800	No	No	Yes	Yes	Yes	Yes	Yes	No	Standard	23	No
E	Bulk Carrier	16500	No	780	Yes	No	No	No	No	4000	Standard	4	No
F	Tanker	11300	No	200	No	Yes	Yes	Yes	No	3750	Standard	6	8
G	Bulk Carrier	16500	No	No	No	Yes	Yes	Yes	Yes	No	Standard	No	No
H	Tanker	9350	No	50	No	Yes	Yes	Yes	Yes	5000	Standard	No	No
I	Tanker	11000	No	50	No	Yes	Yes	Yes	Yes	6500	Standard	85	No
J	General Cargo	6250	2	10	Yes	No	No	No	No	4200	Standard	10	No

Table 4.24 shows hull treatment (HT), steel works (SW), pipe works (PW), cargo hold treatment/cargo tank treatment (CHW/CTW), main engine overhauling (MEO), auxiliary engine overhauling (AEO), main engine turbocharger overhauling (METO), auxiliary engine turbocharger overhauling (AETO), valve overhauling (VO), rudder propeller shaft works (RPSW), electrical motors overhauling (EMO) and pump overhauling (PO) works for the above mentioned ships. Hull treatment (HT) was performed for all ships and the hull areas of each ship are given in m^2. Steel and pipe renewals are shown in tonnes and metres respectively. If cargo hold treatment/cargo tank treatment (CHW/CTW), main engine overhauling (MEO), auxiliary engine overhauling (AEO), main engine turbocharger overhauling (METO) and auxiliary engine turbocharger overhauling (AETO) are performed, then these are indicated as yes or no in the table. Valve overhauling (VO) is performed on many ships, where it is performed is shown with diamter nominals (DN) and where it is not performed is shown with no. Rudder propeller shaft works (RPSW) are performed as standard on all ships. The standard works are explained in Table 4.15. Electrical motors overhauling (EMO) and pump overhauling (PO) works, if any, are shown with their numbers.

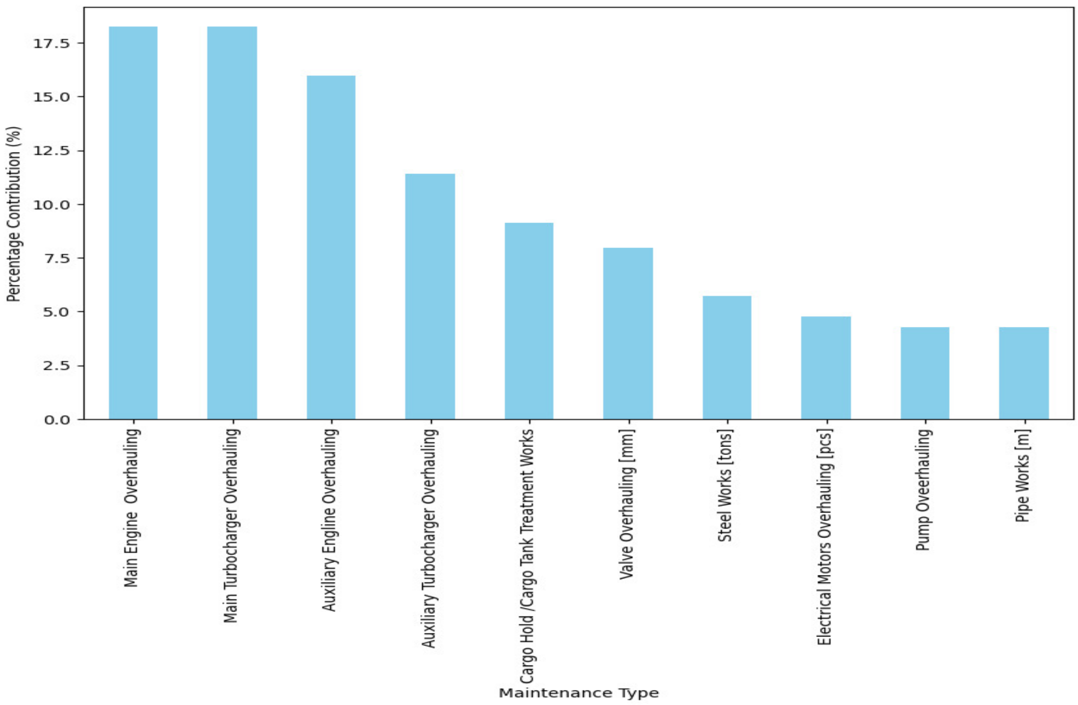

Figure 4.7 : Contribution of each work to all scope.

Figure 4.7 shows the impact of the work done on the 10 ships above on all repair work. It appears that engine overhauling works have more impact there.

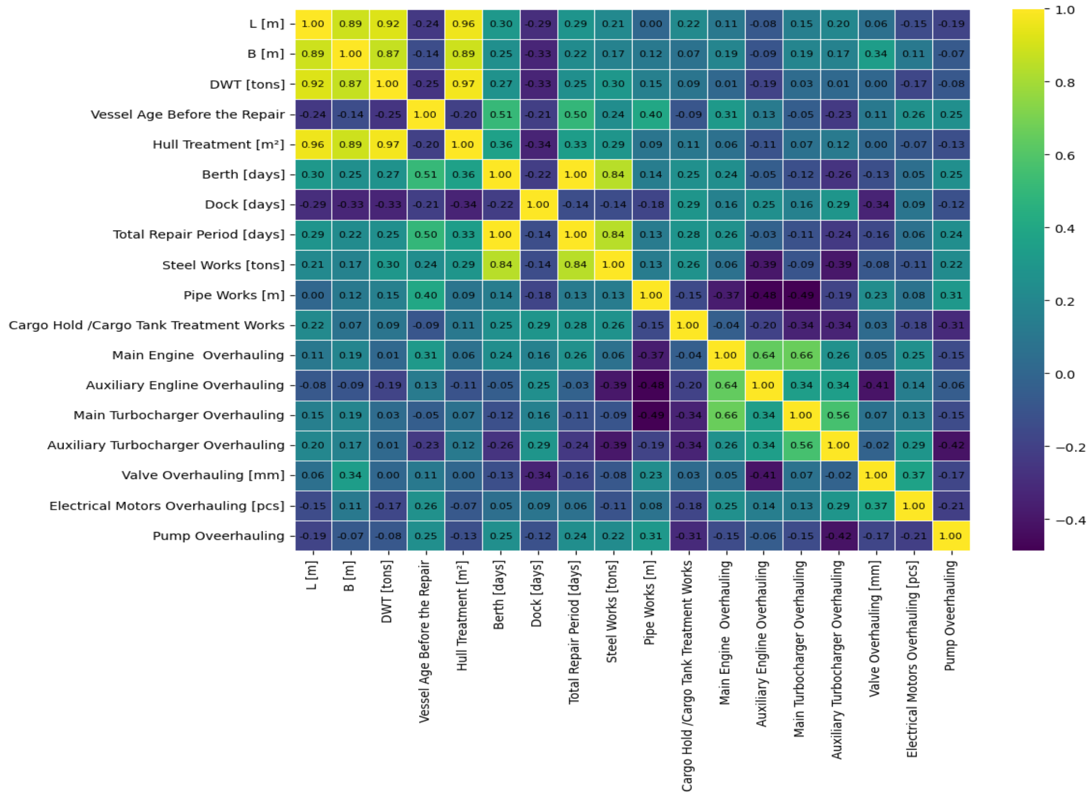

Figure 4.8 : Ship properties, repair periods and all works.

Figure 4.8 shows the correlation matrix between vessel dimensions, age, repair periods and maintenance tasks. The leading cause of longer repair works is likely steelworks, with a correlation of r=0.42.

A correlation between vessel age and total repair period (r=0.85) indicates that older vessels are typically subjected to longer repair works. The relationship between vessel age and pipe works (r=0.44) suggests that ageing-related pipeline deterioration is a common cause of vessel maintenance.

Also if main engine overhauling is done, auxiliary engine overhauling is usually done as well. It is also very common to repair the pumps when doing pipe works.

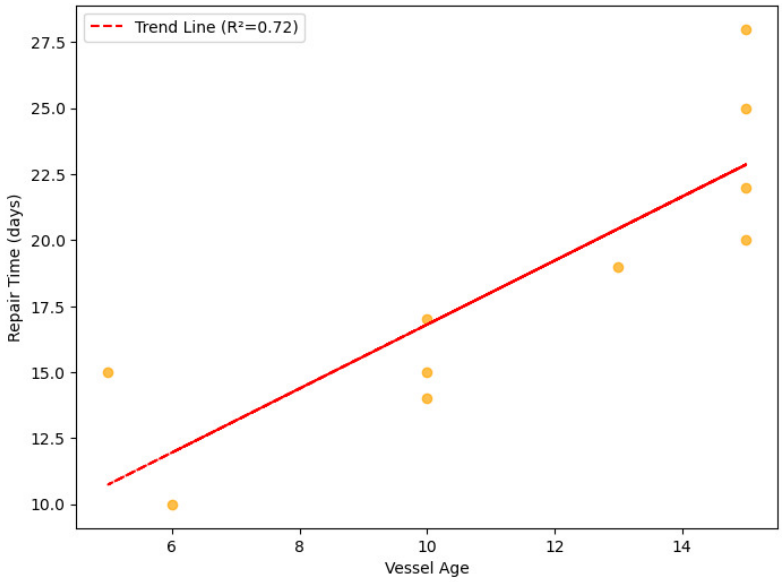

Figure 4.9 : Repair time and age of the vessel.

Figure 4.9 shows the relationship between repair time and ship age. In addition to the mandatory maintenance works required by the shipyards, ships also have other works done according to their condition. As ships get older, their condition declines and some additional problems arise. For this reason, shipyard maintenance times naturally increase in older ships.

5. CONCLUSIONS

This thesis discusses the importance of correct ship repair budget estimation and the need for standardized ship repair specifications to reduce the mistakes in shipyard selection processes. The impact of missing or inconsistent specifications are discussed and it was noted that, in general, inconsistent repair reports lead to improper repair budgeting by shipyards, as well as potential disputes. A clear and uniform format for ship repair specifications would ensure better communication between shipyards and superintendents, accurate repair cost estimations, and reduced delays and cost overruns in the repair operation. From the literature survey it was noted that accurate repair budgeting depends on the availability of complete and precise data. Missing or incomplete information, such as work quantities, technical drawings, or component details, are causes for miscommunication, work delays, and may incurr in additional costs for shipowner. For these reasons, ship repair specifications need to be as precise and complete as possible for an accurate estimation of the total repair budgets. The inclusion of the vessel specifications and dimensions is also of interest for shipyards making bids as they can provide a more accurate quote for the repairs and allow shipowners to select the most appropiate shipyard for the maintenance operation. This study provides a structured framework for itemising and pricing repair tasks. The tables from 4.1 to 4.22 illustrate how these specifications can be formatted to minimise ambiguity before submiting the repair specification to shipyards. These tables would ensure that all works are presented in a cconsistent manner allowing for shipyards to return accurate bids and shipowners to gain more accurate estimates. The proposed framework provides a structured method for itemising and pricing repair tasks. Adopting a standardised framework for ship repair specifications and budgets has the potential to enhance the overall efficiency of repair operations. It not only enables shipping companies to receive consistent quotes from multiple shipyards but also for transparent pricing and simpler evaluations. Moreover, this approach significantly reduces the risk of discovering unplanned repair works once the vessel is already under repair, thus preventing unforeseen costs and delays.

Ship repair times are one of the most important parameters for both the shipyard and the shipping company. The shipyard makes plans for other future ships in line with this parameter, and the shipping company calculates all possible losses along with shipyard expenses during this period when the ship is inactive and makes its plan for the future. Details regarding the ship repair specification content and repair time received from X shipyard are shown in Tables 4.23 and 4.24, and the effects of different jobs on repair times are shown in Figure 4.8. These are the most important works that affect the repair time and is a good reference for ships of different types, sizes and ages, which will be repaired in the future.

It is also shown which parameters the shipyards give prices for. It is understood that a standard offer format should be prepared and that it will be priced by different shipyards with the same logic. It has been explained that non-standard repair specifications will result in longer work times and higher costs.

In this study, mainly the repair works of ships in the shipyard docks are explained. This can be expanded by adding steel works, main engine and other engine works, pipes and other works. Since the works are given clearly, some inferences can be made about the ship repair period. Appendix A contains the list of works can be sent to a shipyard for a ship that will have dock repairs and the assumed quantities for these works. This can be used as a standard repair specification and can be expanded by adding other repair works in the same way. After further development, formulations related to repair budget calculations can be put forward. A more comprehensive study will be interesting for use by maritime companies.

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APPENDICES

APPENDIX A: Standard ship repair specification

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Table A.1 : Standard ship repair specification.

No:	Work Scope Description	Unit	Quantity	Unit Price	Discount Rate	Total Price
A.1	Maneuvering Services					
A.1.1	Docking and undocking of the vessel	each	2			
A.1.2	Berthing and unberthing of the vessel	each	2			
A.2	Wharfage					
A.2.1	Berth period	days	15			
A.3	Gas-free					
A.3.1	Initial gas-free inspection	total	1			
A.3.2	Daily gas-free inspection	days	22			
A.4	Fire Precautions					
A.4.1	Fire line connection-disconnection	each	2			
A.4.2	Fire line water supply	days	15			
A.4.3	Fire watchman	shift	66			
A.4.4	Placement of fire extinguishers	each	10			
A.4.5	Security watchman	days	66			
A.5	Cooling Water					
A.5.1	Cooling line connection-disconnection	each	2			
A.5.2	Cooling line water supply	days	22			
A.6	Air Supply					
A.6.1	Air line connection-disconnection	each	2			
A.6.2	Air supply	days	22			

Table A.1 (continued) : Standard ship repair specification.

No:	Work Scope Description	Unit	Quantity	Unit Price	Discount Rate	Total Price
A.7	Ballast Water					
A.7.1	Ballast water line connection-disconnection	each	2			
A.7.2	Ballast water supply	tons	4000			
A.8	Shore Electricity					
A.8.1	Electricity line connection-disconnection	each	2			
A.8.2	Electricity supply	kW	8800,00			
A.9	Fresh Water					
A.9.1	Fresh water line connection-disconnection	each	2			
A.9.2	Fresh water supply	tons	150			
A.10	Scaffolding					
A.10.1	Scaffolding in an open area	m^3	300			
A.10.2	Scaffolding in a closed area	m^3	500			
A.11	Waste Disposal					
A.11.1	Disposal of bilge wate	m^3	10			
A.11.2	Disposal of mud	m^3	150			
A.11.3	Disposal of sewage	m^3	20			
A.11.4	Garbage disposal	day	22			
A.12	Gangway					
A.12.1	Installation of gangway	each	2			
B.1	Docking					
B.1.1	Docking and undocking operation	each	2			
B.1.2	Docking period	days	7			

Table A.1 (continued) : Standard ship repair specification.

No:	Work Scope Description	Unit	Quantity	Unit Price	Discount Rate	Total Price
B.2	Hull Washing, Blasting and Painting					
B.2.1	High Pressure Washing	m²	16000			
B.2.2	Low Pressure Washing	m²				
B.2.3	SA-2 Grit Blasting	m²	8000			
B.2.4	SA-1 Grit Blasting	m²	8000			
B.2.5	Grit Sweeping	m²	X			
B.2.6	Touch-up Painting	m²	X			
B.2.7	Full Coat Painting	m²	32000			
B.2.8	Boot Top Line	m	490			
B.2.9	Painting of vessel's name and other markings on the hull	total	1			
B.3	Propeller, Rudder, Shaft Works					
B.3.1	Dismounting and mounting of Fixed Pitch Propeller (FPP)	each	1			
B.3.2	Dismounting and mounting of Controllable Pitch Propeller (CPP)	per blade	X			
B.3.3	Propeller polishing	per blade	4			
B.3.4	Dye Penetrant Inspection (DPI) of the propeller	each	1			
B.3.5	Dismounting and mounting of rudder	each	1			
B.3.6	Dismounting and mounting of rope guard	each	2			
B.3.7	Withdraw of shaft	mm	450			
B.3.8	Taking measurements on shaft	each	2			
B.4	Bottom Plugs					
B.4.1	Dismounting and mounting of bottom plugs	each	14			
B.4.2	Vacuum tests of bottom plugs	each	14			

Table A.1 (continued) : Standard ship repair specification.

No:	Work Scope Description	Unit	Quantity	Unit Price	Discount Rate	Total Price
B.4.3	Security cementing of bottom plugs	each	14			
B.4.4	Renewal of bottom plugs	each	X			
B.5	Sea Chest					
B.5.1	Dismounting of gratings of sea chest, cleaning and painting and mounting back	each	3			
B.6	Anchor Chain and Chain Locker Works					
B.6.1	Ranging of anchors and chains for inspection, cleaning and painting	each	2			
B.6.2	Chain Locker washing, blasting and painting	each	2			
B.7	Anodes					
B.7.1	Renewal of old anodes in open areas	each	350			
B.7.2	Renewal of old anodes in closed areas	each	400			
B.8	Overboard Valves					
B.8.1	Removal and cleaning of valves	mm	5500			
B.8.2	Renewal of valves	mm	1500			
B.9	Bow Thruster					
B.9.1	Dismounting of gratings of bow thruster, cleaning and painting inside and mounting back	each	1			
B.9.2	Polishing of bow thruster propeller blades	each blade	4			
B.10	Ultrasonic Thickness Measurement					
B.10.1	Ultrasonic Thickness Measurement	per point	10000			

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